AUGMENTED REALITY AS A NEW MEDIUM: REMEDIATION AND NOVEL FORM

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A DISSERTATION SUBMITTED TO
THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

GRADUATE PROGRAM IN COMMUNICATION AND CULTURE
YORK UNIVERSITY
TORONTO, ONTARIO

May 2014

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ABSTRACT

This dissertation is a pioneering exploration and mapping of the vast terrain of Augmented Reality (AR) as a new medium experienced from the unique perspective of being both a practitioner and academic researcher working with AR for the past nine years. AR has been typically defined as a layering of digital images, including text, audio, video, and 3D models, in real-time atop the physical environment and is experienced through an AR equipped device such as a smartphone, a tablet, a computer with a webcam, or a pair of see-through digital glasses. There is a current gap in knowledge in AR, particularly in the fields of communications, media, and humanities, with the critical need to revisit how we come to understand and define AR, especially at a time when AR is emerging as a medium, no longer just a technology found in Computer Science labs. This dissertation provides a first-hand look and foresight into the new world of AR, its promise and expanded capabilities building from a Communications and Culture foundation as a practitioner and researcher deeply immersed in the field. Setting a course of research-creation enabled a major technological innovation, resulting in ground-breaking work: the world's first AR book designed for the iPad using image tracking. The path of research-creation further led to a proposed visionary framework for the present state and coming future of AR entitled, *The 40 Ideas That Will Change Augmented Reality,* which documents and prescribes possibilities, proposing an articulation of a new language of AR.

This work is dedicated to my incredible family whose endless support has meant the world to me. With great appreciation, thanks, and love, always.

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Introduction

Overview

This dissertation is a pioneering exploration and mapping of the vast terrain of Augmented Reality (AR) as a new medium experienced from the unique perspective of being both a practitioner and academic researcher working with AR for the past nine years. Setting a course of research-creation[1] enabled a major technological innovation, resulting in ground-breaking work: the world's first AR book designed for the iPad using image tracking. The path of research-creation further led to a proposed visionary framework for the present state and coming future of AR entitled, *The 40 Ideas That Will Change Augmented Reality,* which documents and prescribes possibilities, proposing an articulation of a new language of AR.

AR has been typically defined as a layering of digital images, including text, audio, video, and 3D models, atop the physical environment and is experienced through an AR equipped device such as a smartphone, a tablet, a computer with a webcam, or a pair of see-through digital glasses. In his seminal paper, *A Survey of Augmented Reality* (1997), Ronald Azuma discusses the technical aspects and challenges of building AR systems from the perspective of a Computer Scientist. He compares AR to Virtual Reality (VR), distinguishing AR as allowing the user to still see the real world, in contrast to VR, where the user is completely immersed in a “synthetic environment” and cannot see the real world. Azuma comments on how unlike in VR, “AR supplements reality, rather than completely replacing it” (2). He states how in an ideal AR scenario virtual and real objects would appear to the user as co-existing.

Azuma's article is most famous for defining AR traditionally as possessing the following

1 One definition for research-creation comes from the Canada Council for the Arts in 2011 as addressing “artists whose practice combines experimentation, exploration, and research in conjunction with production" (Chapman and Sawchuk, 9). Research-creation is discussed more in depth in Chapter 3: The Importance of Research-creation.

three technical characteristics: 1) It combines the real and the virtual; 2) It is interactive in real time; 3) It is registered in 3-D (2). These three characteristics, as outlined by Azuma, generally still hold true 16 years later; however, AR's definition continues to expand as the medium comes into its own and begins to enter the arts, media, and humanities, moving beyond Computer Science[2], the field in which Azuma's paper was written. There is a current gap in knowledge in AR, particularly in the fields of communications, media, and humanities, with the critical need to revisit how we come to understand and define AR, especially at a time when AR is emerging as a medium, no longer just a technology found in Computer Science labs. This dissertation provides a first-hand look and foresight into the new world of AR, its promise and expanded capabilities building from a Communications and Culture foundation as a practitioner and researcher deeply immersed in the field.

Go Where There is No Path and Leave a Trail

> "You can see just a little PEEP of the passage [...] you know it may be quite different on beyond [...] how nice it would be if we could only get through into Looking-Glass house! [...] Let's pretend there's a way of getting through into it, somehow..."
>
> -Lewis Carroll, *Through the Looking-Glass,* 1871.

Research-creation served as a major source of knowledge and a means of providing a "peep of the passage" into AR as an emerging field. Research-creation has allowed alternate ways of knowing, particularly in a field like AR where there were no previous answers, for as Owen Chapman and Kim Sawchuk point out, "one valuable way 'to know' is 'to do'" (14). Research-creation has been a highly valuable method for me 'to know' and to understand AR by 'doing', especially at a time of making work before the technology was in place and where the only way 'to know' and to seek answers was to create knowledge through work because it

2 I was the first artist to exhibit in the inaugural year of the Arts, Media, and Humanities (AMH) stream at the IEEE International Symposium for Mixed and Augmented Reality (ISMAR) in Orlando, Florida in 2009. Prior to 2009, this very well-respected academic conference focused exclusively on Computer Science since 2002.

was otherwise unavailable.

Through the process of production, the 'peep hole' into AR expanded, for like Alice making her way into Looking-Glass House, I was able to get through and fully immerse myself in the landscape of AR with research-creation serving as the portal. I was able to see just how “quite different on beyond” the field was than I originally imagined when I began the work nine years ago. By researching and working so intimately with AR firsthand, I was able to see a shift in the direction of the medium, that I refer to as the first and second waves of AR, which I describe below. I can clearly see that AR wants to be more and that it can be more than how we so lightly understand it today. As a practitioner, a researcher, and as someone who has become known in this field as a well-respected thought-leader, my goal is to share my knowledge of AR and help to pave the path of where we will go as a community and industry, inspiring a new generation of designers, artists, technologists, writers, and researchers to blaze this trail. Poet Ralph Waldo Emerson wrote, “Do not go where the path may lead, go instead where there is no path and leave a trail.”

One of the objectives of the dissertation has been to document the genealogy of AR and contribute to it through the process of research-creation, at a time while AR is coming into being and we are still able to see and identify the previous forms that are shaping it. What I did not anticipate was a second wave of AR emerging that was so different from the first wave and being able to recognize a set of concurrent forms that are coming to shape and contribute to the second wave of AR. In the introduction to *The Language of New Media*, Lev Manovich discusses how cinema was “painstakingly reconstructed” out of previous cultural forms and posits why “a similar genealogy for the language of computer media” was not attempted “at the moment when it was coming into being, that is, when the elements of previous cultural forms shaping it were still clearly visible and recognizable, before melting into a coherent

language?” (7). We are at this exact moment in AR’s development, more specifically as it enters its second wave, while we can still see the previous forms that are shaping AR, including the first wave of AR, as well as other potentially allying technologies. Furthermore, it is a critical time to be engaged in AR as a practitioner to identify and contribute to the future conventions and capacities that will define this medium.

The First and Second Wave of AR

A goal of the research has been to understand what qualities are specific to AR as a medium that serve to distinguish it from any prior medium. The key characteristics of today's and tomorrow's AR that Azuma's definition of 16 years ago is missing is “context”. Context, referring to both the user and content, has been applied modestly in past and contemporary AR, if at all. Context plays a significant role in AR to separate it from previous mediums, serving to create an experience which is unique to the individual user each time. The content and experience are able to shift and dynamically update accordingly in real-time based on context specific factors and information from both the user and the external environment.

I distinguish the first and second wave of AR with the keywords “overlay” and “entryway”. The first wave, including Azuma's definition, focused on AR as “overlay”, with an emphasis on a primarily visual layering of digital information and 3D models atop the physical environment. In his essay, Azuma identified technological registration and sensing errors as “two of the biggest problems in building effective Augmented Reality systems”(1). At the 2011 IEEE International Symposium for Mixed and Augmented Reality (ISMAR), Founder and Director of the Mixed Reality Lab in Singapore, Adrian David Cheok made a critical statement in his keynote speech expressing how ISMAR needs to urgently move beyond being a conference concentrating on AR tracking and registration and to extend to engaging the other senses in AR. Cheok addressed how as a community of AR researchers we have focused

exclusively on computer vision tracking for too long, and as a result we've forgotten about the other senses. I highly agree with Cheok, and such, with the technology tracking having significantly advanced, we can no longer ignore embracing interaction with the other senses in AR. This is one reason we are coming to a second wave in AR, defined by “entryway”. The second “entryway” wave goes beyond overlay to now grant access to a more immersive, engaging, and personalized augmented experience where content is delivered based on the user's personal preferences and is dynamically adapted to a responsive environment, driven by context. The resulting experience is different and unique to each user.

One important contributing factor in this shift from the first to the second wave is the proliferation of wearable devices and hardware, including consumer AR glasses, combined with the internet of things and smart computing that have entered the market in recent years[3]. All of these things contribute to a greater immediacy and a sense of presence in the user experience, where the user is in an immediate relationship with the content presented and the resulting effect is one of the medium seemingly disappearing (discussed further in the literature review). Having observed AR's progress as a medium first-hand since 2005, the proliferation and rapid growth of such devices and advancements in technology entering the market signifies a major departure away from the most common 'magic-mirror' format experience on desktop computers in AR[4], predating mobile, tablet, and eyewear devices. In 2013, Google brought the possibilities of AR into the public consciousness with the Beta version Explorer Edition of their mass consumer digital eyewear Glass. Other digital eyewear

3 To be noted, this was after the AR book was made, when limited devices existed and AR enabled iPads had just become available.

4 The magic-mirror format commonly used a webcam and a computer to create a scenario where upon holding an AR marker or trackable glyph to a webcam, the image of reality with a layered augmentation would be mirrored back to the user. This created a disconnected experience where the user would see the augmentation as though looking into a mirror. Today, with the proliferation of mobile devices and eyewear, a 'see-through' experience dominates as though looking through a window directly onto reality to view the augmentation.

like Meta Space Glasses move towards a more true AR experience over both eyes (as opposed to Glass and projection over a single eye), and integrates gesture controls beyond Google Glass's voice and touch activation.

The next wave of AR will combine multiple devices integrating various kinds of sensors, wearable computing, big data, machine-learning, and artificial intelligence to create a far more personalized experience catered to each individual user. With the promise of all of this computing power and intelligent connectivity, it will be very difficult for AR to sustain itself as simply an overlay of fairly non-interactive visuals. It needs to progress into the next stage as the novelty of these 2D and 3D visual overlays will wear off. In *Virtual Art: Illusion to Immersion* (2004), new media art-historian Oliver Grau discusses how audiences are first overwhelmed by new and unaccustomed visual experiences, but later, once “habituation chips away at the illusion”, the new medium no longer possesses “the power to captivate” (152). Grau writes that at this stage the medium becomes “stale and the audience is hardened to its attempts at illusion”. He notes how this is results in a stage where “the observers are receptive to content and media competence”. I agree with Grau and I too believe that AR will lose the novelty of its initial visual illusion and that now is the time for relevant content driven by context, which is at the heart of what makes AR unique from other media forms.

From Magical to Life Changing

> “Any sufficiently advanced technology is indistinguishable from magic.”
> - Arthur C. Clarke's Third Law

> “Computing is not about computers anymore. It is about living."
> - Nicholas Negroponte, MIT Media Lab founder

I recall my first encounter with AR in 2005 in the Future Cinema course at York University with Dr. Caitlin Fisher and Dr. Janine Marchessault. Dr. Jay David Bolter led a

guest seminar and presented a demo of AR, showcasing the *Designer's Augmented Reality Toolkit (DART)* developed at the Georgia Institute of Technology. The demo used a desktop computer, webcam, AR software, and six AR fiducial tracking paper markers, which looked like black and white squares with various geometric patterns. The webcam was directed at the six paper markers, with a blue 3D cube appearing to hover over only one of the markers in a magic-mirror viewing experience. The AR illusion was viewed on a screen, more specifically as a projection on the wall. We could see the paper markers in front of us in our physical space, then look away and up to the screen to see the exact same scene in parallel as it existed in reality and concurrent time, yet now with a blue 3D cube appearing on the screen. This was my first experience of AR, and although it wasn't much, merely just the appearance of a 3D augmented cube, it inspired me incredibly; I was captivated and fascinated by the visual illusion and magic of this virtual object that appeared to be in my physical environment, but in reality, was not. It was a 'special effect' of sorts, but in real-time, the likes of something I had never before seen and appeared to be unique to AR alone. Once the amazement of the visual trickery subsided, I recall thinking, “Ok, this is a blue 3D cube, but what can we do with it beyond just making something appear and create something past the magic of the trick? What kinds of content and experiences can we make for this?”

My work and research in the first wave of AR predominantly looked to the magical quality of AR experiences, being inspired greatly by and drawing connections with AR in its early stages to the work of cinema pioneer Georges Méliès (1861-1938). Méliès was a magician before becoming a filmmaker and brought his tricks from the stage to the medium of cinema. Upon seeing film for the first time, he is said to have exclaimed, “That’s for me, what a great trick!”. He became famous for the “trick-film”, which employed a stop-motion and substitution technique. Méliès applied the newfound medium of cinema to extend magic into

novel, seemingly impossible visualities on the screen. I consider AR, too, to be very much about creating impossible visualities, with this technologically emphasized in the first wave. We can think of AR as a real-time stop-substitution as well, which layers content dynamically atop the physical environment and creates virtual actualities with objects—shifting forms, magically appearing and disappearing—as Méliès first did in cinema. Méliès and the connections to AR are discussed in further detail in the literature review.

I first noticed the shift in AR transitioning from magic to context in 2011 when I came across a concept for AR called Invoked Computing developed by a research group at the University of Tokyo (discussed in the *40 Ideas*). Invoked Computing aims to turn everyday objects into communication devices by a user making a gesture to invoke a desired device; the user activates any ordinary object to suit one's communication needs. The computer recognizes what you want to do and will grant the selected object the properties of the tool you wish to utilize. Any object can transform into and adopt the principles of the object required, such as a banana becoming a phone, as demonstrated in the researchers' proof-of-concept.

The Invoked Computing example still possesses an element of magic, connected to what Méliès was doing early on with stop-substitution. In the case of the banana, it transforms into a working telephone in one moment, and returns to its inanimate and natural state in the next, which was what Méliès essentially did in his trick films. Invoked Computing as a form of AR is still shape shifting, however, the emphasis is now on relevancy through context. Invoked Computing applies the best principles of "overlay" of the first wave of AR by overlaying the desired need of the user that creates an "entryway" into a meaningful and contextually rich experience that is personalized to each user and serves to enhance their lives.

In the past two to three years I have begun to see greater utility be demonstrated in AR, with examples like real-time AR translation tool Word Lens come to market, and a significant aspiration from both users and AR experience creators to surpass gimmickry in the field. As I previously mentioned, Google Glass has also greatly contributed to conceptualizing for a mass-audience how AR can be used to help enhance one's day to day life. Technology should not interrupt our lives, yet work in the background, appearing when needed to enhance productivity and connectivity to the things that matter to us most. As AR advances, and as a community of researchers and makers, we must ask, 'How can we design AR experiences to enhance and make a user's life easier and better?' Nicholas Negroponte said, "Computing is not about computers anymore. It is about living". How do we want to live in and with AR, and how will it shape people's lives? The *40 Ideas* reveal the potentials to invent our near future and gateways to consider novel imaginations of AR that move beyond tracking and registration technicalities to be more human-centred. When asked on stage at his Augmented World Expo (AWE) 2013 keynote in Santa Clara, CA, what the killer app for AR is, Dr. Steve Mann, the father of wearable computing, simply responded, "Reality. It's about making your life better." Dr. Mann has always said that AR should help us to see better and to live better lives. Having worked with the technicalities of the medium directly in creating the AR book and conceiving work-around solutions to challenges such as occlusion and tracking difficulties (discussed in greater detail in the research-creation process section), we must now move to an outlook of how AR can be used to create experiences that enhance a user's life and begin there. As Cheok urged in his keynote, AR needs to switch emphasis from tracking and registration to experience. We must now shift to a focus on human possibilities, starting with the user at the heart of the experience, with technology expanding and building from there.

Chapter Summation

Building from here and the introduction, we next move to the *Literature Review* which considers AR's history to look to its future, first understanding how to position AR in digital media and as a new medium. The literature review looks to theories of the virtual, presence, remediation, immediacy, and media specificity, as well as to early cinema, Marshall McLuhan, Dr. Steve Mann, and contemporary devices such as Google Glass.

Once surveying the lay of the land in AR and the theoretical issues at stake, a chapter on *The Importance of Research-creation* follows with various definitions of research-creation outlined. The chapter features a discussion of why this method was of critical benefit to the dissertation and an overview of the knowledge produced, highlighting the significance of research-creation to the AR Book, *40 Ideas*, and AR overall as an emerging medium.

Next, the *Research-creation Critical Reflection* provides a detailed discussion of the production of the AR Book with documentation, insights gained, lessons learned, and new techniques invented and applied. This chapter also reflects on the need for tools for artists, how AR remediates the book, how the AR book can be expanded, and critical insights on presence gained through research-creation relevant to the next wave of AR.

The closing chapter, *The 40 Ideas That Will Change AR*, grows out of the research-creation and AR book produced, and serves as a proposed visionary framework for the near future of AR documenting recent and contemporary case studies as the field rapidly advances. The emphasis is on outlining the possibilities for a media language of AR and begins with an introduction highlighting this shift from the first wave and the transformational moments that defined a demarcation to the second wave, including *The Top 10 Ideas That Have Already Changed AR*. The *40 Ideas* each document a significant moment, advancement in technology, or concept that will greatly impact AR. The epilogue summarizes the key and

overarching themes in the *40 Ideas*, and where I see AR heading as a new medium. It also is a point of reflection on how the work has changed me as a researcher from when I started, and where it will take me next.

And so, on a journey *Through the Looking-Glass* we go.

Literature Review

Introduction

The Literature Review situates AR within a body of literature pertaining to digital media, the virtual, and remediation. This chapter identifies critical points of knowledge to consider in AR and expands on them, looking to theorists such as Jay David Bolter, Lev Manovich, Marshall McLuhan, and Lisa Gitelmann. Further context is provided by looking to both the past, including a discussion of early cinema, the current state of AR, and the impact and relevancy of devices like Google Glass.

Utility and Entertainment, Realism and Illusionism

In the first wave of AR, I observed two major areas that developed over the years, which I group under utility, also referred to as “serious” (Vaughn-Nichols 20) and “practical” (McMillian, 33); and entertainment, otherwise referred to as “novelty” (Vaughn-Nichols, 20) and “gee-whiz” (McMillian, 33). Utility applications included navigation, annotation, training, object identification, and location visualizations. An example is virtual instructions superimposed atop complex machinery to assist in real-time with step-by-step repair and maintenance (Azuma 1997, 5). Entertainment applications included gaming, advertising, and art. In *Picture Theory*, media theorist and art historian W.J.T. Mitchell discusses issues of illusionism and realism in visual culture, which are terms useful in discussing the two areas of AR I have referred to as entertainment and utility within the first wave. For the most part, we can align AR entertainment applications with illusionism, “the capacity of pictures to deceive, delight, astonish, amaze, or otherwise take power over a beholder”, as in trompe l’oeil, and AR utility applications with realism “as a picture accompanied by the tacit legend ‘this is the way things are’” (Mitchell 325).

Let us begin by examining how the first wave of AR can overall be categorized as illusionism. This commences with a discussion of the virtual and how it pertains to illusionism. Media theorist Anne Friedberg defines the virtual as “a substitute” and “an immaterial proxy for the material”[5] (8). Friedberg makes reference to how the term virtual is used in computer science: “Computer terminology invokes ‘virtual’ to refer to a digital object or experience without physical existence” (10). New Media researcher Horea Avram comments on how the virtual “never acquires the level of the actual”, instead relying on “appearance rather than presence” (298). In describing AR, Avram writes, “AR is a place of dynamic encounters between actual reality and simulated space and between the work and the viewer” (298). He furthers, “What is important to note is that AR, although a vast concept, is specifically demarcated here as a visual organization based on an illusionist, immersive intertwining of reality and digital images” (298). We can position AR within Mitchell’s definition of illusionism where “the point is to provide a simulation of the presence of objects, spaces, and actions, to trigger a responsive experience in the beholder” (Mitchell, 325).

Presence and Immediacy

AR’s connection to Mitchell’s statement about illusionism can be expanded to further discuss the concept of presence in the first wave of AR. Media theorist Matthew Lombard defines presence as “the illusion of non-mediation” where “the medium can appear to be invisible or transparent and function as would a large open window, with the medium user and the medium content (objects and entities) sharing the same physical environment”(8). Lombard's above definition echoes Bolter and Richard Gruisin's discussion of immediacy in their book *Remediation: Understanding New Media* (1999), specifically the following description, “The logic of immediacy dictates that the medium itself should disappear and

5 Friedberg’s definition is also interesting to consider in regards to how an AR marker (or fiducial) functions, with the AR marker being substituted with the augmented visualization/material.

leave us in the presence of the thing represented: sitting in the race car or standing on a mountain top” (6). Bolter and Gruisin further describe this as “the user is no longer aware of confronting a medium”, now standing instead in an “immediate relationship to the contents of that medium” (24). The first wave of AR saw an increase in immediacy with a rapid progression in hardware development and a move towards see-through devices like smartphones and tablets. We will see a greater immediacy still to come as AR glasses continue in the second wave of AR where the illusionism will be heightened and it will appear more truly as though we are in the direct “presence of the thing represented”, triggering a more 'responsive experience' in the user, as Mitchell states of illusionism.

In an article written in 2004 with Blair MacIntrye and Maribeth Gandy, titled, *Presence and the Aura of Meaningful Places*, Bolter et al. refer to presence as a term used by Virtual Environment researchers to “describe the mental state of the user in response to being immersed in a virtual application”(36). The authors include another term they tie into presence, called “aura”, which they define as the combination of an object's or place's “cultural and personal significance for a user or group of users”(37). Bolter et. al note that all aura is personal because it describes an individual’s psychological response to an object or place and that the personal nature of aura is essential as “aura can only exist if the individual can connect the object or place to his or her own understanding of the world”(37). It is my opinion that aura will come to effect presence more so in the second wave of AR, as the second wave will be more tailored to personalized experiences for the user based on their preferences and unique context. The authors introduce the work of researchers in the BENOGO project who are studying the uniqueness of physical locations in order to create “more compelling” VR experiences. In respect to presence in VR, they suggest that research in this area has been hindered by typical “generic” visual worlds in VR applications and that

the best method of achieving presence is to place the user in a meaningful context, an approach that they call “contextualized presence”. Again, I see this coming to play a more significant role in the second wave of AR, as contextual experiences will be central in this next phase of AR and hence more directed and meaningful to the user.

The Virtual and Superimposition

In AR, the “intertwining” of realities, as Avram describes, is in fact an illusion if we define the content as virtual, as per Friedberg’s definition with the virtual appearing “functionally or effectively *but not formally* of the same materiality as what it represents”(11). As previously noted in the Introduction, Azuma defines AR as a system that supplements the real world with “virtual objects that appear to coexist in the same space as the real world” (34). The AR content and AR user do not actually share the same physical environment; this is only an illusion served via a screen or other viewing device (in the case of AR glasses or contact lenses, mediation may be minimal or not even noticed hence heightening immediacy). Although it may be perceived that “the same physical environment” is shared, it is important to note that the augmented content is really a virtual superimposition.

It is worth noting that superimposition still plays a role within the second wave of AR, but in a way that differs from the first wave of AR. For example, within the second wave, examples highlighted within the *40 Ideas* include Invoked Computing (where any object can transform into and adopt the principles of the object required, such as a banana becoming a phone), and applications like OrCam (an assistive technology for the blind where the user's finger is able to identify things like objects, people, and text, with the information read back to the user in real-time, the superimposition being audio). Within both of these cases, the superimposition becomes more of a live, active, and adaptive type of AR rooted in a shifting context, in contrast to a static, pre-programmed visual illusion which is a set trick and

presented the same every time for each user, like in the first wave of AR. One way to think of this is that in the first wave, the AR is preset and prerecorded and lies dormant until the experience is triggered and plays back the same way each instance for every individual. We can think of Invoked Computing as a temporary superimposition as well, yet what distinguishes Invoked Computing from just an overlay and the first wave of AR to place it in the second wave of AR, is that a specific function is superimposed that is dependant on each user's specific changing need and context.

In *The World Viewed* (1971), Stanley Cavell compares the audience of a movie to the audience attending a theater production, stating “movies allow the audience to be mechanically absent” (71). He explains that at a movie, “I am present not at something happening, which I must confirm, but at something that has happened, which I absorb”. In the first wave of AR, as described above, the AR is essentially pre-recorded, “something that has happened”, and typically played back the same for each user. The AR experience is triggered by an image marker or fiducial to track, but it is, for the most part, not specific to the user. In the second wave of AR, the user now “must confirm” the experience to initiate it with their unique context and preferences. The user is at the center and “present” at “something happening” for them. The user confirms a personalized experience that now becomes much more relevant through the process of continual confirmation dynamically updated according to his changing context, as exemplified by Invoked Computing and OrCam.

To Deceive the Viewer and To Enable Action

To return to the notion of presence, Avram discusses the possibility of heightening presence by increasing transparent immediacy in the experience of the illusion. The seamlessness of the illusion is reliant on a precision of technical effects to enhance and heighten presence in opposition to ruptures and fractures that may break the illusion. Avram

states,

> But if, in traditional trompe l'oeil, the trick is 'condemned' to be unveiled after a split second, due to the inherent limitations of the medium of painting, in AR the use of multiple perspective and real-time adjustments of the image according to the viewer's position in space, the illusion becomes more flexible, making the trick not only harder to unmask but more acceptable to the viewer (306).

Lombard also notes factors that can contribute to presence, and thereby an illusion of non-mediation, including the precision of visual alignment, synchronization with the environment, and the speed with which the environment responds to the user's inputs and movements.

Such techniques of presence to deceive the viewer recall Manovich's article, *To Lie and To Act*, in which he discusses representational technologies. Manovich writes:

> Throughout human history, representational technologies have served two main functions: to deceive the viewer and to enable action, i.e. to allow the viewer to manipulate reality through representations. Fashion and make up, paintings, dioramas, decoys and virtual reality fall into the first category. Maps, architectural drawings, X-rays, and telepresence fall into the second. To deceive the viewer or to enable action: these are the two axes which structure the history of visual representations (1).

Manovich includes VR in his description above, identifying it as belonging to the first function, 'to deceive the viewer'. Manovich may have designated VR to this axis as a VR experience occurs within an artificial or illusionary space created entirely by the computer, and is closed off from the 'real world' or physical environment. In addition to uses for entertainment, VR has been used in more 'serious' applications, including VR psychotherapy, notably such case studies as exposure therapy treatment for fear of heights and post-traumatic stress disorder, which I'd like to suggest can be positioned within the second function Manovich describes, 'to enable action'. The second wave of AR is also pointing more towards enabling action, and moving away from the dominant forms of gimmickry and primary focus on visual illusion in the first wave of AR.

Studies utilizing AR technology in psychotherapy treatment (fear of spiders and cockroaches) have been conducted (Juan et al. 2005), which, parallel to the example of VR treatments, can situate certain applications found within the first wave of AR as belonging to the function of 'enabling action'. It can be posited, however, that the success of this action and the level of the desired outcome is reliant on the first function Manovich notes, 'to deceive the viewer'. In the case of AR, this can be interpreted as buying into the illusion of the representation and temporarily suspending disbelief to foster activity or enactment in the 'real world'. Here we can see a hybridization emerge in AR applying Manovich's functions to form a causal relationship; action becomes reliant upon (visual) illusion.

Illusionism and Realism

Manovich's axes of deceiving the viewer and enabling action, can be aligned respectively with Mitchell's definitions of illusionism, "the capacity of pictures to deceive", and realism, with a power now taken back from illusionism's grip (325). The examples Manovich cites as characteristic of each function are interesting to note in regards to Mitchell's descriptions of illusionism and realism, and to begin to understand how to position the first wave of AR between the critical thinking of these two theorists. Manovich identifies maps, architectural drawings, and X-rays as belonging to the function of enabling action, which we would align here with Mitchell's description of realism, as 'transparent windows onto reality' (325). The artifacts Manovich lists may all be said to manifest scientific and/or mathematical knowledge, information, and objectivity. As Mitchell notes in regards to realism, here, too, in the examples Manovich cites, is an implied "embodiment of a socially authorized and credible" view presented (Mitchell 325). Further, the items Manovich details as pertaining to the function of deceiving the viewer, including make-up, paintings, dioramas, and decoys, which we would equate with Mitchell's definition of illusionism, are interested in the falsity of

surfaces, trompe l'oeil (as Mitchell also notes of illusionism) and an implied superficiality. Primary importance is placed here on visual appearance and perception, or as Mitchell notes, upon a legend of "this is how things look" as opposed to "this is the way things are" (as in the case of realism) (325).

AR to Treat Phobias

Researchers at Universidad Politecnica de Valencia utilized AR to treat a fear of spiders and cockroaches. In the article, *Using Augmented Reality to Treat Phobias*, researchers Carmen Juan et al. state,

> AR gives a greater feeling of presence (the sensation of being there) and reality judgment (judging an experience as being real) than VR because the environment and the elements the patient uses to interact with the application are real (31).

The researchers also draw attention to the fact that in AR the user can see one's own hands and feet, and so on, whereas in previous VR-based approaches, this experience was only simulated. Within this experiment, subjects can touch the real table ('this is the way things are'/realism) that insects appear to be crossing ('this is how things look'/illusionism) and see their own feet as the insects are running on the floor, creating an intersection of both realism and illusionism. Among the advantages listed by the researchers were conditions of a safe and controlled environment "because the elements the patients fears are virtual elements they can't hurt him or her", in contrast to treatment occurring in a real environment "where the elements the patient fears are also real and might not behave as the therapist desires" (32).

During the AR exposure session, patients allowed (computer-generated) spiders to approach and cross over their hands; patients killed these spiders with a fly swatter; and patients picked up dead computer-generated cockroaches to put them into a box (35). Several common psychiatric testing tools were adapted within the AR study, including a Subjective Units of Discomfort (SUD) scale, and fear and avoidance scales. Upon completing

the AR session, therapists encouraged patients to interact with real spiders or cockroaches; all of the patients were able to approach the live insect and kill it themselves (35).

Heightening a Responsive Experience

What, then, can be said of AR in this hybrid form that is based in both illusionism and realism, in regards to presence? Presence, as previously discussed, can be thought of as a measure of action to determine how effective an environment is in creating a desired effect by means of illusionism. This can be linked to Mitchell's discussion of illusionism as the power of images to deceive, as "in trompe l'oeil or the special effects in cinema", of which "the point is to provide a simulation of the presence of objects, spaces, and actions, to trigger a responsive experience in the beholder" (325). This "responsive experience" can be viewed as a temporary suspension of disbelief and can be linked back to Bolter's and Gruisin's definition of "immediacy" in *Remediation* as "a style of visual representation whose goal is to make the viewer forget the presence of the medium and believe that he is in the presence of the objects of representation" (273).

In the case of AR, this "responsive experience" or "immediacy" is heightened by the fact that the illusion occurs within reality, in the viewer's physical environment, through which the viewer is left to negotiate the realism of the experience with the illusionism presented. As in the case of psychotherapy treatments, AR affords a unique scenario in which it demands the attributes of both illusionism and realism, in which a trompe l'oeil effect need first occur and take power over the viewer's vision and perception to enable an opportunity for further action based in reality. Within this example, AR presents a new way of seeing, one that can be said to employ the "superficial" (illusionism/deceive the viewer) to empower "real" and authentic beneficial experiences in the physical world (realism/enable action).[6]

6 As discussed in the research-creation critical reflection chapter, the AR book created was inspired by VR and AR psychotherapy studies of phobias, specifically the research studies at the Universidad Politecnica de

The Process of New Media Emerging

In the introductory essay to *New Media, 1740-1915,* Media Historian Lisa Gitelmann describes the process of New Media emerging, reflecting on how all media were once “new media”. Gitelmann writes,

> We might say that new media, when they first emerge, pass through a phase of identity crisis, a crisis precipitated at least by the uncertain status of the given medium in relation to established, known media and their functions. In other words, when new media emerge in a society, their place is at first ill defined, and their ultimate meanings or functions are shaped over time by that society's existing habits of media use (which, of course, derive from experience with other, established media), by shared desires for new uses, and by the slow process of adaptation between the two. The 'crisis' of a new medium will be resolved when the perceptions of the medium, as well as its practical uses, are somehow adapted to existing categories of public understanding about what that medium does for whom and why.(xii)

As mentioned in the Introduction, Google Glass, although only scratching the surface of possibilities of what can be experienced with AR, has helped to begin the process of creating a general public understanding and perception of the medium and its practical uses. AR is passing through the identity crisis Gitelmann describes and heading towards a mass-market use via hardware devices like Glass and Meta Space Glasses. Google, a technology giant and leader, is aiding to shape society's potential future habits and adoption of AR by bringing their product to market and by building desire for Glass and AR experiences with their *Beta Explorer* program, limited to 8,000 selected users. AR as a medium will continue to become more defined as Gitelmann explains, which is why the present is a critical time for practitioners to become directly involved to help shape AR's future as a medium, further identifying and designing AR experiences in response to 'what it can do and for whom'.[7]

Valencia around fears of spiders and cockroaches. The book is a critical contribution to the first wave of AR, but it hints at an extension into a new phase, one where visual illusion is used to enable meaningful action and to improve people's ways of interacting with the environment around them (which will become more personally meaningful in the second wave of AR with contextually focused experiences), in this case, assisting with conquering one's fears.

7 The *40 Ideas* create a framework in which 'what it can do' begins to be answered.

Stages Through Which Media Pass

In *New Media: A Critical Introduction*, Media and Technology Scholar Brian Winston formulates the stages through which potential communication technologies or media will pass; they are as follows:

1. There must be a basis in society's general scientific competence so that a certain kind of technology is feasible. This is the ground for a technology's possibility.

2. Next there is a stage of 'ideation' when an idea or concept of how that available scientific competence may be given a technological application is envisaged – typically not by one inspired individual but by several in their supporting contexts and in a number of locations. This may lead to the building of recognized or confirmed as useful social technologies by the social groups with the will to invest in them or the power to realize them.

3. Then there is the stage of a technology's 'invention'. Invention [...] is when a technology can be said to exist properly as it moves beyond an idea and the prototype stage as a clear necessity or use is seen and it finds social acceptance. (107)

Both waves of AR have passed the first stage Winston identifies as scientifically competent and feasible. The stages I currently see AR at as a whole are numbers two and three where (a) applications are being envisaged by several individuals and groups who have the will to invest in AR and the power to realize these applications, such as Google with Glass; and (b) where AR is moving beyond the prototype stage and finding social acceptance and identification as a necessity (this is in process). Glass's *Explorer* program has greatly assisted with this process by, just as the name of the Beta program describes, asking the 8,000 selected individuals to 'explore' and envisage real uses and legitimate applications for Glass. By releasing Glass into the public, Google has also helped to build social acceptance for the hardware and AR as a medium. It is worth noting that there has been social resistance with some establishments banning Glass and even an impaired driving ticket issued while an individual was wearing Glass on the road. Such instances, however, have also helped to bring Glass into further media reports and thereby generating further public exposure and

discussion.

The Birth of a Medium

In *The Cinema as a Model for the Genealogy of Media,* Andre Gaudreault and Phillipe Marion describe three key moments in the birth of a medium: “appearance, emergence, and constitution” (14). Gaudreault and Marion use the medium of cinema as an example to discuss this process, “The history of early cinema leads us, successively, from the *appearance* of a technological process, the apparatus, to the *emergence* of an initial culture, that of 'animated pictures', and finally to the *constitution* of an established media institution” (14). I believe AR is currently in a transitional period from the stage of the appearance of AR as a technological process to an emergence of an initial AR culture, as well as in a transitional period within the medium itself from the first wave of AR to the second. The first wave of AR saw an 'emergence of an initial culture', of what I would like to refer to as 'superimposed pictures' (in fact similar to cinema's history and initial culture of 'animated pictures'). The second wave of AR is seeing an emergence of a culture of context and highly personalized user experiences. As I previously mentioned, superimposition still does play a role in the second wave of AR, but it is not so much about the appearance of visual information as in the first wave, rather now it is a superimposed action pending contextual information and relevancy.

Gaudreault and Marion identify key players in the process of the birth of a medium on the level of production with numerous *inventors* being responsible for the medium's appearance, *camera operators* responsible for its emergence, and the first *film directors* as responsible for its constitution. 'Camera operators' around the world in AR are beginning to contribute to its emergence as a medium, specifically through the Glass Explorer program on a mass and international scale, and through that process, beginning to contribute and work

towards the potentials of a media language of AR.

Gaudreault and Marion further state, “After the recording device appeared, film production defined itself as a practice, making it possible to pass to the next step, the emergence of 'animated pictures' (As previously noted, in many ways this is what the first wave of AR was, animated superimposed pictures, remediating cinema when it was first new, and literally layering animated pictures atop the real-world through AR). Practitioners, or the 'camera operators', as Gaudreault and Marion name them, will play a critical role in advancing AR as a medium. It is important here to re-emphasize practice in regards to medium, as defined by Raymond Williams (in Lister's *An Introduction to New Media*):

> A medium is more that the technology it depends on; it is also a practice. It is a kind of skilled work on raw materials (whether they be words, photographic materials, or digitized analogue media) which uses conventions, structures, and sign systems to make sense, convey ideas and construct experiences (107).

In the article *Formal Analysis and Cultural Critique in Digital Media Theory,*
Bolter emphasizes the design choices of “makers”, which I believe is critical to the advancement of any medium. Practitioners will lead AR's evolution from a technology to a medium, through a practice that is “a skilled work” to “convey ideas and construct experiences”, as Williams describes.

Remediation

Bolter writes, “Producers or creators of digital media forms borrow the representational practices of other (earlier or contemporary) forms, while at the same time, seeking to refashion these older forms”, a process he and Gruisin call 'remediation' (82). Bolter discusses how computer games remediate Hollywood film, identifying how game designers “focus on certain formal qualities and certain genres of Hollywood film”. He writes, “The games also borrow the conventions of the Hollywood style: first-person, point-of-view camera

shots and techniques of continuity editing as well as the use of background music and diegetic sound tracks.” Bolter points out how games “also rely on the conventions of various genres, especially the detective film, science fiction, and the action-adventure film.” Bolter describes how games “appropriate the authenticity” of a genre, “but also seek to 'improve on' the genre by allowing the player to participate in the action in a way not possible for a film viewer.” He comments on how the game player is “offered the opportunity to enter into and take part in a recognizable film world”, with this being the point of the remediation.

AR also remediates computer games which remediate Hollywood films. Within the first wave of AR, designers have 'appropriated the authenticity' of the first-person shooter convention within the action-adventure genre, and “improve on the genre” by allowing the player to participate in a way not possible on the computer: taking the action into the real world and physical environment. Through a process of remediation in AR, the “recognizable world” Bolter comments on is two fold: of the appropriated conventions and genres of the established mediums of computer games and film, and of the viewer's familiar physical surroundings, which are now viewed with superimpositions in AR.

One approach to answering the question of what AR presents that is new and distinct to it as a medium can be arrived at through theories of remediation. In *Remediation*, media theorist Steven Holtzman argues that approaches of repurposing “don’t exploit the special qualities” of a medium, and that “it’s those unique qualities that will ultimately define entirely new languages of expression”(49). He describes repurposing as a “transitional step” that permits “a secure footing on unfamiliar terrain”; however, Holtzman urges that we must “transcend the old” to discover the new for, “Like a road sign, repurposing is a marker indicating that profound change is around the bend” (49). And profound change is in fact just around the bend, particularly as we bare witness to the emergence of the second wave of AR.

We can describe the first wave of AR as a 'transitional step' where we saw techniques like 2D video being layered atop paper in AR, such as in augmented books and newspapers (an example of a previous media form seen within a new format). The second wave of AR begins to truly 'exploit the special qualities' of the medium of AR, which is context. I view the first wave of AR as repurposing and one of novelty as being necessary to get to the second wave.

Innate Qualities

Gaudreault and Marion comment on the cinematograph's status as a novelty during its first phase of the technology's appearance. The novelty aspect of the apparatus dominated at the time and "did not give rise to a definite predilection for narrative" (17). This echoes film theorist Dan North's discussion in *Magic and Illusion in Early Cinema* of Tom Gunning's concept of a 'cinema of attractions' where "the machine which made the pictures move was the source of fascination rather than themes and stories represented" (North 70). Gaudreault and Marion comment upon the innate and "essential" qualities of cinema, "The act of capturing and reconstituting lies at the heart of the medium's technology. What is most essential is the innate storytelling quality the technology derives from its ability to show duration to project moving images upon a screen" (17).

During the process of creating the AR Book and exploring the first wave of AR as a practitioner, I believed that like cinema, AR also possessed an innate storytelling quality in its ability to show duration by uniquely superimposing or projecting images, moving or still, upon reality and the physical environment. Now I can look back and see how this is limiting from the higher and further progressed vantage point of the second wave of AR. What lies at the heart of the second wave of AR is context. After writing the *40 Ideas*, it is more clear to me that AR goes far beyond a superimposition quality and towards an emphasis on a real-time awareness, translation, and understanding of our immediate and dynamically changing

environment. It is about applying contextual information to define the experience, making it unique and personalized each time, as opposed to an essentially dead and static superimposition that is the same each time. The second wave of AR is heading towards the integration of multiple sensors and detection capacities with a continual analysis of the environment to provide the best contextually relevant experience versus prescribed content that is the exact same for each individual. AR has the possibility to become a far more dynamic medium to create more relevant and meaningful experiences beyond novelty and gimmickry.

Early Cinema and Pioneer Filmmaker Georges Méliès

I have often compared AR, particularly the first wave (although at the time, I was not aware of the emergence of a second wave), to early cinema. The shift from novelty to narrative and storytelling in early cinema is significant to reference and draw similarities with. Discussing early cinema, Gaudreault and Marion state, “Once the apparatus loses its ‘novelty’ aspect, another paradigm quickly takes its place”; the authors call this, “monstration”, which “rests upon the operator-filmmaker’s desire to organize and plan what is shown and to act upon representation, unlike what is produced under the paradigm of capturing and reconstituting.” Filmmaker Georges Méliès was one of cinema’s great masters, and although Gaudreault and Marion do not mention him in this particular article, I believe Méliès was one of the first to apply this approach of “monstration” to early cinema in planning his intricate sets and scenes to film (unlike the “actuality” films of the Lumiere Brothers). In a separate article, *Theatricality, Narrativity and Trickality: Reevaluating the Cinema of Georges Méliès,* Gaudreault discusses the work of Méliès in detail. Gaudreault comments on the pitfall of historians identifying Méliès’s style solely with theatrical representation and artificial sets, a generalization which “often prevents them from also appreciating the cinematic originality of

Méliès's films" (112). In describing monstration in *The Cinema as a Model for the Genealogy of Media,* Gaudreault and Marion discuss the "inherent features of the medium", which Gaudreault brings attention to in Méliès' unique contribution to the medium (highlighting editing as a cinematic trait distinct from the theater) in his article *Theatricality, Narrativity and Trickality,* and as something historians oversee. Gaudreault seems to claim that the historians are too focused on the remediation of theatre as opposed to the medium specificity demonstrated in Méliès's work.

Returning to narrative and storytelling, Gaudreault comments on how narrativity can be interpreted and understood as an important part of Méliès's work in "the spatial and temporal articulations made possible through such uniquely cinematic processes as editing" (112). Gaudreault states, "It must be clearly understood that the post-1915 cinema – the narrative representational cinema – is the product of a concept that did not exist at the turn of the century." It was not that early filmmakers did not tell stories, they "told stories using a different, more flexible form of narrative." He comments on how telling stories was not the only preoccupation of early filmmakers that, "They wanted to astound and fill people with wonder at the new form of magic made possible by the motion picture camera (many films, obviously including some of Méliès's, existed for that primary purpose)." I believe the same held true in AR, particularly in AR's novelty or 'appearance' stage in the first wave, which I think we are now largely moving past and into an 'emergence' stage with the second wave into one of greater utility.

Media Specificity

In the article, *Video From Technology to Medium,* Yvonne Spielmann discusses how mediums develop "from the emergence of a novel technology and through the articulation of a

specific media language" and "aesthetic vocabulary" that is specific to the medium's capacities (55). Writing specifically about video she notes, "Once such a media-specific set of means of expression is achieved, video becomes a medium that can be distinguished from other, already existing media." Spielmann identifies through the article what technical characteristics video *shares* with other media forms like television, how it *builds upon* these qualities, and how video-specific images *differ* and *deliberately depart* from other media forms. These are important questions to ask about AR in a process of remediation and how AR can be distinguished from existing media forms through media specificity.

Let us look specifically at how AR builds on Film as a medium. I believe the first wave of AR shares with film a means of applying media such as motion graphics, audio, and recordings as a means of representation through editing, and artistic decisions, to tell stories that are fact or fiction, documentary or fantastical. It builds upon film by extending these possibilities dynamically in real-time to any surface now possible to be used as a screen or venue. AR experiences differ and deliberately depart from film by presenting these stories as a real-time layering, or post-production, in-situ atop reality.

In *Medium Specificity Arguments and Self-Consciously Invented Arts: Film, Video and Photography,* Noel Carroll raises the dangers of medium specificity. My reading of Carroll is that he is in opposition to arguments of medium specificity in which "essential characteristics and conditions" and properties of a medium are used in favour, or to substantiate, one artistic style over another as the proper style or genre. D.N. Rodowick concurs in *The Virtual Life of Film* stating, "And indeed Carroll is probably right to argue that most medium-specificity arguments are less 'ontologies' than 'briefs in favour of certain styles, genres and artistic movements" (37). However, I do see value in applying media-specificity as an argument, particularly this early in AR's development and am not advocating for one artistic style over

the other, as the medium has not yet reached this phase fully. Carroll states, “Once a medium is accepted as an art, once the struggle for legitimacy is won” that artists can “go on to do whatever they like” with the issue of uniqueness dissipating when a “medium is acknowledged as an art” (147). He furthers,

> Perhaps, on the horizon, video artists, once their medium is unequivocally accepted, will cease worrying about the uniqueness of their form. Thus, given this story, medium specificity polemics might appear to have a valuable sort of work to do, i.e. have an acceptable function to perform, in the historical and social context of the emergence of an artform, especially from a reproductive technology. In other words, medium specificity arguments and their related recommendations may seem to have a legitimate use at least in certain situations. (147)

Here, with Carroll, I do agree, that medium specificity does have value, particularly as AR is emerging as a media form that artists, designers, and makers are beginning to access and experiment with. My position is that as both researchers and practitioners we question and attempt to begin to identify what properties, and unique capabilities of AR are beginning to define AR as a medium and to observe what conventions, syntax, strategies, and styles are beginning to take shape.

Point-of-View as a Stylistic Trope

One stylistic trope I can see beginning to take effect with Google Glass, and that I believe will emerge in AR, is Point-of-view (POV). In May 2012, Google first shared first-person perspective photographs and video captured directly from a Glass prototype featuring video of a Glass team member doing a backflip on a trampoline and photographs that would be quite difficult for you to take while holding a camera in your hands. In a presentation at the Google+ Photographer’s Conference, Tech Lead Max Braun stated, “I think this can bring on a new style of photography that allows you to be more intimate with the world you are

capturing."[8] Braun also pointed out how Glass is a connected device and how the moments you capture can be immediately shared. While going through some of the photographs team members had taken using Glass, he noted, "Some of the shots make you really feel like you're there." He referred to Glass as "an evolution of cell phone photography. It's the next step of the camera that's always with you."[9]

AR eyewear and Glass will take us to new heights, quite literally: the first sequence in the *How It Feels [through Glass]* video was shot via Glass in a hot air balloon. It was 155 years ago that the first aerial photograph was taken on a balloon flight in 1858 over Paris, France by artist Nadar (born Gaspar Félix Tournachon)(1820-1910). A pioneer in the newly emerging medium of photography, Nadar also explored underground photography using artificial light to produce pictures of the catacombs and sewers of Paris. Nadar's technical experiments and innovation took us to places via his camera that were previously inaccessible to photography, inspiring new ways of seeing and capturing our world.

Although Glass is still rudimentary (Dr. Mann calling it a 'generation 1 glass', comparable to his glass from the late 90s), and the photography and video that have been shared by Google are not AR, Glass does offer intriguing possibilities for how such AR eyewear can alter how we come to capture and share images and video of our surroundings and what new aesthetic styles of imagery this may generate.

David Hockney and Immediacy

The photographs (and even video) from Project Glass, for me, recall artist David Hockney's (1937 -) photographic collage work, known as his "joiners", in which multiple individually shot photographs were layered to compose a larger image. In *Cameraworks*,

8http://www.theverge.com/2012/5/23/3040004/sergey-brin-max-braun-project-glass-photography
9Ibid.

Hockney states an “ordinary photograph” is missing “lived time”, referring to photography as “looking at the world through the point of view of a paralyzed Cyclops – for a split second”, and hence not conveying a true “experience of living in the world” (9). In conversation with friend and author Lawrence Weschler, Hockey notes, “If instead, I caught all of you in one frozen look, the experience would be dead – it would be like looking at an ordinary photograph” (11).

Is there something extraordinary, then, about the photographs captured with *Glass*? Yes, I believe there is, and we’re only beginning to see what might be possible. So what’s so special about these images then; how do they differ from “ordinary photographs”? It’s interesting to think of the Glass photos as being captured by a “Cyclops”, to refer to Hockney, because, well, that’s basically what they are: a single lens attached to your head that sees and captures the world from a first-person perspective. Yet, to continue with Hockney’s conceptualization, I believe these images get closer to conveying “a true experience of living in the world”, one where your experience in that moment is documented as is without having to stop and grab your camera. Braun comments on “how effortless and natural it is to do so”, with Google Co-Founder Sergey Brin adding, “I think this can bring on a new style of photography that allows you to be more intimate with the world you are capturing, and doesn’t take you away from it.” From a perspective of remediation, we can say that Glass improves upon traditional photography by now allowing hands-free imagery to be captured that can be more spontaneous and in the moment, and hence more immediate. Glass captures what you are in fact seeing in that moment, and very close to how you are seeing it, minimizing mediation. The experience is still very much alive, not 'dead', as Hockney argued of ordinary photographs, and ‘living’ also in the sense that these experiences can immediately be shared with others over a network in real-time.

Point-of-Eye

AR eyewear like Glass (2013) and Dr. Mann's Digital Eye Glass EyeTap (1981) are worn in front of the human eye, serving as a camera to both record the viewer's environment and superimpose computer-generated imagery atop the present environment. With the position of the camera, such devices present a direct 'Point-of-Eye' (PoE), as Dr. Mann calls it, providing the ability to see through someone else's eyes. AR eyewear like Glass remediates the traditional camera, aligning our eye once again with the viewfinder, enabling hands-free PoE photography and videography, in a scenario where 'eye′ am the camera.

Glass captures what you are seeing as you see it through PoE, very close to how you are seeing it. I believe that devices like Glass will bring on new stylistic modes and conventions through PoE, which also appears to be influencing other mediums outside of AR. Take for instance the viral Instagram series *Follow Me* by Murad Osmann[10] featuring photographs of his hand being led by his girlfriend to some of the world's most iconic landmarks and two other examples in contemporary music videos as identified in the article, *How Will Google Glass Change Filmmaking?*[11]: the viral first-person music video for Biting Elbows[12] and the award-winning music video for Cinnamon Chasers's song *Luv Deluxe*[13].

Marshall McLuhan and the Tetrad

Moving beyond stylistic effects, Marshall McLuhan's tetrad of media effects (published after McLuhan's death by his son Eric McLuhan in 1988 as *Laws of Media*), is valuable to apply to AR in analyzing prior forms which AR has evolved from and where it may go in the future. The tetrad is divided into four categories as a means to examine the effects of any medium on society: Enhance, Obsolesce, Retrieve and Reverse. Let us examine AR as it

10 http://www.businessinsider.com/follow-me-instagram-series-goes-viral-2013-3?op=1
11 http://tribecafilm.com/future-of-film/will-google-glass-change-filmmaking
12 http://www.youtube.com/watch?v=Rgox84KE7iY
13 http://vimeo.com/6540668

pertains to each of these effects, looking at both waves of AR, as I have identified them.

What aspect of society does AR enhance or amplify? I believe the first wave of AR enhances the visible, making visible the invisible through a layering of digital information atop the real world. The first wave enhances information retrieval and annotation (including tourist information about landmarks and sites, repair instructions, and navigation), entertainment, learning, and in-situ visualization (both historical and future, including planned architecture). The second wave of AR enhances the human senses beyond sight, natural user interaction through gesture and motion controlled interfaces, the user's changing environment through context rich experiences, personalization, the delivery and consumption of timely relevant information, and more free time liberated from menial tasks through cognizant computing. It also makes the visible now invisible, with technology blending into the background in a more ubiquitous experience. In specific examples within the second wave of AR, like Invoked Computing and 4D printing (discussed in the *40 Ideas*), environmentalism is enhanced with less waste, convenience is gained through on demand objects, and there is a freedom presented of carrying less gadgets.

What does AR ‘obsolesce’ or push aside? I believe the first wave of AR obsolesces VR and virtual intangible environments, and post-production in film, which is now possible in real-time. The second wave of AR obsolesces the gimmickry and visual illusion of the first wave of AR; static AR experiences are now replaced with dynamic and interactive personalized experiences. The desktop and webcam experience in AR are also obsolesced in the second wave with new interfaces and devices giving way to greater immediacy.

What does AR ‘retrieve’ and pull back into center stage from the shadows of obsolescence? I believe the first wave of AR retrieves a physical engagement that was beginning to be lost in digital experiences, a novelty in technology (like early cinema), as well

as the single-user looking device (for example early Victorian media like the stereoscope). The second wave of AR retrieves a greater tactility and the engagement of other senses through media outlets, pulling back concepts like the Sensorama. It retrieves human gesture in communication, mobility (no longer tethered to the desktop), engaging directly with life and the real world without technology getting in the way as a barrier, and being hands-free with devices like AR glasses.

The final category asks what a medium reverses or flips into when the medium has run its course or been developed to its fullest potential. In *Digital McLuhan,* Paul Levinson writes, “Of the four laws of media applied to a new medium, only reversal has not yet taken place” (100). Since we are looking at the first and second wave of AR, we can begin to see the initial reversal of the first wave. I believe the first wave of AR is already in a process of reversing to cognizant computing, Artificial Intelligence (A.I.), and machine-learning to create highly personalized context-aware experiences, and where our devices will intimately know and understand what we need and proactively present it. My prediction is that the second wave of AR will reverse into the window and screen where there is no identifiable filter/mediation and the individual is no longer able to distinguish reality from the virtual, it will all just be reality. The second wave of AR also has the potential to reverse into advanced sensory technologies where the brain is linked to the digital realm in a scenario where there is a direct interfacing of the brain with the world. As our devices become smaller and faster, we will become more cyborg-like with enhanced technological extensions, that are embedded closer and even within our bodies. AR technology will come to act on our behalves with issues of privacy reversing to no privacy.

Hot Media and Cool Media

In *Understanding Media* (1964), McLuhan distinguishes hot media from cool media

based on the degree of effort required by the user, with hot media as “low in participation” and cool media as “high in participation or completion by the audience” (30). McLuhan further describes a cool medium as leaving much more for the listener or user to do than a hot medium” (352). Cool media invites the user or audience to fill in the gaps, and be involved in a more interactive and two-sided experience. Levinson discusses the telephone as an example of cool media that invites participation. He writes, “Unlike the radio and the phonograph, the phone provided the listener with a live, interacting person on the other end of the connection. Whatever the level of heat or coolness of the radio and recordings, they could never warrant the level of involvement of the telephone” (10). This discussion of the telephone as cool media for me recalls Bertolt Brecht's statement in *The Radio as an Apparatus for Communication (*1936) of how “radio is one-sided when it should be two”.[14] Brecht writes,

> It is purely an apparatus for distribution, for mere sharing out. So here is a positive suggestion: change this apparatus over from distribution to communication. The radio would be the finest possible communication apparatus in public life, a vast network of pipes. That is to say, it would be if it knew how to receive as well as to transmit, how to let the listener speak as well as hear, how to bring him into a relationship instead of isolating him.

In addition to sounding like a description of the Internet, this statement from Brecht sums up what I believe AR wants to be and extend into: a two-way mode of communication to create a more engaging, relevant, and personalized experience. For the most part, the first wave of AR is one-way; it is low in participation and we can think of it as hot, or perhaps luke-warm. There is an illusion of interaction, but it is not truly two-way. The AR content already exists, lying dormant, waiting to be triggered; it's already there, static, and is the same for each user. In the second wave of AR, the user is actually in a dynamic and ongoing “relationship”[15], as Brecht

14 http://www.medienkunstnetz.de/source-text/8/

15Dr. Genevieve Bell, Director of Interaction and Experience Research at Intel, predicts that in 2020, technology will come to anticipate our needs and we will enter a much more reciprocal relationship with computers where technology begins to look after us and do things on our behalves. This is discussed in further detail in the *40*

states, with his or her environment through a continual call and response, delivering what is needed at the opportune moment. The assistive technology *OrCam,* detailed in the *40 Ideas,* does just what Brecht explains above by reading text, recognizing faces, and identifying places and objects to its wearer as requested in real-time.

Levinson describes the coolness of a medium as being defined by an “invitation to fill in the details”(107). The 'filling in of details' in the second wave of AR, or the way we come to engage with and participate with AR, will be in an entirely new way: it will be done in the background, for us, indirectly, yet with our knowledge and permissions; to use Cavell's term, we will “confirm” it quite actually. I predict that this will be done in AR through cognizant computing, machine-learning, and A.I.; it will be an invitation we extend to technology to learn us very well -- our habits, our preferences, our behaviours, etc. -- in order to act on our behalves. We will open up and extend our privacy to give way to this greater participation and interaction of a fully two-sided and dynamic “cool media” experience in AR.

I believe that what will sustain a new medium is how it changes us, how it enhances our lives, how it helps us to tell new stories, and how it shows us our world in a different light. This is where the next wave of AR is going and it needs as many designers, artists, and makers of all kinds to create compelling use cases and user experiences that apply the principles and foundations of AR as best as possible. This is required to gain further awareness and knowledge of the developing characteristics and unique abilities of the medium, to accomplish what no other before it could. The *40 Ideas* will help to serve as a step in this direction by identifying the new powers and promise of AR in this second wave.

Ideas section, *Cognizant Computing and Digital Devices as Personal Assistants.*

The Importance of Research-creation

Introduction

This dissertation considers creative practice as research in which the Augmented Reality (AR) Book iterations aim to contribute to and generate knowledge in the field of AR and through praxis begins to trace out where the future of the medium is quickly heading as the technology rapidly advances. I engaged in this practice to think through questions of presence, medium specificity, immediacy, and remediation, with an objective of identifying what constitutes a framework for AR and what is novel about AR. The process of 'creation-as-research' brought forth a “revealing” (terms Owen Chapman and Kim Sawchuk apply to research-creation) of a culmination of ideas and insights within an emerging media language of AR.

As a professional artist, I have worked with AR as my medium of choice for nearly a decade, since 2005. I began with small experiments, continually iterating and evolving the work. The technology was in a very nascent stage and did not yet perform how I wanted it to. I was a pioneer paving my own way with the tools at hand, hacking away at and breaking existing demos to insert my own content. My work came to influence and inspire the creation of new software tools for artists such as *Snapdragon, Drag and Drop 2D AR Authoring* created by York's AR Lab in 2009.

I recently gave a talk on my research in AR at the Future Innovation Technology Creativity (FITC) conference in Toronto where Robert Wong, Chief Creative Officer at Google Creative Labs, delivered an inspiring closing keynote. Wong described how his team of storytellers created a two minute concept video for Google Glass in 2013. The video made such an impact on the public and executive team at Google, that the engineering direction of Glass changed to be more like the vision Wong and his team had imagined. I was impressed

by this important shift in design thinking where designers, artists, storytellers, and non-engineers had a major impact in technological innovation and defining the direction of a new technology early on through an 'exercise in pretend', as Wong referred to it. I saw connections between my work in AR and Wong's process of making. Different from Wong and his team, when I began the work many years ago, I started with the technological restrictions and limitations of AR as design parameters to guide the work, eventually breaking past them and pushing the capabilities in new ways. This method allowed me to get under the hood of AR and understand how the technology worked and to evolve it in new ways. Although I worked with technological restrictions, my first foray into AR was completely novel, integrating video into fiducials at a time when no one else was, with 3D models dominating the field. Although we seemingly took a different approach to making, my process also resulted in a 'blue sky' methodology of what I imagined for AR, like that of Wong and his team, which came to have an important impact on the field, namely in the tools created (such as Snapdragon) for other non-programmers to utilize.

My early AR experiments evolved into full scale works that were publicly exhibited. I was the first artist to be showcased in the IEEE International Symposium on Mixed and Augmented Reality (ISMAR) exhibition, in their inaugural Arts, Media, and Humanities stream in Orlando, Florida in 2009. (ISMAR had strictly been a Science and Technology conference since 2002.) I have also presented juried papers annually at ISMAR from 2009-2012, which discussed my creative work in AR combining both theory and practice. In 2010, I was invited by the Ontario Science Center in Toronto to produce a solo exhibition in collaboration with the AR Lab featuring my AR and Mixed Reality work. The exhibition was entitled, *The Amazing Cinemagician: New Media Meets Victorian Magic* (2010) and was experienced by over 400,000 visitors in 4 months. I have given numerous public talks around the world on my AR

practice including TEDxYorkU in 2010, TEDxDubai in 2011, and Augmented World Expo annually since 2010. I have come to understand and learn about AR so well over the course of these nine years by working with the technology directly, reflecting on it both theoretically and creatively in an ongoing process of making and writing. I understand AR and know the medium inside and out because I make AR work as an artist, which enables me to produce critical knowledge that is unique to this field previously dominated by Computer Science.

The Role of the Artist in the Creation of a Medium and its Possibilities

In *The World Viewed* (1971), Stanley Cavell describes how the creation of a medium and the discovery of new possibilities for a new medium is a "matter of the relation of an artist to his art, each discovering the other" (73). He notes "the aesthetic possibilities of a medium are not givens", but rather they are made and defined by the artist. Cavell explains how the first successful movies "were not applications of a medium that was defined by given possibilities, but the *creation of a medium* by their giving significance to specific possibilities. Only the art itself can discover its possibilities". With AR emerging as a new medium, artists and designers will be the ones to discover and prescribe its possibilities through a process of engaging directly with the medium. Research-creation is a critical method in enabling these discoveries.

Research-creation Defined and 'Revealed'

The Social Sciences and Humanities Research Council (SSHRC) define Research-creation as:

> Any research or activity or approach to research that forms an essential part of a creative process or artistic discipline and that directly fosters the creation of literary/artistic works. The research must address clear research questions, offer theoretical contextualization within the relevant field or fields of literary/artistic inquiry, and present a well-considered methodological approach. This means that the research or the approach to research must contribute to the development of one or more forms of artistic expression and contribute to knowledge (which may concern the development of techniques) in the relevant

discipline(s). (1)

Research-creation has a rich tradition in the United Kingdom; “Practice-Based Research”, another name variation, is becoming increasingly established. In the article, *Knowing Through Making: The Role of the Artifact in Practice-Based Research*, Maarit Makela describes Practice-Based Research as “characterized by a focus on issues, concerns and interests that are explored and manifested through the production of creative artifacts” (2). The objects or artifacts created “facilitate the constructive, solution-focused thinking of the artist or the designer”.

The making of the artifact determines the direction of the practice-based research process, with praxis having an essential role (3). Artifacts are presented “as part of the answer to research questions posed at the outset. In this way, the practice-based enterprise is different from many other approaches, since it does not simply use objects as evidence, but attempts to present the objects created during the research process as arguments”(3). Practice-based research proposes a combination of artifact and “a critical exegesis that illustrates how the artifact advances knowledge, understanding and insight”(3).

Research-creation and Augmented Reality

The creation of the AR Book is a major technological innovation because it was the first AR Book created on the iPad using image tracking (as opposed to black and white glyph fiducial markers) and a 'see-through' mode (departing from the common style of 'magic-mirror' AR). As such, it is a critical and unique contribution to advancing knowledge in the field. There were no prior examples to replicate; the work entered unchartered terrain and led by being the first. The process was one of continual storyboarding, ideation, and rapid-prototyping, trying new things as I went, and trying again when experiments failed. The book later evolved through a second iteration, improving upon the technological limitations and challenges I had

experienced with the first iteration.

The AR book is not only an argument and exploration of the first wave of AR, it is now also a historical object within the genealogy of AR. It is an original critical contribution as the first AR book created for the iPad and serves as a central piece from where to advance the next wave of AR with knowledge formed and contributed as both a practitioner and researcher. As discussed in the literature review, media theorist Steven Holtzman describes the process of repurposing in remediation as a “transitional step” that permits “a secure footing on unfamiliar terrain”; however, Holtzman urges that we must “transcend the old” to discover the new for, “Like a road sign, repurposing is a marker indicating that profound change is around the bend” (Bolter and Gruisin, 49). Through research-creation I first “repurposed” AR and remediated prior media to create an AR book for the iPad, ‘to secure a footing’, as Holtzman described, and then ventured to ‘transcend the old’ by looking to AR’s unique qualities as both a practitioner and researcher in order to prescribe possibilities and propose an articulation of a language of AR in the *40 Ideas* as a guide for future new expressions in the medium.

In the article *Research-Creation: Intervention, analysis and "family resemblances"* (2012), Owen Chapman and Kim Sawchuk discuss research-creation as an emergent category within the social sciences and humanities. Chapman and Sawchuk refer to the Canada Council for the Arts definition of research-creation in 2011, described as addressing “artists whose practice combines experimentation, exploration, and research in conjunction with production" (9). Chapman and Sawchuk point out, “what is important from the Council's definition is that research is situated as a part of an investigation that involves trying things out, as opposed to gathering data[16], as it is often conceived in traditional academia”(9). My

16 Chapman and Sawchuk later describe Research-from-creation as a means of data gathering.

process of investigating AR has been one of ongoing experimentation, tests, exploration and research to understand the possibilities for the medium, what it does well, and how it can grow. Because AR is a new medium, with no conventions as yet, the act of continually “trying things out” as a pioneer in the field has been my primary way to engage with AR as both a practitioner and researcher.

Chapman and Sawchuk address the conjunctive moment in research-creation, drawing attention not to the two primary terms, but how they see them as “mutually constitutive” , which I agree with (14). The authors further state, “A research project that produces creative outcomes and/or employs creative processes gains access to a broad series of potential audiences and contexts of dissemination”. With AR being an emerging field, not only does a broad audience of creatives, technologists, and academics exist to whom the research-creation work is of value and interest, it is also critical that these audiences access the work and knowledge created to join the conversation by further contributing to the expansion and rise of AR as a new medium in this early state. Chapman and Sawchuk also bring attention to how research-creation additionally allows alternate ways of knowing, “namely that one valuable way 'to know' is 'to do'”. Research-creation in this sense has been a highly valuable way for me 'to know' and understand AR by 'doing', particularly at a time of making work before the technology was in place and where the only way 'to know' and to get answers was to create knowledge through work because it was otherwise unavailable.

The Four Modes Within Research-creation

Chapman and Sawchuk identify four modes within research-creation including: "research-for-creation," "research-from-creation," "creative presentations of research," and "creation-as-research”. The authors state they do not claim that these categories are mutually

exclusive, rather that they only stand as useful terms for expanding upon discussions around various approaches to research-creation.

"Research-for-creation" acknowledges the initial "gathering" of "material, ideas, concepts, collaborators, technologies, et cetera, in order to begin" creation as being research in itself (15). This gathering is akin to "reading through recent journal articles, tracking down important references, or conducting interviews". Chapman and Sawchuk state, "The gathering is research because it is directed towards a future 'revealing', enabled through an artistic perception of technology as a practice or craft". Crafting the *40 Ideas* has been a part of the research-creation not only as vectors that have evolved from the production of and knowledge gained from the AR Book iterations, it is an ongoing act of research-creation to document the medium as it evolves through a gathering of ideas, concepts, and related emerging technologies all "directed towards a future 'revealing'" of the second wave of AR. The category of research-for-creation for me has not been a process that stopped once the AR Book iterations were made; it has been a continual process of sourcing the materials and concepts as an active practitioner in the field "in order to begin", as Chapman and Sawchuk write, and help prompt this next wave. It goes beyond recent articles, references, and interviews; it is a perception that I have developed in the field as an active participant, "enabled through an artistic perception of technology as a practice", as Chapman and Sawchuk state. In ways, my process of engaging in research-for-creation can be aligned with the work of futurists in prompting 'beginnings'. In the book, *Future Frequencies* (2004), Futurist Derek Woodgate writes,

> I see futurists as "concept engineers," for we are establishing context and unexpected yet fresh directional perspectives that lead to unique future potential, whether human, product, future category, or markets. Once this potential is distilled and packaged,

thinking shifts towards improving, extending, and enriching the future concepts. (122) The *40 Ideas* framework offers a fresh directional perspective for a second wave of AR leading to a unique future human potential. As Woodgate describes, once this potential is distilled, thinking shifts towards extending the concepts for the future. This is where I see the *40 Ideas* serving to inspire and motivate further action by others in AR. I'd like to expand Woodgate's use of the term “concept engineer” to a term I've referred to myself as, specifically in my TEDxDubai talk in 2011[17], which applies to my process of research-creation: “make-believer”. In my presentation, I discussed my AR Book and spoke to the importance and power of the imagination and make-believe. I described how I am both a practitioner and a researcher, a maker and a believer. As a maker/practitioner, I do, create, experiment; as a believer/researcher I consider, anticipate, and seek. I am a make-believer working with a technology that is about make-believe, about imagining possibilities atop actualities and aspiring to give future form to these conceptions.

The second category “research-from-creation” looks at “ways of generating research data that can then be used to understand different dynamics” as a result of the work. An example of this is the participation of individuals and testing groups who may be an intended audience that can then be used to aid in building out the project and future initiatives. This can lead to the development of new research questions, leading “back to more 'conventional' forms of research and produce new hybrid forms of scholarship” (17). I relate my process more to the previous category of “research-for-creation”, as I describe above, than “research-from-creation”.

“Creative presentations of research” is the third articulation which speaks to the interests and needs for academics to engage with more evocative and creative forms of

17 My TEDxDubai 2011 talk is available online at http://www.youtube.com/watch?v=7QrB4cYxjmk

expression. Chapman and Sawchuk write, “Knowledge is not separate from the practice of inscription; indeed, it is through the ways we iterate our projects back to ourselves that we come to know” (18). They make note of academic performer Jackie Orr (2005) who writes using collage and language to communicate the panic disorder which she describes. In a way, the AR Book is a “creative presentation of research” in that it uses AR to tell a story about AR research, specifically psychotherapy studies of phobias of spiders and cockroaches from researchers at the Universidad Politecnica de Valencia. The AR Book is a novel approach to AR storytelling as it was also the first case to use the medium of AR to tell a narrative about AR.

Chapman and Sawchuk identify the final category, “creation-as-research”, as the most complex:

> “Creation-as-research" involves the elaboration of projects where creation is required in order for research to emerge. It is about investigating the relationship between technology, gathering and revealing through creation [...] while also seeking to extract knowledge from the process. Research is more or less the end goal in this instance, although the "results" produced also include the creative production that is entailed, as both a tracing-out and culminating expression of the research process. It is about understanding the technologies/media/practices that we discuss as communication scholars (for instance) by actually deploying these phenomena, and pushing them into creative directions.(19)

In a still novel and emerging field, creation-as-research was required for research to emerge in this new field and to make an original contribution of knowledge. Extracted knowledge from the process is detailed in the chapter that follows, including the development of novel techniques, as well as knowledge gained in regards to such aspects as presence. A deployment of AR offered a deep understanding of this emerging field, with insights gained that would not have been accessible without creation-as-research. It allowed a great stepping stone to a new vantage point from which to better see the horizon ahead of AR through the “results” produced, and to see how AR is beginning to expand in new ways. Creation-as-

research empowered a way to navigate this new terrain, where there were no previous answers, and to ask questions and discover knowledge in between the “technology, gathering, and revealing” made evident through the work.

Research-creation as a Mapping and Revealing a Distinction of Waves in AR

The process of research-creation has enabled me to obtain a much clearer perspective from a higher, more informed access point as a result to see that the landscape is far bigger than I could have imagined when I began the work. Creation-as-research has provided me with a means as both a practitioner and scholar to map AR: to chart where we have been and where we can go. A map is defined as: 1. a proactive tool to make the invisible visible 2. an object used to excavate centers of value that are currently undiscovered 3. A visualization of complex relationships 4. A key to working holistically across systems.[18] Creation-as-research has served as a “proactive tool” to “reveal” and excavate valuable knowledge that was not visible before within this new medium, with new forms like the AR Book coming into being. Creation-as-research has allowed me to visualize the “complex relationships” of the second wave of AR that are beginning to emerge. Lastly, creation-as-research has afforded a means to work holistically across research and practice, between the theoretical and technical explorations of the technology, the gathering of both scholarly sources and materials as a practitioner, and the revealing of knowledge through creation in continuous making and writing, with each reciprocally informing the other.

The AR Book creation was central because it enabled me to see a distinction of AR in two separate waves, that I have referred to as “overlay” (wave one) and “entryway” (wave two). The first wave of AR, of which the AR Book was a pioneering work in, emphasized an overlay of information atop reality, with a focus on visualization. This superimposition of

18 EPIC Life Ideas Salon Agenda .PDF document emailed by Seth Goldman and Randy Fiat, February 2014.

content atop our physical environment was static for the most part, with minimal interactivity overall. Its power was in producing a 'magical' effect (however, not as much as when first novel). In the process of creating the book and reflecting on the promise of AR through both making and theoretical inquiry, I saw first-hand and understood that AR has the tremendous potential to be so much more than an “overlay” and leverage AR's unique capabilities such as context. In the second wave, which is speedily nearing to become a reality, AR begins to combine things like Artificial Intelligence (A.I.), machine-learning, context-awareness, big data, and wearables to expand on a superimposition of content, to create a highly personalized experience based on the user's dynamically changing context. As I give talks in the field, attend conferences, hear presentations, and continue to read articles daily, my observations and thoughts on AR are confirmed that this second wave is the direction the field is headed in and it is my aspiration that the *40 Ideas* serve as a guide as to where we take AR from here.

Research-creation Critical Reflection

(Documentation video of the work is available at: https://vimeo.com/25608606)



Fig. 1: AR Book *Who's Afraid of Bugs*, both iterations shown.



Fig. 2: Screenshot of AR butterflies and AR pop flowers as viewed on iPad. Page from Iteration 2 shown.

Overview

The research creation piece, the Augmented Reality (AR) Book, *Who's Afraid of Bugs?*, (Fig. 1) is the world's first AR book designed for the iPad 2 and iPhone 4. No other AR book prior had been designed to be experienced on the iPad; the majority of prior AR experiences used a computer and webcam, with smartphones just beginning to be used in AR. The iPad 2 was the first version of a tablet to have a rear-facing camera and be AR enabled.

It also presented a new mode of interaction in AR beyond the common 'magic-mirror' approach (Fig. 3) (of looking at a screen and seeing your environment and yourself mirrored back to you with digital content appearing to be layered atop reality): you could now have a

direct sight-line over the environment (Fig. 4), with augmentations appearing layered on top of what you saw, as though looking through a window or looking glass. As both a practitioner and researcher, I viewed this as an incredible and timely opportunity to be the first to create an AR Book experience for the iPad 2 as this emerging medium was expanding. I designed the book to work on both the iPad 2 and the iPhone 4, with the larger viewing screen of the iPad being preferable.



Fig. 3 Example of a Magic Mirror AR experience, as seen in *AR Wonder Turner,* designed by Helen Papagiannis, exhibited at the Ontario Science Center, 2010.



Fig 4. AR Book for iPad demonstrating a direct sight-line over the environment, in contrast to Magic Mirror approach.

The book combined hand-crafted paper-engineering (physical 3D popups integrated with tactile moveable elements like pull tabs) with AR on mobile devices to create a hands-on storybook that explored the fear of bugs through narrative and play. The book is a playful

exploration of fears using AR in a meaningful and fun way. Rhyming text takes the reader through the storybook where various ‘creepy crawlies’ (spider, ant, and butterfly) are awaiting to be discovered, appearing virtually as 3D models the reader can interact with. I chose to integrate image tracking (Fig. 6) in the design, as opposed to black and white fiducials (Fig. 5) commonly seen in AR at the time, which made it possible to enjoy the book alone as a regular pop-up book, or supplemented with augmented digital content when viewed through a mobile device equipped with a camera, such as the iPad 2 or iPhone 4.

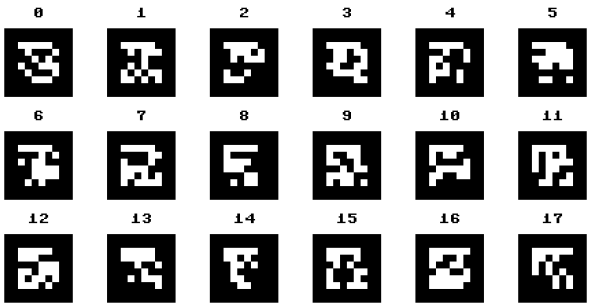


Fig. 5 AR fiducial markers, ARtag.



Fig. 6 AR image tracking powered by String working on iPhone.

It was important to create a book led by a story with content that would be relevant to the medium of AR, that could use AR to best tell the story. AR form and content came together in the book where the story itself was driven by content that was about AR, making it very suitable as the book was inspired by AR psychotherapy studies for the treatment of

phobias such as arachnophobia[19]. AR provides a safe, controlled environment to conduct exposure therapy within a patient's physical surroundings, creating a more believable scenario with heightened presence (defined as the sense of really being in an imagined or perceived place or scenario) and provides greater immediacy than in Virtual Reality (VR). The book created a playful experience exploring tackling fears through the medium of AR.

Although *Who's Afraid of Bugs?* was the first AR Book for the iPad, previous AR Books had been designed for computer desktop experiences, most notably the AR Magic Book from the HIT Lab New Zealand, and artist Camille Scherrer's book *Souvenirs du Monde des Montagnes.* In addition, no prior books combined AR with paper engineering or physical pop-up elements; these were only previously simulated in AR, remediating the traditional pop-up book.

Process: Iterations

Two iterations of the book were created. The first iteration was created independently using Metaio's Junaio AR software and presented publicly for the first time at the major AR conference in Silicon Valley, Augmented Reality Event (ARE), in April 2011. The second iteration of the book was expanded in 2012 in collaboration with Daqri, an AR software company based in Los Angeles, California. In working with Daqri, I had access to a developer to program under my instruction, building on challenges encountered from the first iteration which used Metaio's software. The process behind each iteration is detailed below.

Iteration 1

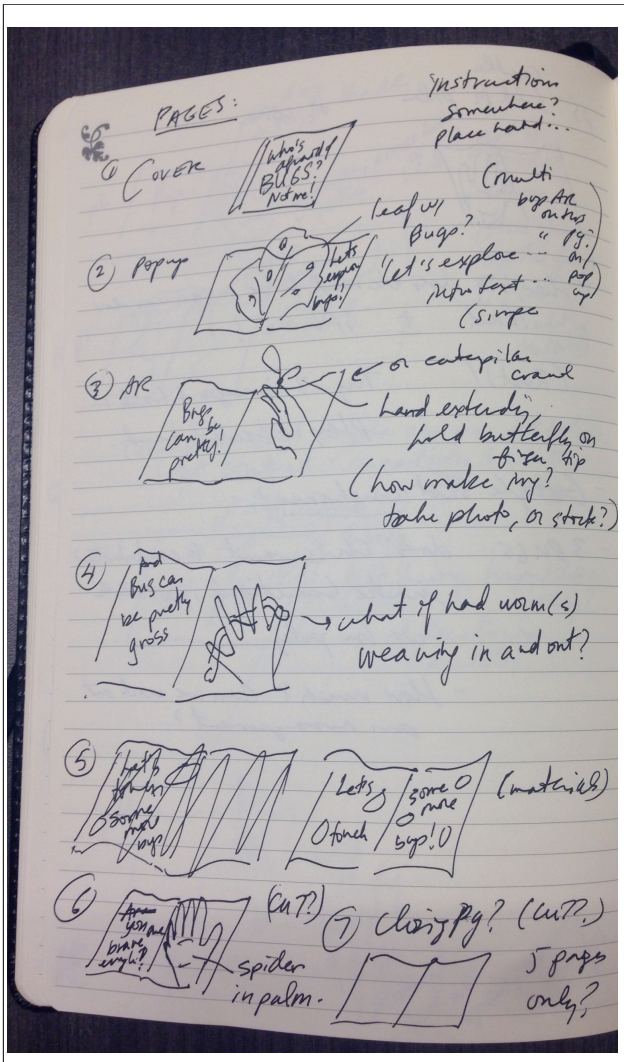
The first iteration commenced with the story and inspiration of using AR as a means to help conquer phobias. Defining early design decisions was an important part of the process, including everything from tracking images, to 3D models, to the overall look and experience of

19 The AR psychotherapy arachnophobia studies from researchers at the Universidad Politecnica de Valencia are discussed in detail in the literature review.

the book. The pages and experiences were storyboarded with tracking images, 3D models, interactions, physical pop-ups, text, and design layouts of each page spread identified, sourced, and designed (Fig. 7-8).

Metaio had, at the time, identified on their website the type of tracking images that worked best: high contrast with a variety of shapes, and asymmetrical. This was my first time working with non-fiducial tracking in AR and the challenge was to integrate images that would track well and suit the overall design and story. I decided to use photographic imagery throughout the book to create a heightened sense of reality. I purchased stock photography images and collaged the images together digitally to create the scenes for each page. By manipulating and adjusting the images in Photoshop, I was able to create a better trackable image based on the criteria Metaio identified.

As mentioned, image tracking (Fig. 5), as opposed to fiducial tracking (Fig. 6), was new to me. I had used only fiducial tracking in previous AR projects I designed and found the tracking to be very quick and robust. It, however, posed visual design challenges where the fiducial often distinctly stood out (as a black and white square with geometric patterns inside the square), unless fully integrated as part of the design composition, using similar shapes, grey-scale, etc. to create a better cohesion. Using image tracking was an experiment for me to evolve my practice in AR, to see what worked and what didn't with this new method of tracking and how it would change the design and interaction in an AR experience overall.



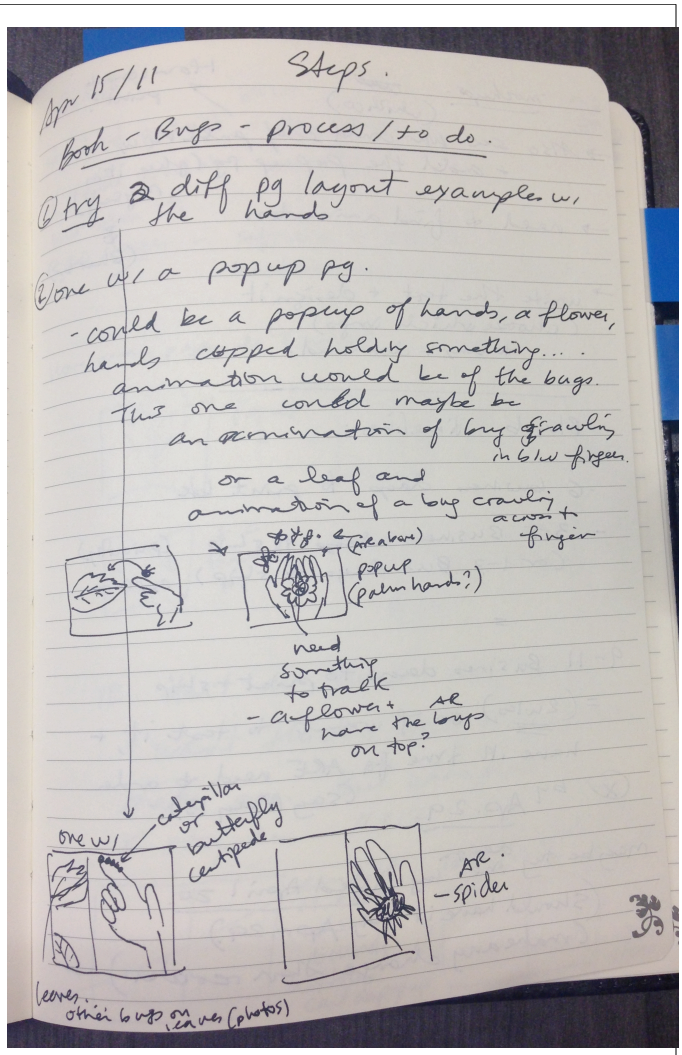


Fig. 7 Initial page layout storyboards

Fig. 8 Notes on pages to build

Through my previous design experiences in AR, I found that one benefit of using fiducials, in addition to robust tracking, was that they served as a visual cue to the user to clearly indicate the placement of an AR experience. With image tracking, unless there was an icon integrated into the design layout or other identifier, such as text, it made it difficult to know where to point the AR enabled device or that there was even an AR experience awaiting.

As the story explored the emotion of fear, I decided to not indicate where on the page

the AR experience was located, inviting the reader to use their mobile device to hunt around in anticipation and search over the page to unveil the experience. This increased the aspect of discovery and heightened the emotional intensity (perhaps even anxiety) of the experience, not knowing where the augmented bug would appear. By including image tracking, this also allowed the viewer to enjoy the book on its own, without AR, and without intrusions of potentially visually distracting fiducial markers.

This was also my first time working with 3D models in AR, as my previous practice was focused on 2D video in AR. I avoided using 3D models in AR prior to creating this book as I felt they typically looked too cartoony and not real enough, in a way shattering the illusion and immediacy of the AR experience. I welcomed this as a good opportunity to integrate 3D models as both something new to my work and as suitable to the story, of having an object (in this case bugs) that appeared to have more of a weight and presence in 3D rather than a 2D flat video.

One of the challenges in creating the book was finding suitable and inexpensive 3D models to use as I did not have any experience in 3D modelling. Junaio required a very low polygon count for 3D model integration (Fig. 9) and strictly utilized the .md2 file format, which was an outdated and very uncommon file mode. I used the 3D stock model website *Turbosquid* to source free and relatively inexpensive low polygon count 3D models (Fig. 10), which I then had to convert to .md2 files. Interaction was limited within Junaio to three actions: a one tap change of animated state of a 3D model, loop animation, and hyperlinking from a 3D model to a website. These animations would also have to be part of the Turbosquid models, as again, I had no 3D model building experience. Knowing the technical parameters from within which I had to work and the criteria I had to search for in regards to models, I asked myself how I could craft interactivity with these elements to enhance the story and

show AR's capabilities.

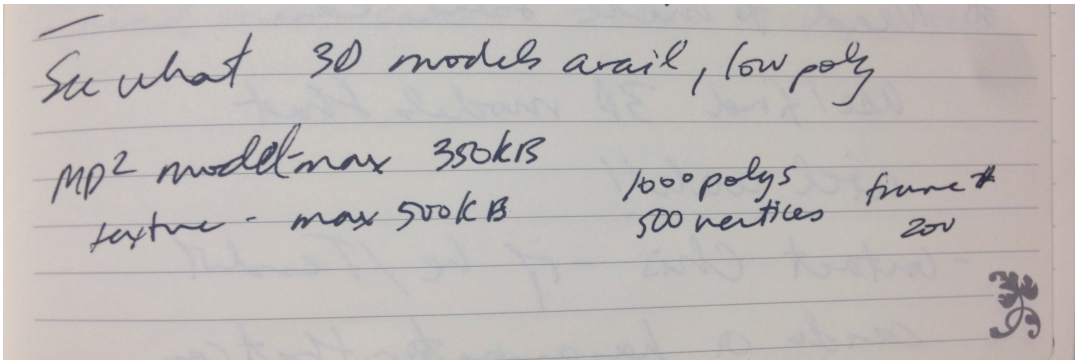


Fig. 9 Notes from production journal indicating file types, polygon counts, vertices, and texture maximum counts within Metaio's software.

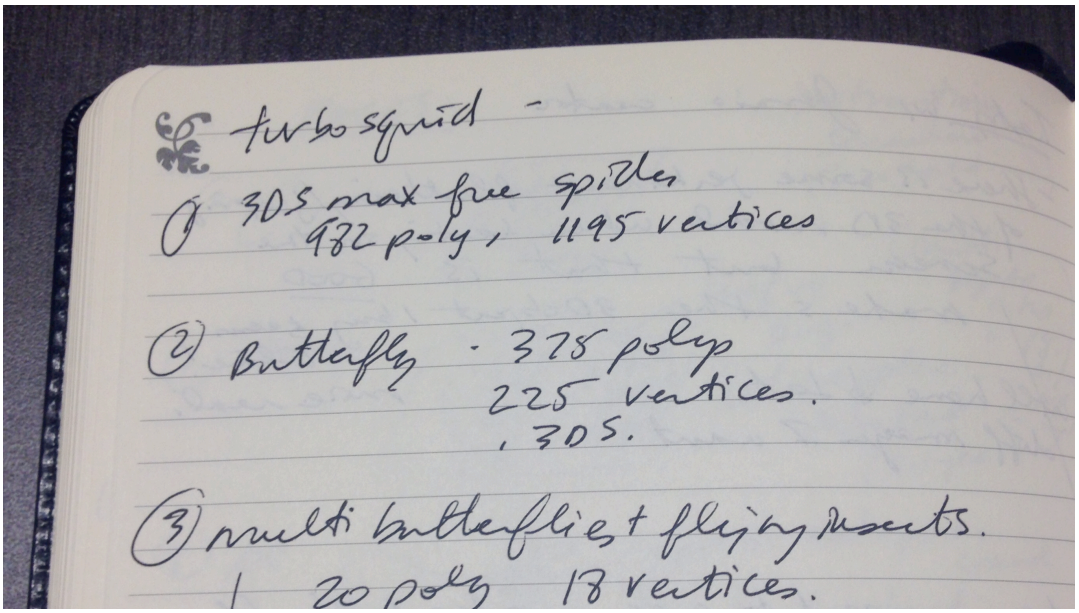


Fig. 10 Notes from production journal identifying selected 3D models and the polygon and vertices counts to make sure they are within the maximums. The spider 3D model just made it with 982 polygons out of a 1000 maximum polygon count.

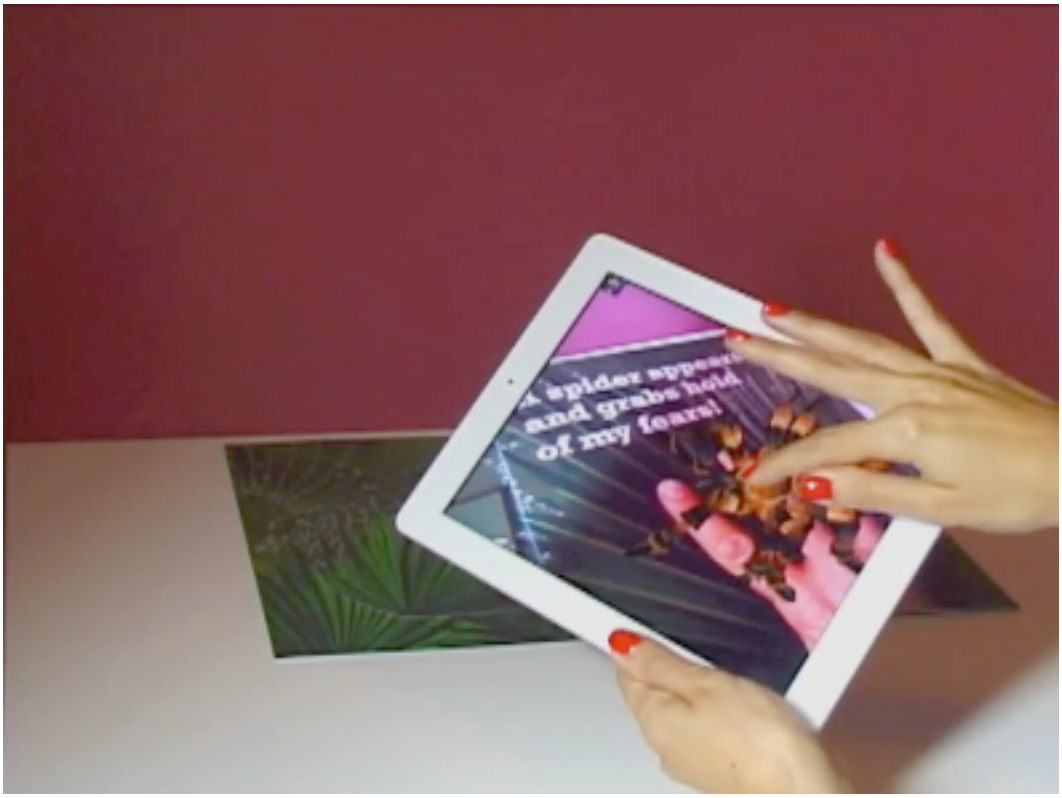


Fig. 11 Showing tap effect applied with the AR spider layout.

The 'tap effect' was applied with the spider (Fig. 11) as it was the most intimidating model of the three page experiences. When the 3D augmented spider was touched on the screen, the spider appeared to retaliate and lunge one of it arms forward, creating a surprising responsive effect. The augmented 3D ant model was used to hyperlink to a Wikipedia webpage when touched on screen, with more information and educational facts on different species of ants presented. Lastly, the 3D butterfly applied the looping effect available within Junaio to quite a beautiful effect of flapping butterfly wings appearing in motion.

All of the digital AR assets, including the tracking image and the 3D models had to be uploaded via the web to the Junaio server and stored through cloud computing. I created a channel on the Junaio mobile AR browser (Fig. 12) through which the AR experience was made accessible on both the iPad 2 and iPhone 4 (Fig. 13). The process throughout was one

of trial and error, of continually testing and prototyping within the browser to make sure all of the digital and non-digital paper elements fit and worked well together with the overall story.

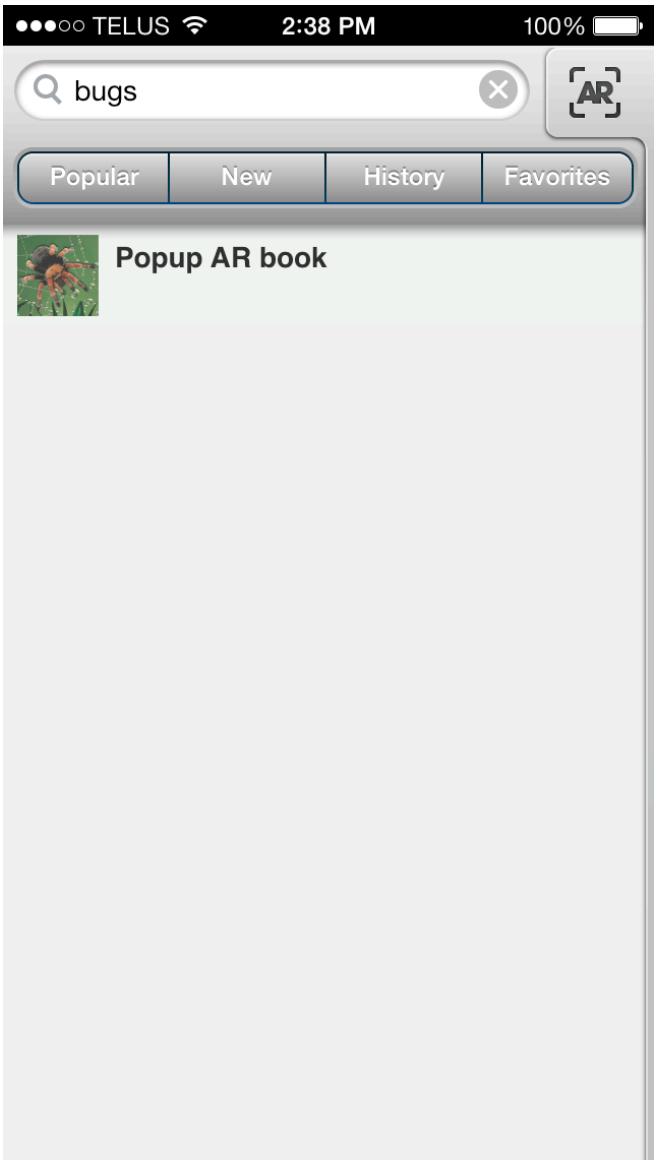


Fig. 12 Screenshot of Junaio Browser channel created



Fig. 13 Screenshot of ant page working in Junaio browser

The paper engineering and physical pop-ups were all created by me by hand. I have a large pop-up book collection and looked at various books to see what techniques I thought would work well and often reverse engineered paper techniques from existing books. I

enjoyed the tactility of integrating the physical pop-up elements and wanted to create something that spoke to how AR can bridge physical interactivity with digital interactivity. There was also a hand motif throughout the book as a design element to speak to the presence of the hand, touch, and tactility. On the first page, the hand was used as a visual indicator to place your own hand down (if you dared), to have the 3D spider (appear to) crawl over your hand (Fig. 14).



Fig. 14 First page of AR Book showing a hand as visual indicator for reader to place their hand atop the page.

This aspect of placing your hand down on the page and having the spider appear to crawl over your hand without interrupting the tracking or making the spider disappear was novel and innovative in AR at the time. This, however, was an illusion. It appeared as though the software was tracking the photographic image of the hand on the page, which if it was, when you placed your actual hand down over the photograph, would interrupt the tracking

and hence the AR spider would disappear. Typically in AR experiences, the position of where the 3D augmentation appeared was directly above the fiducial or image it was tracking. I wanted to experiment with this and see what else was possible. I tried several experiments in which I tracked the top left corner of the page, where the text appeared, and moved the x and y location of the augmented 3D object to appear off of the image being tracked (Fig. 15-20). This improvised technique was very effective in creating the desired illusion.

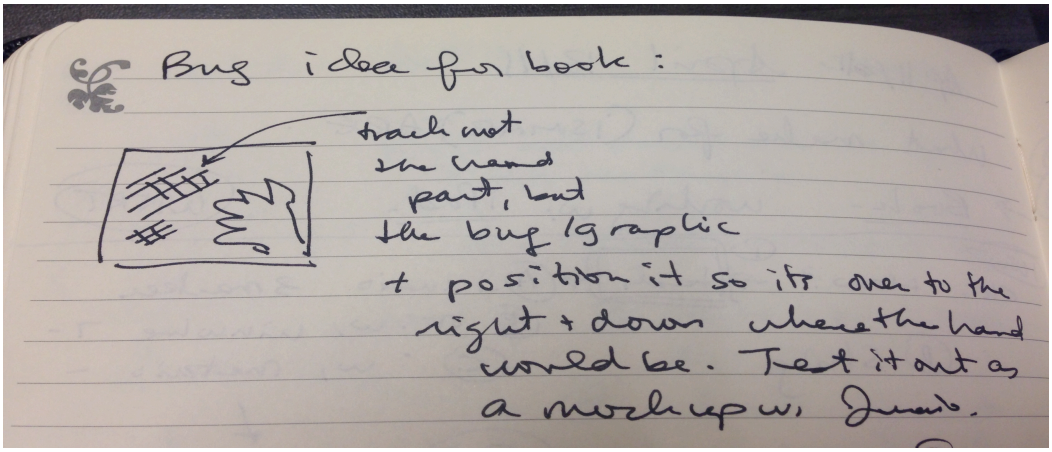


Fig. 15 Workbook sketch noting to track not the image of the hand, but a graphic on another part of the page, with the augmentation positioned to the right and down from the image tracker.



Fig. 16 Early tracking tests for the spider page are shown working in the Junaio browser. Stand-in 3D models (blue triangle) and image trackers (spider) were used for proof-of-concept, later swapped out with actual content. The image target is the spider at the top right, with the augmentation of the triangle appearing in the center.



Fig 17 Another test comparable to Fig 16. The image tracker is the snail on the left, with 3D model horse appearing in the center. Again, stand-in content was used in these experiments and later replaced in the final files.

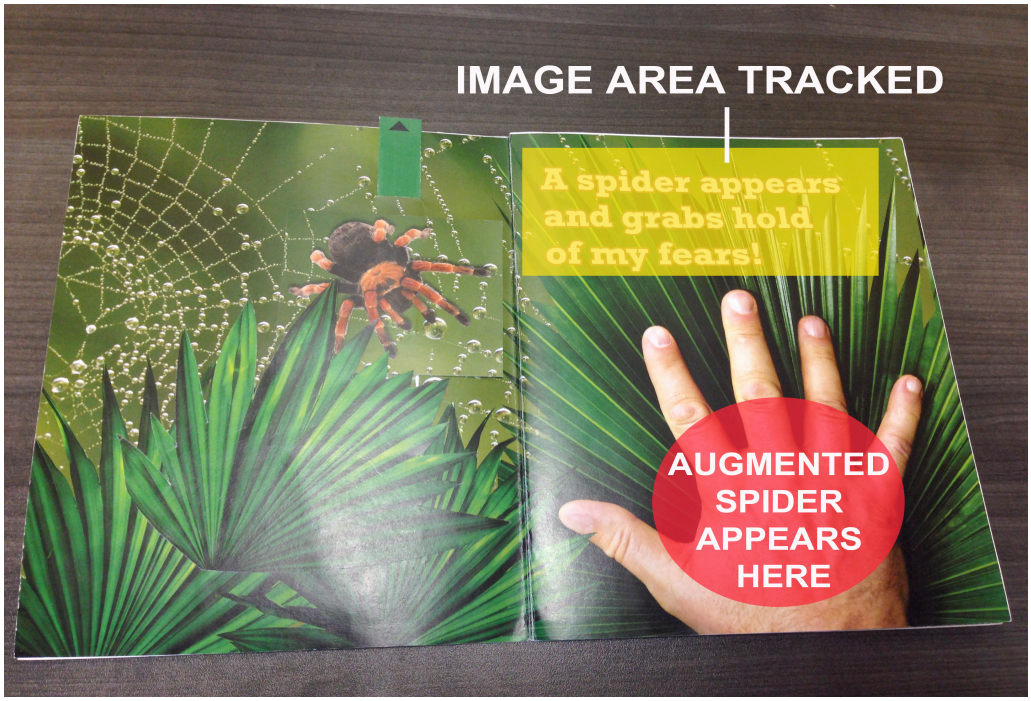


Fig. 18 Final spider page layout after initial tests and making sure the tracking worked. Top right area of the page indicted by yellow rectangle is the final image area that was being tracked, with the AR spider appearing off the tracking area and towards the bottom center of the page, indicated by the red circle.



Fig. 19 Screenshot of AR spider working in Junaio browser on iPad over AR book.



Fig. 20 Placing hand underneath iPad to hold the virtual spider

With the spider page utilizing the 'tap screen to animate' functionality in Junaio, the ant page layout applied the touch screen to hyperlink action. A pop-up picnic table was paper-engineered atop which a 3D ant appeared (Fig. 31). When the user found and touched the AR ant on the iPad screen, a Wikipedia web page opened with further information on ants, including various diagrams. Although the functionality was basic, it demonstrated a means of using AR in a book to access additional up-to-date information on the Internet. The interaction

and design of the ant page were expanded significantly in Iteration 2.

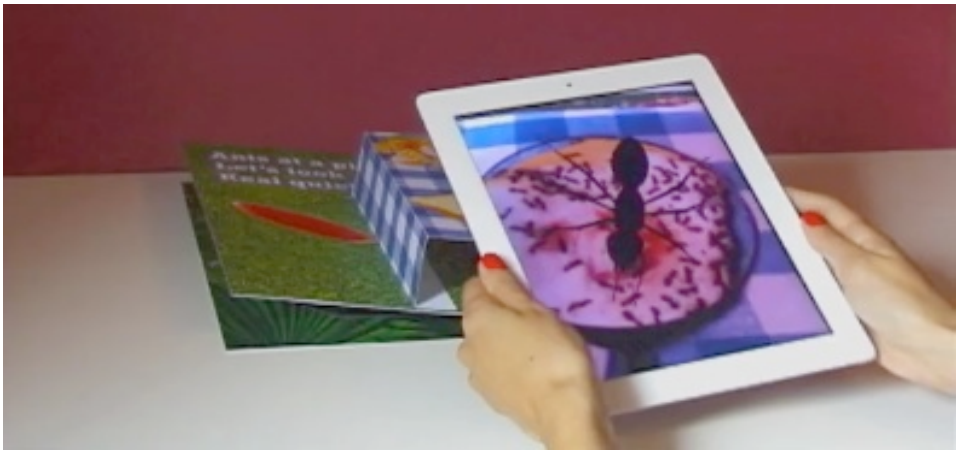


Fig. 21 Iteration 1 showing ant page with 3D AR model of an ant as seen on iPad.

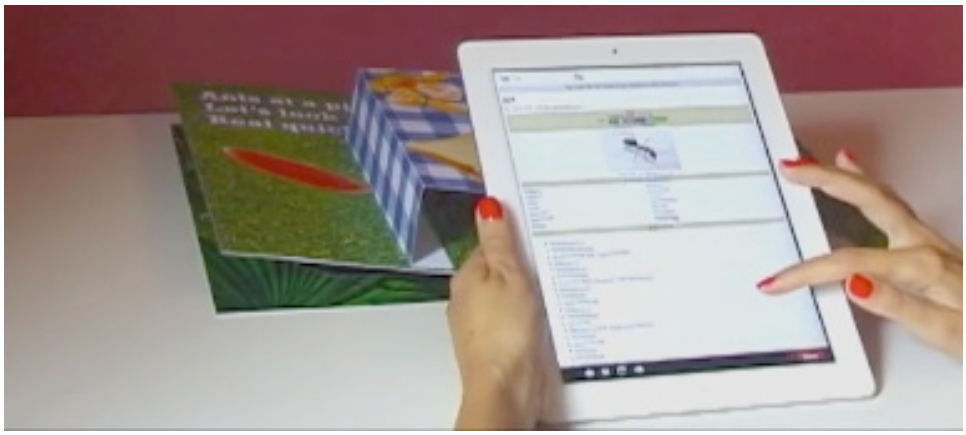


Fig. 22 Once the reader taps on the AR ant on the iPad screen, the Wikipedia webpage with further information about ants appears on the iPad screen.

The major challenge in the end with using Junaio was the butterfly page spread. The other pages all tracked a flat image, whereas on the butterfly page, the tracking image was the physical 3D pop-up of hands holding a flower, atop which the butterfly would appear in AR. The tracking was particularly difficult on this physical pop-up image marker because the lighting would change each time the book was displayed in a different location with pending factors like the height of the table the book was placed on (affecting the distance of the viewer and viewing device to the tracking image). Image tracking in Junaio functions by assigning a flat, still image to track. Because the tracking image for the 3D butterfly was not flat, a

photograph was taken of the physical pop-up and then uploaded to the Junaio server and treated as the flat tracking image. Each time the lighting conditions and location the book was shown in changed, I had to take a new photograph of the pop-up image marker with the iPhone camera (as the iPad camera was of lower resolution and quality), re-upload it to the Junaio web server, and test it in the Junaio mobile browser (Fig. 23). This, unfortunately, did not always work, which made it difficult to view the book in an uncontrolled setting. It was a good experiment to try, and a challenge posed to myself to overcome, to understand how tracking could work on non-flat images and objects in varied locations.

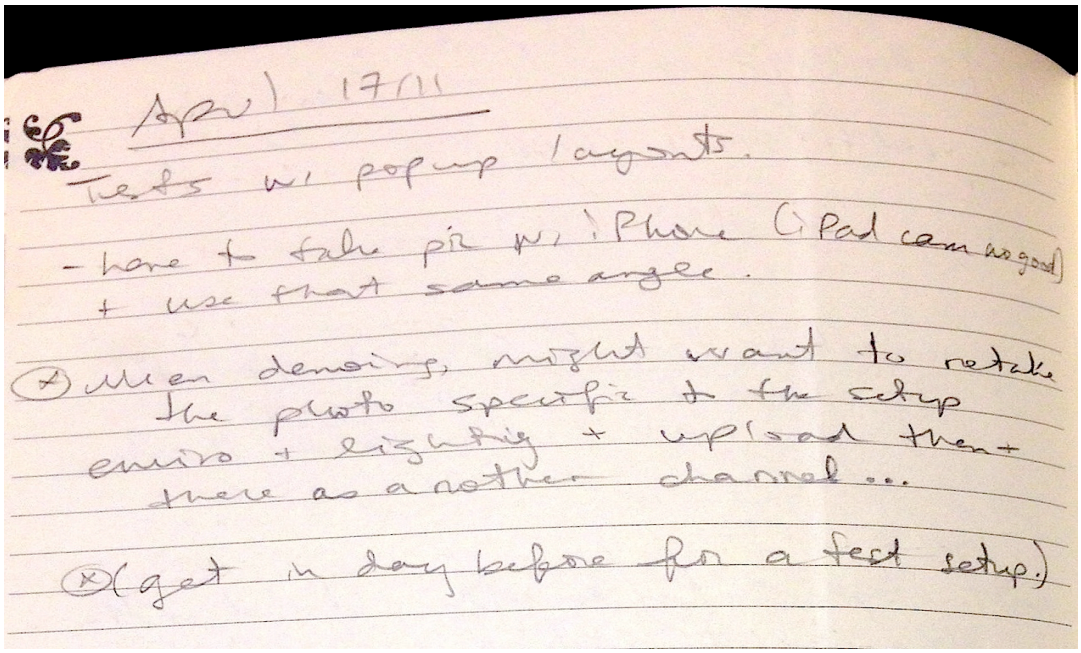


Figure 23: Work book notes on re-photographing image marker popup specific to each setup

The physical pop-up of the hands holding the flower also needed a designated background behind it. Beginning with a white background first to ensure the 3D physical pop-up would track (Fig. 24), rather than flat images normally used in AR tracking, tests were done to apply the best background image for tracking (Fig. 25).



Fig. 24 Screenshot from Junaio browser testing AR tracking working on 3D physical popup element with place holder 3D image and white background.



Fig. 25 Screenshot from Junaio browser testing AR tracking working with background image with place holder 3D image.

It is important to note that my iterative process included numerous incremental testing steps (Fig. 26) before applying the final design layouts, as exemplified by the butterfly page. Tracking methods first had to be confirmed as working, with image layouts coming last. It would have been unwise and a poor use of time to begin with an intricately visually designed page with graphics that may or may not have worked with the image tracking methods and interactivity.

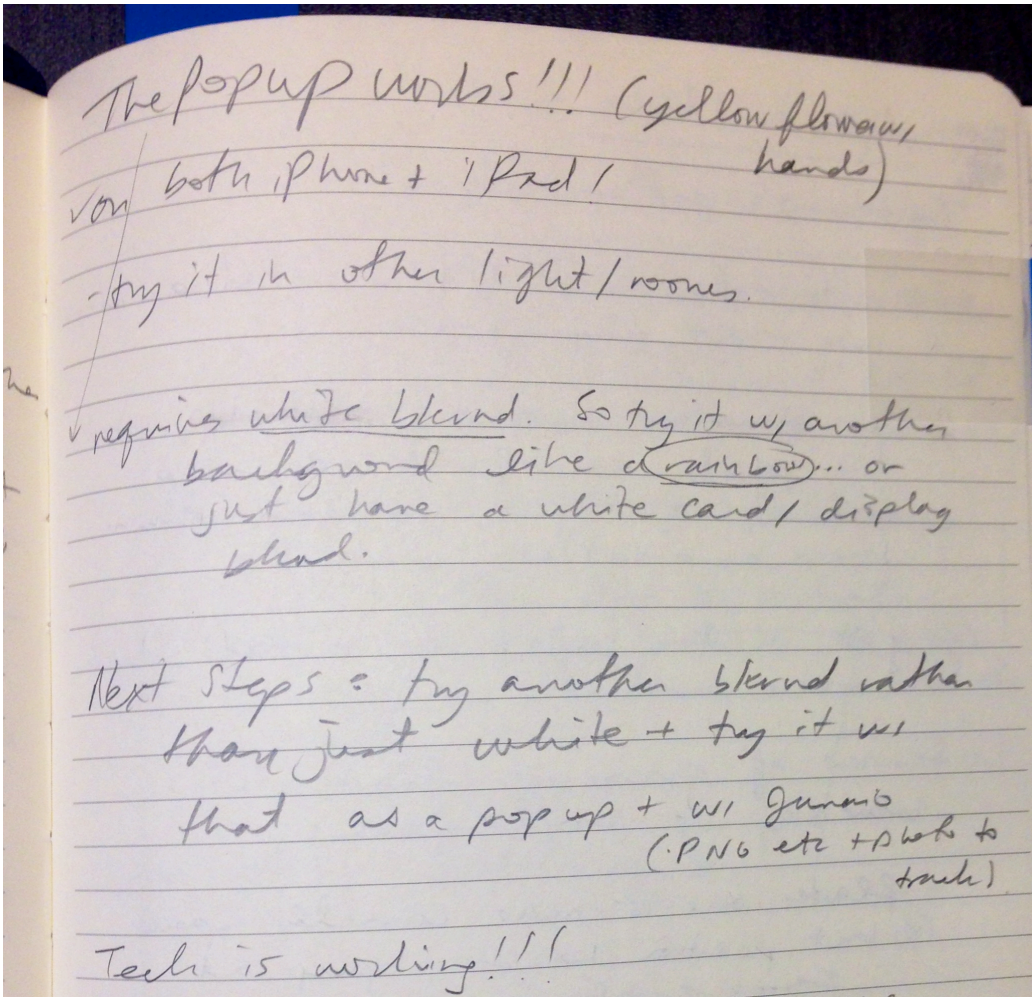


Fig. 26 Workbook showing test tracking worked on the physical pop-up and next steps to try it with another background other than white as seen in Figures 24-25.

Lastly, once all the image tracking and interactivity testing was complete and final visual layouts determined and prepared, the files were printed on 11 x 17” paper card stock at a local office supply store (Staples). The individual physical pop-ups were hand assembled and glued onto the page layouts, with all of the pages bound together in a final book (Fig. 27).

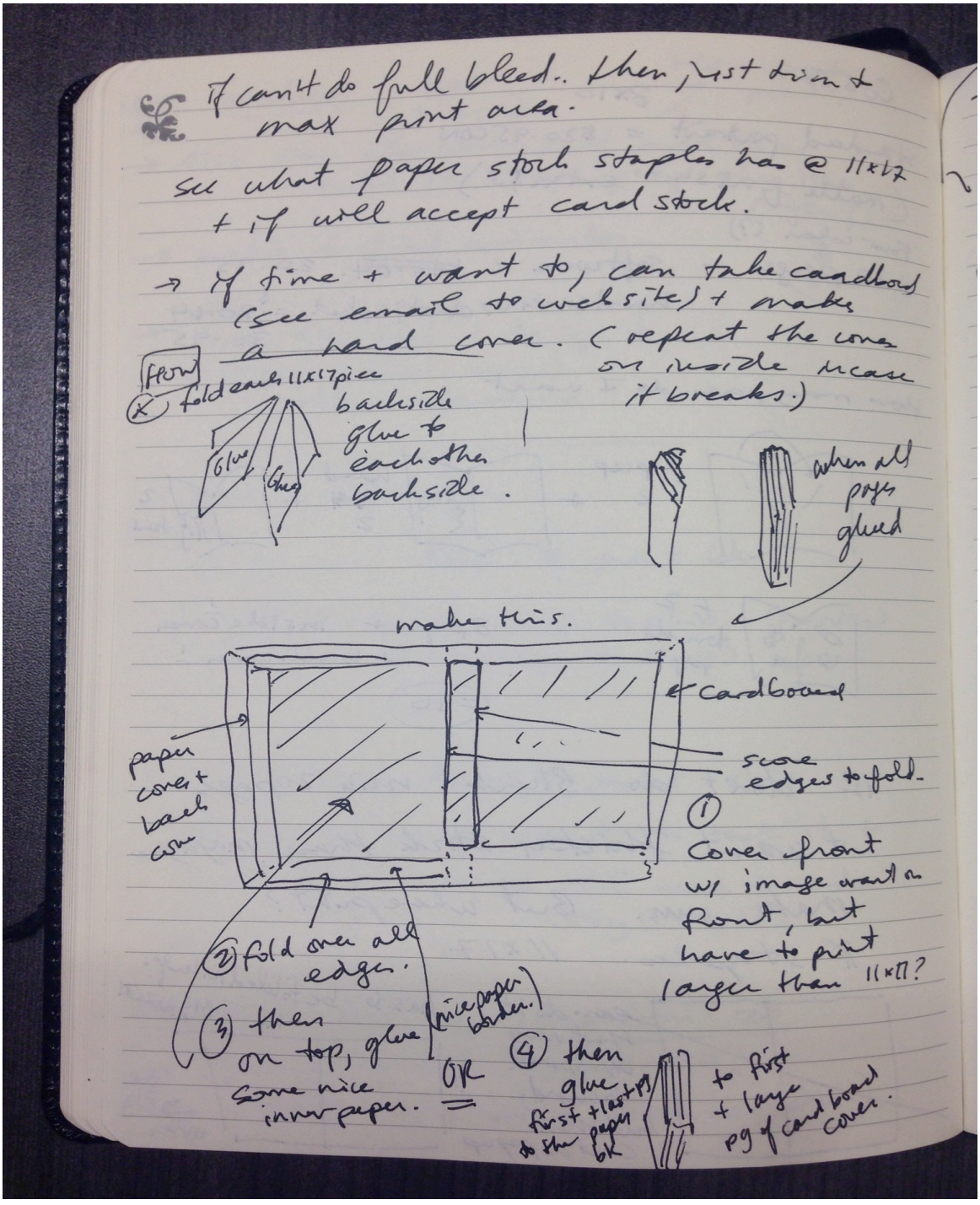


Fig. 27 Workbook notes showing assembly of final book and all pop-up pages brought together.

Iteration 2

The problem with tracking on the butterfly page from Iteration 1 was the primary reason of creating a second iteration with different software. In 2012, I was approached by AR company Daqri to collaborate on expanding my book. I wanted to further develop the experiences in the book and worked with Daqri to create a second iteration in hope of solving the tracking problem of the physical 3D pop up. We worked together to include more interactivity including 3D butterflies appearing to land on your hand upon placing your hand on the page, spatialized audio for each 3D model (with the sound getting louder the closer you moved the mobile device to the model, and softer audio as you moved the iPad away), and a 3D moveable magnifying glass that you could turn on and off to explore the picnic table scene. In addition, whimsical royalty-free stock music was added to each page of the book to enhance the playfulness and sensory experience; the previous iteration had no music included.

Daqri's software appeared to be more robust than Junaio and working directly with a programmer enabled me to build in more functionality by communicating and directing the interactivity I wished to integrate. It was still, like the first iteration, a process of trial and error, and required more dedicated time than the first as I was now working with a programmer, rather than being able to rapidly prototype all of the work myself. This required clear communication and direction, and because the work was done remotely, between Toronto and Los Angeles, I could also not work and prototype in person directly with the programmer. Versions, or “builds”, were sent to me to test, to which I would respond to with feedback and further directions in email and telephone conversations.



Fig. 28 Ants page layout from Iteration 1. The page layout had to be redesigned for Iteration 2 to remove the magnifying glass in the physical layout and place it back virtually in AR.

The ants page from Iteration 1 was redesigned to include an AR magnifying glass the user could touch on the iPad screen and drag around the scene to zoom in on elements on the picnic table. We began with assessing the trackability of the picnic table since the magnifying glass in the Iteration 1 design would have to now be removed from the graphic, to instead appear virtually in AR. The programmer, Michael French, emailed me with helpful tips on what could be done to increase the tracking value of the image layout (Fig. 29) and included a series of visualized suggestions (Fig. 30). We entered into a discussion and series of tests of various visual layouts to experiment and find the best tracking (Fig. 31). Michael asked me if I had any "specific ideas for possible additions to the page" and was very conscious of the overall design and noted that it was important that my vision for the aesthetics of the page be maintained as we looked for optimal tracking results (Fig. 29).

Hi Helen,

Attached is an image that is intended to demonstrate the way an image's trackability improves as more distinct areas of contrast are added.

Please note that I am not necessarily advocating these as actual finished designs (I used images grabbed from the web without concern for copyright, etc.); these are simply to help our discussion of what might be done to increase the tracking value of the page. For example, the branch / leaves image might be odd contextually, but it shows clearly how organic, non-repetitive shapes and areas of high contrast help the tracking. There may be other image options we can consider that will have the same effect on the trackability if you are open to additions like this.

Anyway let me know if you have specific ideas for possible additions to the page; obviously it's most important that we not muddy your vision for the aesthetics of the pages as we look for ways to make them track better.

Note that we have had very satisfactory results with an image that receives a score of 3 stars - it's neither necessary nor even possible in most cases to shoot for a perfect score.

-Michael

Fig. 29 Email from programmer Michael French collaborating with me on Iteration 2

The images first sent to me by Michael with the initial tracking tests were taken from a Google image search, and hence likely not royalty-free. I created a layout with a similar composition using royalty-free sample images with watermarks from the website Shutterstock (in advance of purchasing them to make sure they first worked) and digitally collaged them in PhotoShop. I redesigned the page layout and sent it to the programmer. Michael ran another tracking quality test for me, which returned only two stars. He suggested adding a visual element at the bottom of the page (Fig. 31). I edited the layout one final time to optimal tracking results (Fig. 32). Once the image layout scored a favourable tracking result of three stars, I purchased the Shutterstock royalty-free high resolution watermark-free images and began designing the final layouts.

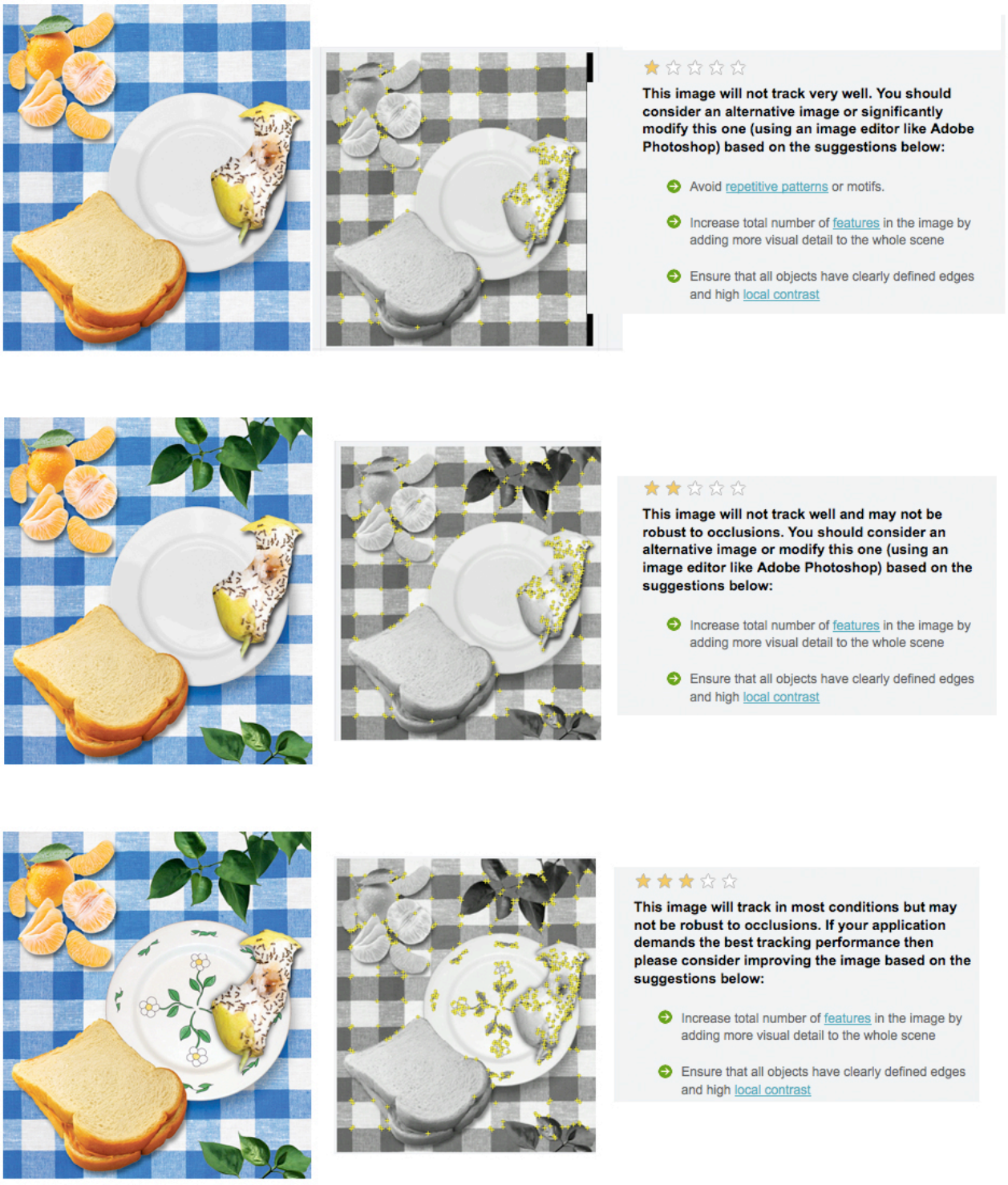


Fig. 30 Documentation of tracking improvement increasing (indicated by stars on right) as visual details are added including asymmetrical leaves and plate decoration. Score of 3 stars indicates very satisfactory results.



Fig. 31 Top image was the layout I sent to the programmer. It only scored two stars on trackability.

He suggested adding a visual element of a cluster of strawberries at the bottom for a higher trackability score.



Fig. 32 Based on the layout and scores sent back to me, I adjusted the final layout to resemble what the programmer had mocked up. I replaced the cluster of strawberries with grapes.
This was the final layout.

The ant page was updated to now have multiple smaller randomized AR ants programmed as opposed to one large AR ant appearing in the first iteration. The first iteration also had the static image of a magnifying glass integrated into the design, under which the 3D augmented ant appeared; in the second iteration, the magnifying glass appeared in AR as a mode you could toggle on and off and use your iPad to magnify elements on that specific page. There were technical problems with this including if you didn't turn the magnifying glass off before turning the page, the magnifying glass would appear on other pages, where it was not supposed to be, and did not work. The perspective of some of the elements magnified were also off and did not make sense visually (Fig. 35). In the end, the AR magnifying glass was removed due to the technical glitches. The interactivity from Iteration 1 remained the same, except now instead of touching one 3D ant to open the Wikipedia webpage, the user could touch any of the multiple moving AR ants to trigger the Internet hyperlink. A final addition to the ants page in Iteration 2 included ambient audio playing in the background to enhance the feeling of being outdoors at a picnic.



Fig. 33 Iteration 2 ants page shown, screenshot from iPad. Magnifying toggle button seen in bottom left corner. Augmented randomized ants seen atop pair.



Fig. 34 Magnifying toggle option shown own, screenshot from iPad. Enlarged ant viewed under magnifying lens. User drags the magnifying glass around the iPad screen through touch to magnify regions of the scene.



Fig. 35 Magnifying toggle mode working incorrectly: a magnified element that didn't make visual sense.



Fig. 36 Iteration 2, 3D augmented spider crawling over image of hand, screenshot from iPad



Fig. 37 Iteration 1 spider layout with pull tab on left page.

The spider page was expanded with the addition of music in Iteration 2, but it remained the same overall with the spider crawling over the user's hand (Fig 36), and showing an attack mode animation when the 3D spider was tapped on the iPad screen. The physical page

layout changed slightly: instead of a pull tab with a paper spider on the left page in Iteration 1 (Fig. 37), a flap in the form of a leaf was added, that when flipped up revealed a pop-up paper spider (Fig. 38). This paper-engineering element was added to complement the hide and reveal form of virtual interaction with the AR, now also possible in a tactile way in the physical book.



Fig. 38 Iteration 2 spider layout with lift flap on left page and pop-up spider hiding under leaf.

The butterfly page was also further enhanced by adding a second interaction with two 3D butterflies and a series of virtual pop-up flowers, in addition to the first butterfly from Iteration 1 that appeared augmented on top of the physical 3D popup flower. As I mentioned,

spatialized audio was added to the 3D models; the original butterfly from the first iteration now had the added element of the sound of flapping wings intensified as the user came closer with the iPad. The AR tracking was also far superior to Iteration 1; you could move in extremely close on the flower and on various angles without it losing tracking and the AR butterfly still appearing (Fig. 39-40).

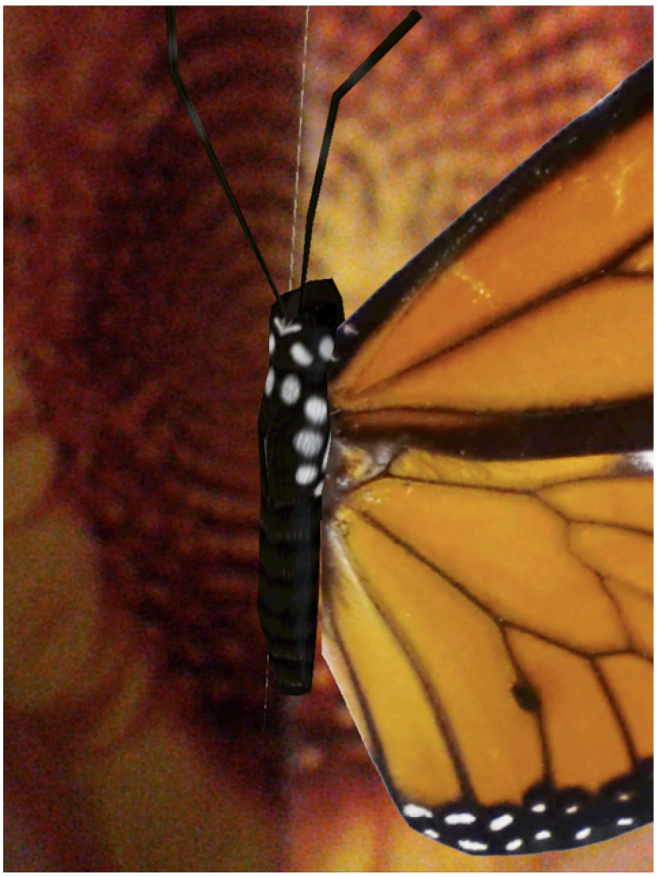


Fig. 39 Robust tracking even when bringing the iPad extremely close. Audio was also spatialized and became louder the closer the user moved the iPad to the image.

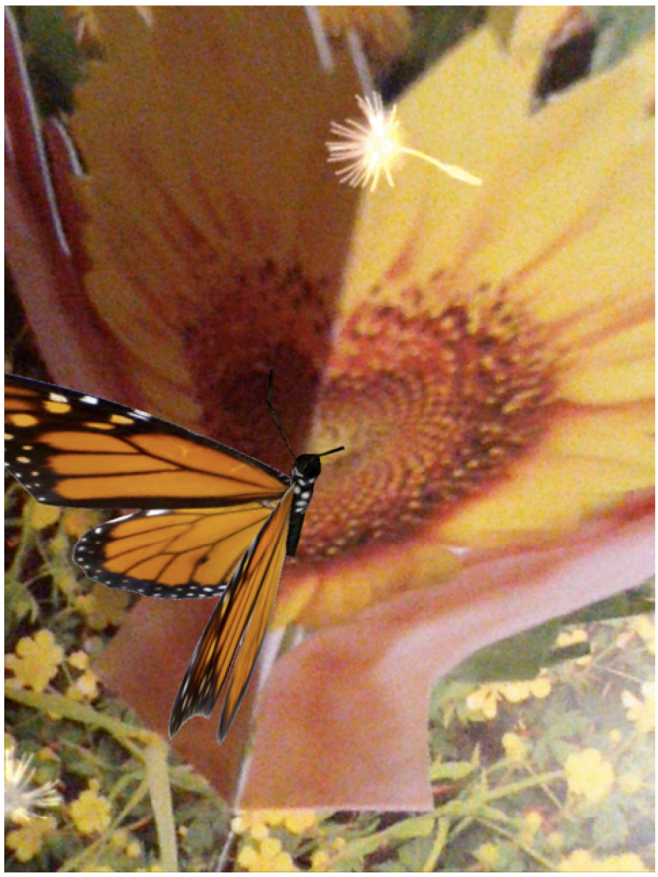


Fig. 40 Tracking was well maintained from various angles, unlike in Iteration 1 where the iPad had to be directly atop the tracking image, straight on.

The second interaction added to this page featured two butterflies fluttering around (Fig. 41) until the user placed their hand on the page, upon which the butterflies would land

(Fig. 42). This element had the illusion of hand-tracking, but in actuality, rather than tracking your hand, this was faked. It was triggered when the tracking of the designated zone of the page was interrupted (Fig. 43). In actuality, it did not have to be the user's hand that was placed down on the page, it could have been a piece of paper or any object, as long as it covered that particular zone of text. This technique was extended from Iteration 1 and lessons learned in the spider pages; however, in Iteration 1, I was working with occlusion rather than avoiding it. In the spider page, I didn't want to break the tracking when you placed your hand over the hand image, so I tracked another region of the page and positioned the 3D model of the spider in another location on the page. In the instance of the butterfly page in Iteration 2, once you placed your hand over the text, it 'broke' the tracking and triggered another action in which the butterflies hovered over that area of the page (Fig. 43), giving the illusion they were tracking to the user's hand. The illusion was very effective.



Fig. 41 Iteration 2 added interactive AR elements of virtual flowers appearing to pop-up, echoing the paper-engineering in the physical book, with two additional butterflies.



Fig. 42 When the user put their hand down over the text, the butterflies would stop fluttering around the 3D flowers and land directly atop their hands.



Fig. 43 Red rectangle indicates tracking region: where user would place their hand down on the page to have the butterflies appear to land on their hand.

Lessons Learned from Iterations 1 and 2

I found I preferred working independently overall with the medium myself as opposed to with a collaborator. It allowed me to experiment with the software directly and experience glitches to learn from and victories first-hand as they happened; I felt more in tune with the medium working solo. This personal realization on working directly with the medium recalls for me the following quote from Blair MacIntyre, Steven Dow, and Jay David Bolter's article, *DART: A Toolkit for Rapid Design Exploration of Augmented Reality Experiences* (2004):

> Unfortunately, tight collaborations between designers and technologists is not effective for less well-specified design projects, where AR is the medium being used by a designer to explore a problem. Designers are most effective when working directly with a medium, and working through an intermediary seriously hinders (or even destroys) the creative process. Consider the difference between a painter directing an assistant where to apply oil to a canvas, rather than holding the brush. Or a 3D animator describing to a programme how a character should move, rather than manipulating the model directly. (197)

I find this description to be extremely apt, particularly at the beginning of a new, still undefined medium, when I believe that it is critical for the artist to be able to work with the medium directly in order to learn the medium's nuances, find creative inspirations, explore tangents, tinker and experiment (This is a matter I address further in this Chapter, in the section, *The Need for Artist Tools in AR*). The other side to be noted is that there is also something to be gained in collaboration (at a time which may be better suited later in the process, when the artist has had an opportunity to work intimately with and understand the new medium first), where ideas the technologist or programmer has can come to light that the artist might not have considered.

Considering Presence and Aura in AR Content and Experiences

Content has been a general challenge in the field of AR, where content has simply been remediated from other forms with AR as a new container. For AR content to be successful, we must ask 'why AR?' In my research, I have found that content and experiences with contextual relevance and heightened presence (as I discuss in the literature review) are best suitable to AR.

The AR Book created a potentially fearful experience (dependant on the user's fear level) with heightened presence. Interactions such as having bugs appear on the user's hand intensified presence. As detailed in the literature review, Bolter, MacIntyre, and Gandy used the term “aura” when discussing presence, defining aura as the cultural and personal significance for the user. The authors note that “aura can only exist if the individual can connect the object or place to his or her own understanding of the world”(37). In the AR Book, the aura was the personal fears of bugs each user brought with them.

Through the creation of the book, I was able to introduce presence into my work, but it also helped me to better understand that there was another important side of designing for

presence that was missing in my work and in the first “overlay” wave of AR generally: integrating aura intentionally in AR experiences through personalization. Looking back at my PhD comprehensive exam oral presentation notes, I see that I had identified personalization early on as a minor point, but did not make the connection to aura at the time. I was now able to clearly see this after creating the work and going down the first path of AR as “overlay”; the process of research-creation contributed greatly to this insight. If I hadn't created the work first hand with the AR Book, I can say with confidence that I would not have been able to make this important observation. By intentionally applying aura through customized content, presence can be further heightened to produce a highly meaningful experience for each user. This contributes to the “entryway” theme of the second wave of AR.

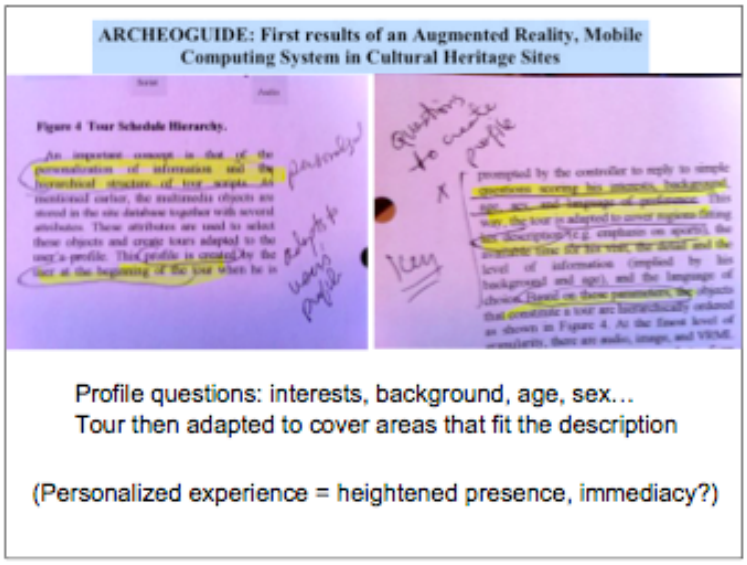


Fig. 44 Screenshot from PhD oral exam presentation notes, Archeoguide article.

Looking back at my notes from my PhD oral examination presentation, I listed the notion of a personalized experience to heighten presence as “an afterthought” (Fig. 44). I was referring to an article on the 2001 Archeoguide project in Pompeii, an AR historical recreation experience for users focused on integrating drama and narrative, not just 3D architectural models. The Archeoguide tour content would adapt to each user based on their answers to a few questions about their background (demographics) and interests. I drew a connection with the Archeoguide example to Dr. Mann's work on Mediated Reality in 1999, which he differentiated from AR in that the virtual info added is modified by a visual filter in real-time to create a highly personalized and custom experience. For example, Dr. Mann would virtually replace billboards with personal notes and directions that would appear overlayed atop the billboards (Fig. 45) and viewed through his digital eyeglasses and wearable computer. Dr. Mann described Mediated Reality and his WearCam eyewear as enabling a finely customized visual interpretation of reality unique to the needs of each individual wearer. These highly personalized experiences could allow for a different interpretation of the same visual reality. Emphasizing personalization, Dr. Mann coyly wrote in a 1999 article in the Linux Journal, “Just as you would not want to wear undergarments or another person’s mouth guard, you may not want to find yourself wearing another person’s computer” (8).

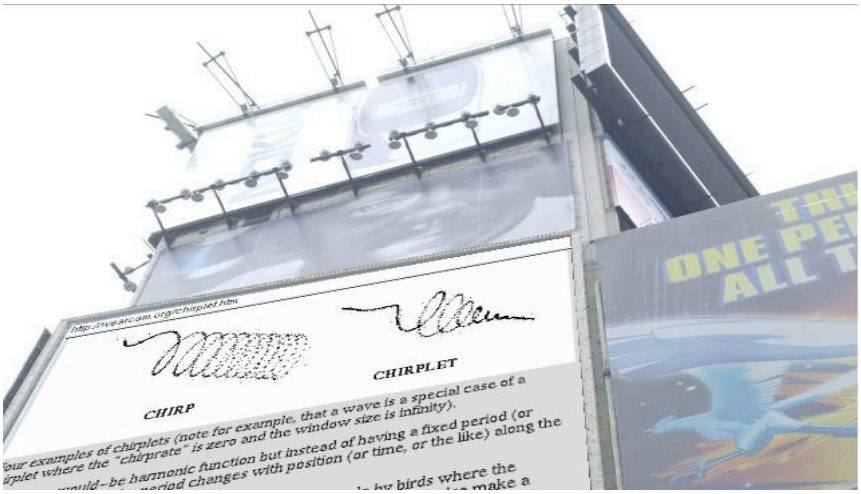


Fig. 45 Example of Mediated Reality by Dr. Steve Mann showing a billboard virtually overlaid with customized content as selected by Dr. Mann and viewed through his AR glasses.

The other point that I linked to and discussed in regards to the Archeoguide project and personalized content in Mediated Reality from Dr. Mann was deep-packet inspection applied in advertising (Figure 46) (as something Dr. Mann was trying to get away from with his edited customized billboards). Again, looking at this after creating the AR book, and observing current trends, I now saw that this type of personalized experience is very likely in AR, in the second “entryway” wave. Unlike Dr. Mann personally identifying what content he wanted to appear, I strongly believe that smart devices will do this for us in the second wave of AR. Intelligent software will learn us, our preferences, be responsive to our dynamically changing environments and act on our behalves to deliver relevant content and experiences in real-time AR as we need it. Within all of this, the two major areas of AR I identified in the literature review as having developed in the first wave, “utility” (like Dr. Mann's personal notes on billboards, with a move in this area to a personalized everyday experience around productivity) and “entertainment” (like the Archeoguide tour questionnaire example, with a move in this area towards personalized entertainment experiences), will continue within the

second wave of AR. Unlike the questionnaire being provided to users before taking the Archeoguide tour, and Dr. Mann actively virtually overlaying his personal notes and directions himself, I predict that we will see more of a 'deep-packet inspection' method, where all of this is done for us (with permissions granted to access our information), based on machine-learning and detailed profiles of each individual built overtime, done quietly with technology receding into the background.

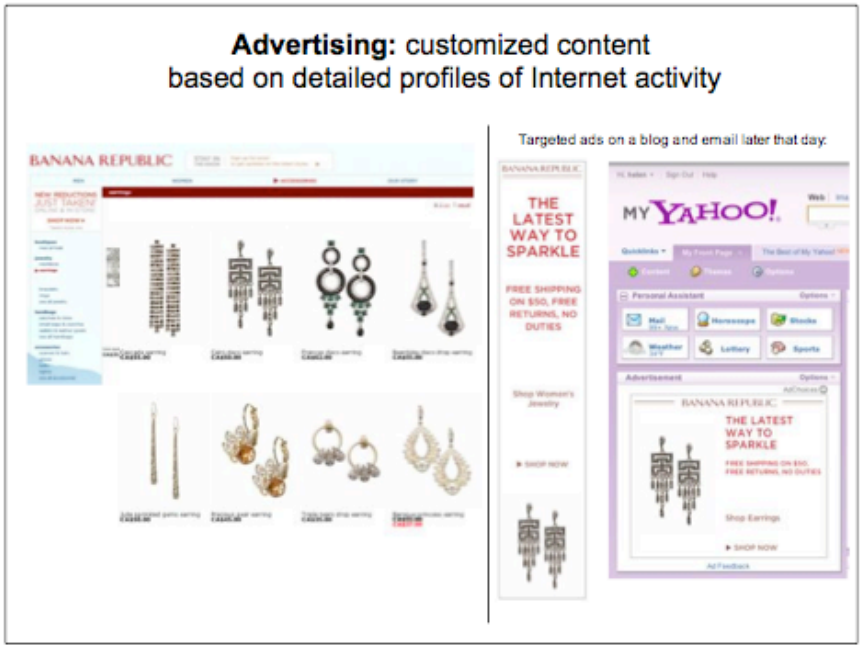


Fig. 46 Screenshot from Oral Exam presentation notes on "Deep Packet Inspection"

Contribution to Knowledge, Venues Exhibited At, and Press Coverage

The AR Book, *Who's Afraid of Bugs?*, has become a historical and original contribution to the AR field. The book has been exhibited at: Augmented Reality Event (ARE) 2011 in Silicon Valley, presented at TEDxDubai, featured in the hands-on exploration arena at the Cinekid festival in Amsterdam, demoed live at Xmedia Lab in Perth in a keynote talk, juried and accepted for demo at the International Symposium for Mixed and Augmented Reality (ISMAR) 2011, featured at the 4D Conference in Long Beach, California aboard the historic Queen Mary, and presented live on stage at the Next Media conference in Berlin. The AR book was also included in the AR Innovators section of the book, *Augmented Reality: An Emerging Technologies Guide to AR*, published in 2013, which profiled my creative practice and research. *Who's Afraid of Bugs?* also contributed to my being named among the NEXT 100 Top Influencers of the Digital Media Industry in 2013 (coming in at 16th place). The AR book had a terrific reception online with over 10,000 views of the video on Vimeo.com, and coverage on various blogs and websites including *Wired.com, The Creators Project* (a collaboration between Intel and Vice), *The Next Web, Games Alfresco, Adafruit*, and *VR News*. Lastly, the book was featured in print publications including *Web Designer Magazine*, *Dots*, and the inaugural issue of *AR[t]: Magazine on Augmented Reality, Art and Technology***.**

Expanding the Book

If I were to expand the book in the future, I would like to integrate haptics (providing tactile feedback) into the interactivity to heighten the realness of the experience. I would use haptics, either built into the touch screen of a mobile device, or add a haptics device, such as a special glove, to bring in tactile sensations, such as being able to feel the hair on the spider's body.

With terrain detection possible today (tracking and recognizing objects and obstacles in

the real world, through which the augmentation can interact with like bumping into a real wall, or moving under an object), I would include this feature to have the virtual bugs crawl or fly off the book page and interact with the user's real world environment to heighten presence such as landing on a vase, or crawling up and around the edge of a wall.

The AR book also enables future opportunities for multiple readers at the same time with multiple devices that can grow and change the experience, for instance increasing the amount of bugs seen when multiple devices come together.

As we are entering the second wave of AR, I see this book becoming more of a personalized and customized experience, growing with you and knowing you and your specific fears. Your experience of the book would be different from say your sibling's or friend's experience and reading.

The problem of being hands-free and holding the device while also turning the page could be resolved by wearing AR glasses as opposed to using a tablet or smartphone, which would also serve to heighten immediacy and presence (as discussed in the literature review). This could be dependent on the user's fear level: glasses would certainly be a more immersive experience that could also be more fearful, whereas a mobile device would be potentially less scary and easier to put down or turn away from the augmentation.

How AR Remediates the Book

Bolter refers to the term remediation as the process by which, *"*Producers or creators of digital media forms borrow the representational practices of other (earlier or contemporary) forms, while at the same time, seeking to refashion these older forms" (*Formal Analysis* 82). The new media form also seeks to "improve" upon the earlier form. Let us examine how the AR Book I created, which belongs to the first wave of AR, remediates the traditional book and any other prior forms.

In addition to the traditional book, pop-up books, and moveable books of the Victorian era, the AR book also partly remediates CD-ROMs, VR, and interactive experiences like Flash plug-ins on the Internet. The AR Book provides possibilities for improving upon the traditional book by becoming a living document that is updatable and no longer final once printed. The traditional book can further pack in even more resources and information by hyperlinking to the web. The AR Book also enhances pop-up and moveable books by expanding on the delight, wonder, and interactivity such books already create in an analog way, with novel imagery, animations, and 3D elements magically appearing. The AR Book partly remediates the interactivity of CD-ROMS and integration of multimedia elements like audio, video clips, animations, 3D models, and computer graphics, but now all possible in the real world and potentially off the screen of the desktop computer. Similarly, the AR book remediates the simulations of VR, yet improves upon the issues of accessibility in VR (expensive equipment to experience VR such as CAVE environments and Head Mounted Displays) and brings these simulations into our physical environment.

In regards to education, AR Books can improve on the traditional book by having students able to see real-scale 3D models relevant to the topic of learning (for instance in the subject of Science). In the case of both non-fiction and fiction-based books, AR can present visual aids (through video, graphics, animations etc.). This is particularly useful in instructional books such as cooking or mechanical assembly. These are all instances of how the AR Book remediates prior media within the first wave of AR.

It is worth questioning how the second wave of AR may come to remediate the book and other prior media. If a book was to be created in the second wave of AR, I envisage it being closer to an intelligent agent or personal assistant, with the properties and content of the book shifting and adapting based on your context and knowledge of your preferences. For

instance, if visiting Brazil, the book could present text from a local Brazilian author within your favourite genre of fiction. The characters in the book could also shift to reflect your reality and include the friends in your social media networks or even star you. Interactive content could be exclusive to the medium, so not replicating videos that would also appear on *YouTube* for instance, as we saw in the first wave of AR. The book of the future, if created within the second wave of AR, will dynamically adapt to you and your environment, predicting and presenting to you what you would like to experience at the apt moment. I also envision the book as dynamically updating continually on its own without work from the reader or user needing to initiate the updates. It will be a living, evolving book, which grows with its reader.

Art and Technology and the Need for Tools for Artists in AR

C.P. Snow's seminal 1963 essay *The Two Cultures: A Second Look,* discusses a dichotomy and lack of communication between the arts and sciences, noting a widening gap and no place where the two cultures seem to meet. Snow points to a convergence of the worlds of art and science to create opportunities for innovation and creativity, and stresses the need for the exchange of knowledge and understanding across traditional boundaries. There was a growing interest in the early 1960's in establishing collaborations among artists and scientists. Such initiatives included the Bell Laboratories in New Jersey, and Experiments in Art (E.A.T.) in New York City. In 1966 Bell Labs scientist Billy Kluver and artist Robert Rauschenberg worked together to organize a collaborative effort in which thirty engineers worked with ten artists on a series of performances presented at the 69th Regiment Armory in New York. This experience led Kluver and Rauschenberg to found E.A.T. upon the idea that, "a one-to-one equal collaboration between an artist and an engineer was the best way to bring technology to the artist, and that such collaborations would benefit both artists and engineers as well as society as a whole" (Harris, 9).

One of the pioneering programs for artists working with emerging technologies was the Art and Virtual Environments Project at the Banff Centre for the Arts in the early 1990's. The program provided artists with access to new media resources and technical practitioners to facilitate the creation of their work. The book *Immersed In Technology* (1996) documents the artists' explorations in Virtual Reality and their resulting work, drawing attention to the changing conditions of artistic involvement in the development of new technologies. "Artists no longer sit on the sidelines eventually to become grateful users of borrowed tools but have become active in development, creating a disturbance in the field with new contingencies" (MacLeod ix). Where artists were once excluded from the development of new technologies, the contribution of artistic insight to advancing technology grew to be recognized over the past few decades as beneficial and even profitable.

Some fear, however, that profitability and commercialization could signify the end of such experimental artwork in emerging technologies. Douglas MacLeod, Director of the Banff program at the time, and author of the preface to the resulting publication, wrote in 1996, "Most worrisome of all, a new approach to cultural initiatives (not only in Canada but throughout the world) suggests that all explorations must have commercial or revenue-generating potential" (xiii). Stephen Wilson, artist and technologist, and author of *Information Arts: Intersections of Art, Science, and Technology* (2002) comments upon the dangers of relying on market forces, noting that, "Valuable lines of inquiry die from lack of support because they are not in favour of particular scientific disciplines. New technologies with fascinating potential are abandoned because they are judged as not marketable. Our culture must develop methods to avoid the premature extinction of valuable lines of inquiry" (35). Wilson suggests that the arts can contribute a critical role as an independent area of

research, in which artists can offer a critical commentary and participation in technology.

Availability to new virtual imaging equipment and facilities for artists during the time of programs like the Banff Centre's Art and Virtual Environments project was further complicated by the fact that artists remained largely reliant on corporations and institutions for access to the technology. Mary Anne Moser, McLeod's fellow editor of *Immersed In Technology,* draws attention to the fact that the motives or research interests of the artists may be worlds apart from those of the corporations, yet, in order to obtain access to the technology, the artists need to offer the corporations something in exchange. Moser questions, "Is there a way that artists can work with this medium without heavy constraints imposed by industry?" (xxiv)

For artists to be free to experiment with a new technology without corporate control or commercial constraints, artists must gain free reign to such tools. This entails overcoming both the high costs associated with the equipment and necessary development tools, and acquiring the technical knowledge necessary to work directly with such new technologies, previously assigned to the role of engineers or scientists. Such a preposition is perhaps more viable in contemporary times, for as Craig Harris writes in *Art and Innovation* (1999), "Many artists and scientists now have more sophisticated and integrated multimedia computing power in their home offices or studios than research facilities had at their disposal twenty years ago" (5). Virtual Reality (VR), in both cases of cost and technical access, was greatly limiting to artists who wished to work independently. Although this was predominately the case, it should be noted that tools like VR2GoTM, created in 2003, were developed to overcome such barriers. VR2GoTM was designed to reduce expensive software, hardware, and workstation costs, and enable all creative developers, including artists and children to create VR content (Sauter 2003). Although developed over a decade after the VR boom, after

the initial excitement and interest had fizzled, one wonders how such a tool could have influenced the field had artists been working with such an application in parallel to developments by commercial industry. VR2GoTM may have been the precursor to early AR applications like *DART* (Designer's Augmented Reality Toolkit), which I was exposed to at the very beginning of my AR practice when searching for a way to work directly with this emerging medium.

Unlike VR, where access to artists was seriously limited, AR affords incredible possibilities for experimentation by artists outside of industry, particularly in the first wave of AR. AR experiences can be developed with off-the-shelf equipment: a personal computer, inexpensive web cam, tablet, smartphone, and downloadable open-source software. The major obstacle, however, to most artists is a lack of programming knowledge required to build AR applications. This is where programs like York University's AR Lab's software *SnapDragon* (to which my creative work and research contributed to), Metaio's Junaio *Creator*, and Layar's *Creator*, permit artists access to the means to work directly with AR without the need of an intermediary, which can gravely hinder the creative process. Previous artistic explorations in emerging technologies like VR were predicated upon models of art and science collaborations or partnerships where artists relied heavily on the assistance of engineers to build the artwork. Tools like *SnapDragon* allow artists to become core participants, working directly with the technology, rather than being observers.

As much of an advancement as these tools are in enabling artists and designers to work directly with the medium, they are, however, still limited and restricted. Layar and Metaio both offer very basic interaction in AR and are part of the first wave of AR. An incredible opportunity exists for artists to drive innovation in the field of AR in parallel to current

investigations by industry, and to aid this medium to reach its full potential as we move into the second wave of AR. I believe where the new challenges rest are with the more sophisticated programming knowledge that will be required in this second wave of AR that will be heavily influenced by machine learning, artificial intelligence, and cognizant computing. Perhaps what will be needed here, in advance of artist and designer tools being developed, particularly for artists and designers who do not have these programming skills, will be a thorough understanding and hands-on experience of the first wave of AR in order to collaboratively work with programmers and technologists in defining the possibilities for the second wave. I personally face this challenge being limited in programming knowledge, and this will be my approach as AR is a medium I want to fully see through (with pun emphasized).

The 40 Ideas That Will Change Augmented Reality (AR)

Introduction

As I have already discussed throughout the dissertation chapters, in my nine years of working with Augmented Reality (AR) as both a researcher and practitioner, I have observed a shift in AR from a first wave I've labelled “overlay” to a second wave I refer to as “entryway”. AR is quickly advancing into a new phase of contextually rich personalized experiences. The second wave of AR will surpass novelty and extend our human capacities to better understand, engage with, and experience our world in new and meaningful ways. Our devices will be highly cognizant of our constantly changing environments delivering personalized solutions with highly relevant content and experiences.

The *40 Ideas* is a visionary framework which documents and prescribes possibilities to propose an articulation of a new language of AR. The *40 Ideas* highlight the proliferation of a new grouping of emerging technological capabilities that fall in close proximity to one another around the central sphere of context, a unique feature of AR as a new medium distinct from others. As a researcher and practitioner I have observed new patterns, characteristics, and themes emerge which point to a new AR. It is important to first briefly highlight *The Top 10 Ideas That Have Already Changed AR* over the past few years before we continue to *The 40 Ideas That Will Change AR*.

The Top 10 Ideas That Have Already Changed AR (Illustrated)



Fig. 1 Wayne Piekarski's wearable computing design for outdoor AR, 2004, University of South Australia. http://www.tinmith.net/wayne/thesis/



Fig. 2 Outdoor AR in 2012 on mobile devices including smartphones and tablets. HIT Lab NZ researcher Dr. Gun Lee (left) and Professor Mark Billinghurst photographed with their AR technology.

1. **The untethered freedom of mobile computing in AR.**

   Mobile devices (Fig.2) have made it much easier to take AR outdoors without the need of clunky and heavy wearable computing. We have certainly come a long way from Wayne Piekarski's PhD thesis in 2004 documenting his work on outdoor AR wearable computing devices at the University of South Australia (Fig.1).



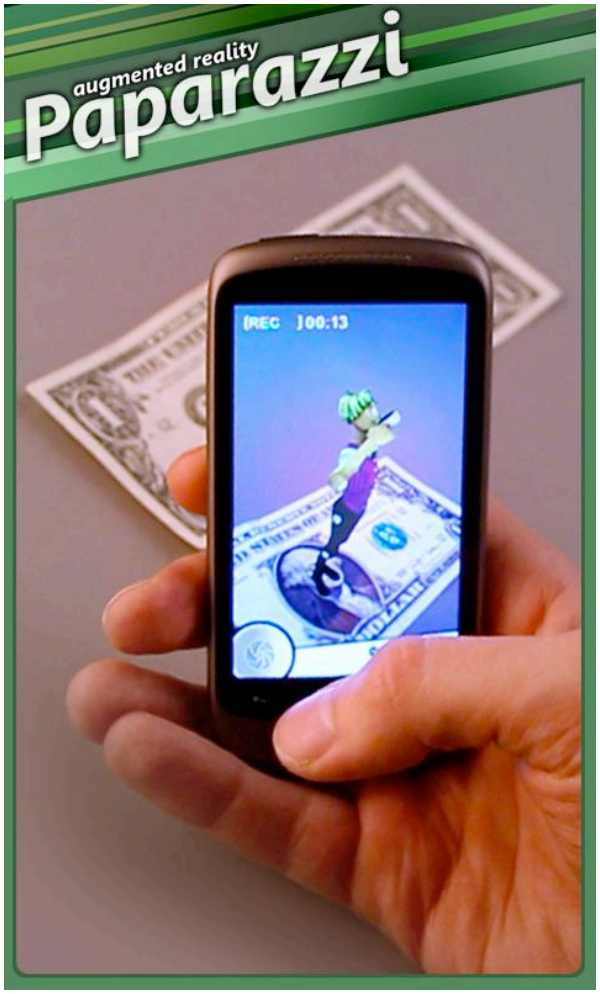


Fig. 3 AR Fiducial marker shown on cover of *Esquire* Magazine, 2009	Fig. 4 AR game *Paparazzi*, 2011. Image tracking shown using an ordinary American dollar bill (with character augmentation appearing on mobile phone) using Qualcomm's Vuforia image tracking

2. Advances in image tracking, departing from fiducial marker tracking.

My early work in AR began with AR fiducials (Fig.3) and advanced to the use of image tracking (Fig.4) in the AR Book. Image tracking allowed for more liberty in design layouts; however, it did create the challenge of how to communicate to a user that an AR experience was waiting to be discovered and not have it hidden.

	Fig. 5 Designer's Augmented Reality Toolkit (DART), Georgia Tech, 2005. Six fiducials were required for one AR 3D cube to appear
	Fig. 6 *AR Joiners, Colosseum*, 2009 by Helen Papagiannis. Multiple fiducial markers were used to simultaneously show multiple AR 2D video. The project was created using SnapDragon software by the AR Lab at York University

3. Single target tracking expanding to multiple target tracking.

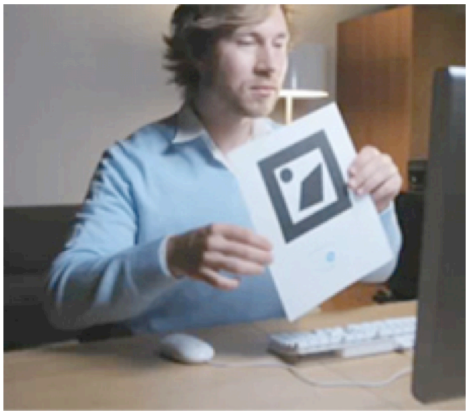
When I began working with AR in 2005, six fiducial markers were required for one 3D AR cube to appear (Fig.5). Tracking advanced quickly, allowing for multiple markers to be tracked and multiple augmentations to now appear simultaneously (Fig.6).



Fig. 7 *Three Angry Men*, Augmented Environments Lab at Georgia Tech, 2002. Top right corner shows user wearing a head-mounted display through which she can experience each one of the juror's perspectives

4. Dramatic narrative experiences with multiple points-of-view in AR.

The Augmented Environments Lab at the Georgia Institute of Technology was one of the first to explore dramatic narrative in AR with *Three Angry Men*, 2002 (Fig.7). *Three Angry Men* was a multiple point-of-view AR experience in which the user was able to witness the drama from one of the three juror's perspectives through a head-worn display. At any time, the user could get up and sit in another chair to experience a different side of the story from another juror. This was an incredibly advanced concept at the time when AR focused primarily on tracking and 3D models rather than on story or narrative.



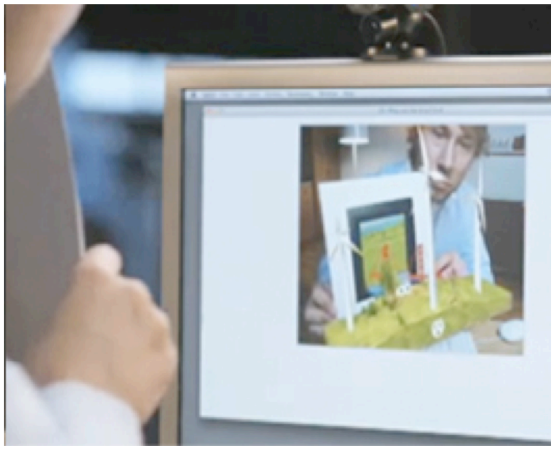


Fig. 8 General Electric (GE) Augmented Reality experience using FLARToolkit to create a 3D interactive windmill, 2009







Fig. 9 FLARToolkit used in Ontario Science Center Exhibition postcard takeaways for *The Amazing Cinemagician* exhibition by Helen Papagiannis in collaboration with the York University AR Lab, 2010

5. The introduction of FLARToolKit.

FLARToolKit is the Flash Actionscript version of the ARToolKit tracking library that enabled the quick development of web-based AR experiences. Prior to FLARToolKit, AR experiences were available only through software that had to be downloaded to each computer where the experience was wished to be viewed. FLARToolKit was a significant step in accessibility both for developers and audiences. FLARToolKit was used in several advertising campaigns, most notably General Electric's AR windmill experience (Fig.8), which also appeared on the cover of *Popular Science* in 2010.

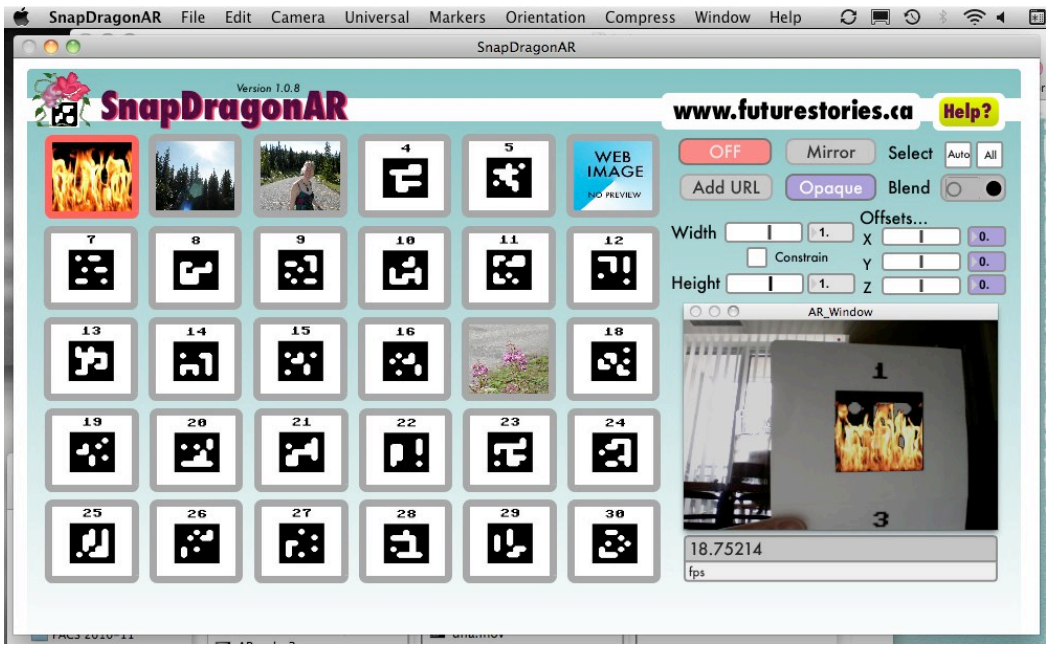


Fig. 10 SnapDragon AR desktop authoring software for artists and non-programmers applying a drag and drop interface. Created by the AR Lab at York University, 2009



Fig. 11 Layar Creator drag and drop AR web-based software for non-programmers to design AR experiences

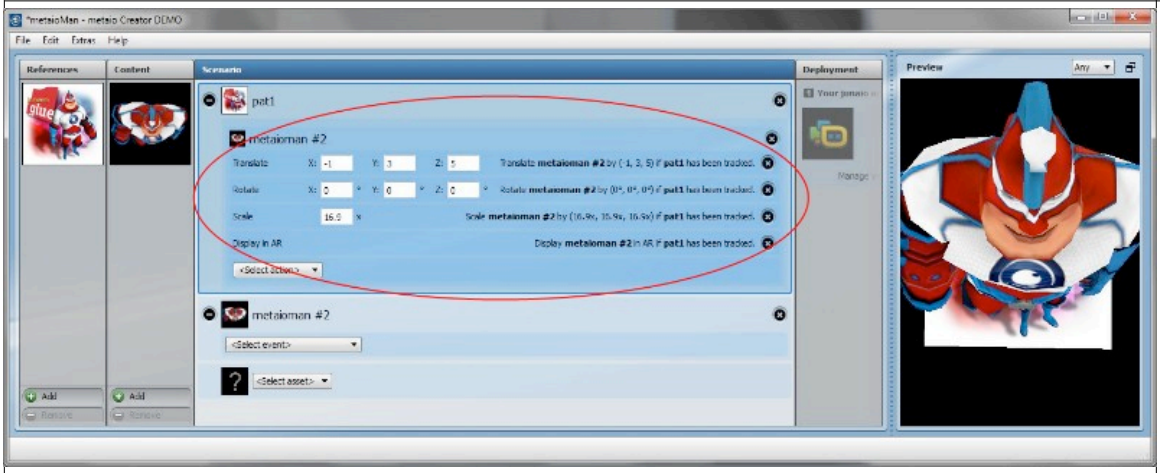


Fig. 12 Metaio Creator web-based software for non-programmers to design AR experiences

6. AR development tools for non programmers.

The AR Lab at York University was the first to create a drag and drop AR desktop authoring tool for artists and non-programmers in 2009 integrating Mark Fiala's ARTag tracking library (Fig.10). Metaio (Fig.11) and Layar (Fig.12) also made comparable web-based 'creator' tools available targeted at commercial applications. Overall, such tools have made AR accessible to a broader public of both makers and users.



Fig. 13 Example of a Magic Mirror AR experience, as seen in *The Amazing Cinemagician* exhibition, designed by Helen Papagiannis in collaboration with the York University AR Lab at the Ontario Science Center, 2010.

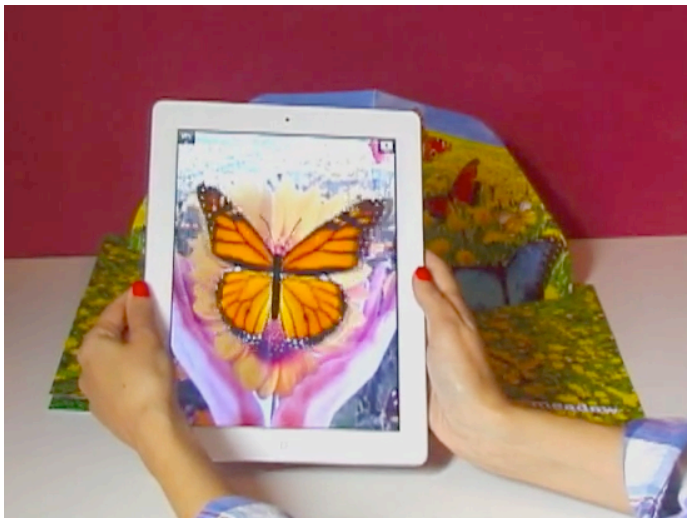


Fig. 14 AR Book for iPad (by Helen Papagiannis) demonstrating a direct sight-line over the environment, in contrast to Magic Mirror approach.

7. Magic-mirror AR expanding to see-through AR experiences.

Prior to AR working on mobile devices like smartphones and tablets, AR was predominantly a 'magic-mirror' experience applying a web camera and computer screen that would mirror back your physical environment with an augmentation tracked to a target, which then appeared on the screen (Fig.13). This mode of viewing AR was applied with FlarToolKit and often created a poor user experience as the user would have to peer over the paper marker (Fig.8) to even see the AR content mirrored back to them on the screen. Mobile devices like the iPhone and iPad allowed for a direct

sight-line (Fig.14) onto the AR tracking target, as though holding a looking-Glass and peering into another world.



Fig. 15 Google introduced its Glass Explorer program in 2013



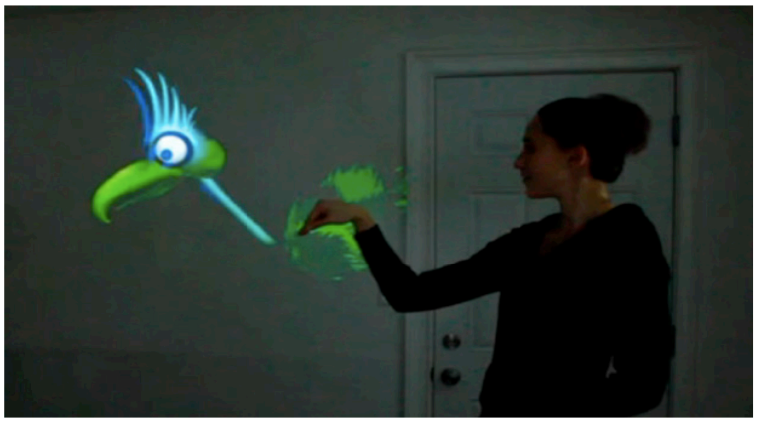
Fig. 16 Helen Papagiannis wearing Google Glass, 2013

8. The introduction of Google Glass to the public.

As discussed previously in the dissertation, Google's introduction of Glass and its exclusive *Explorer* program (Fig.15) was a significant progression of AR entering into the public's perception and making the possibilities for AR popular and known to a mass-audience. Although Glass only scratches the surface of what AR can really do, it has helped to promote AR as an emerging technology that is not to be ignored.



Fig. 17 ARTag tracking library creator Mark Fiala wearing a suit of AR fiducials. The AR costume is mirrored back to him on the screen, tracking all of the AR fiducials, 2009.



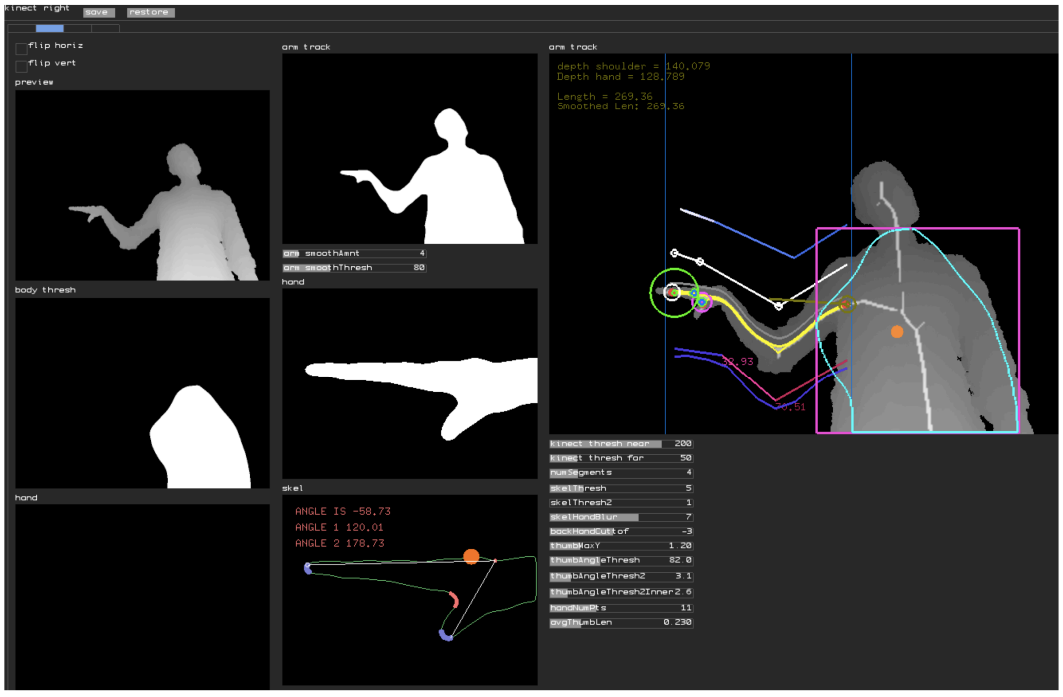


Fig. 18 A Kinect AR project by Theo Watson and Emily Gobielle, *Puppet Parade.* The Kinect allowed for skeleton tracking as seen in the images, with a user's hand and arm now being the trackable target, removing the need for fiducial systems like Mark Fiala's above.

9. Kinect AR.

The creation of AR experiences with Kinect signified a massive expansion of AR's technical capabilities: the user now became the tracking target (Fig.18) without the need for fiducials (Fig.17) or image tracking. Kinect allowed for greater access to skeleton and face-tracking.



Fig. 19 The mobile app *Word Lens* first appeared in 2010 offering a real-time translation experience in AR.

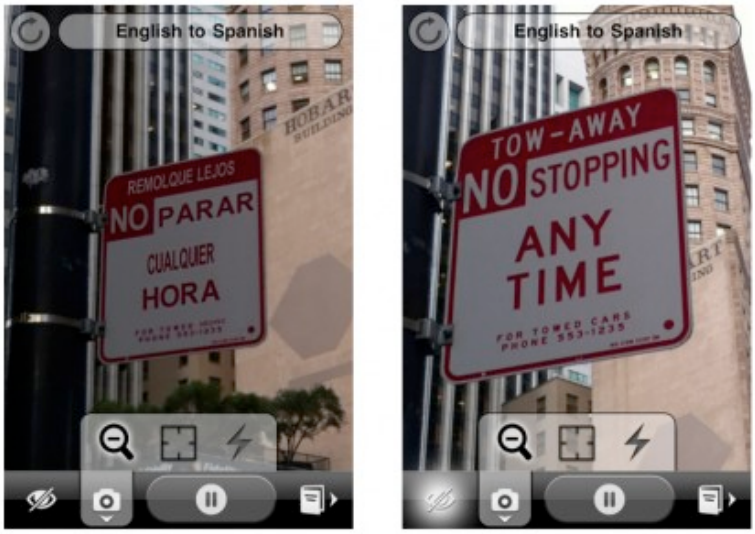


Fig. 20 *Word Lens* applied the same font of the sign or text that the user wished to translate.

10. The real-time AR translation tool Word Lens.

Word Lens signified another important shift in what was trackable in AR: words and language itself now became a tracking target (Fig.19). Signs in foreign languages could now be translated on the fly using a mobile app, with the text appearing layered atop the foreign language in the same font (Fig.20). *Word Lens* was very effective in providing great utility in a real-time language translation experience.

With the exception of one case (#4), *The Top 10 Ideas That Have Already Changed AR* all signify technological advances, either in software or hardware. This has been a problem in AR to date: the design and production of compelling content and relevant experiences have played a secondary role with the primary focus being on technological advancement. Azuma's seminal paper, discussed in the dissertation introduction, focused on improving the technological aspects of AR back in 1999. We've come a significantly long way since then. We are now ready for content and meaningful experiences in AR, with this medium making a real-difference in people's lives and changing how we come to interact with and see the world through AR. This will begin with context, with personalization dominating the next wave of AR. Issues of presence and immediacy, as discussed in the literature review, will play a significant role in the second “entryway” wave of AR.

The last two cases in the *Top 10 Ideas That Have Already Changed AR:* Kinect AR, and the real-time AR translation tool *Word Lens* signified an important demarcation point to the next wave of AR. Both are examples of experiences that are significantly tied to the varying context of each specific user. They are also examples of a heightened presence and immediacy where the technology and tracking target seem to disappear. In the case of Kinect AR, the user's body now becomes the tracking target, allowing for deeper immersion into the AR experience. In the *Word Lens* example, the subtle, yet clever design of the translation text appearing in the same font as the original sign also creates a heightened illusion of non-mediation, where the medium appears to be invisible. In both examples, the user is now standing in “an immediate relationship to the contents of that medium” (Bolter and Gruisin, 24).

The second “entryway” wave goes beyond overlay to now grant access to a more immersive, engaging, and personalized augmented experience where content is delivered

based on the user and is dynamically adapted to a responsive environment, driven by context. The *40 Ideas* each expand on this documenting a significant moment, advancement in technology, or concept to propose the coming capacities and opportunities that will advance and shape this important second wave of AR. The *40 Ideas* do not shy away from technological advancements, but highlights these forays, with an eye to and hope for the types of experiences the technology can bring forth and inspire in the next generation of AR designers, technologists, and researchers.

The 40 Ideas That Will Change Augmented Reality (AR)

1. **Breaking the Screen/Frame**
2. **The Méliès Effect**
3. **Vertov**
4. **Thing Theory**
5. **Context-Aware Computing**
6. **Geo-fencing**
7. **EEG (Electroencephalography) Brain Computer Interface**
8. **Invoked Computing**
9. **Buildings That Shift and 4D Printing**
10. **3D Printing**
11. **Synesthesia**
12. **Empathy**
13. **Haptics and Touch**
14. **Taste and Smell**
15. **Point of View: Object**
16. **Electroreception: Seeing and Hearing With Your Tongue**
17. **The Armchair Traveller**
18. **Human Body as Touchscreen Replacement**
19. **Spatial Augmented Reality (SAR) and Projection-based Augmented Reality**
20. **Dynamic Brand Identities**
21. **Ghosting**
22. **Non-Traditional Gaming**
23. **Journalism**
24. **Memory**
25. **A Second Self for Self-improvement**
26. **Facial Recognition, Detection, and Analysis**
27. **Non-Facial Recognition Alternatives**
28. **Emotion Analytics**
29. **Eye-tracking**
30. **AR Eyewear**
31. **Motion Control**
32. **Neo-Baroque space: The User at the Center**
33. **Subversive Augmented Reality**
34. **Translation**
35. **Cognizant Computing and Digital Devices as Personal Assistants**
36. **Responsive Clothing**
37. **Body Implants**
38. **Artificial Intelligence and Machine Learning**
39. **Calm Computing**
40. **User Experience (UX)**

Breaking the Screen/Frame

AR presents the opportunity to interact with a whole new dimensional space that traces a history of illusion from trompe l'oeil to the magic lantern to stereoscopic 3D films. Early cinemagoers were said to have been astonished by the first films, witnessing trains that seemingly charged off the screen and directly at the audience. That couldn't be a better way to describe some of the visual special effects AR can make possible today; however, we're now able to step inside that scene and look at that train from a multitude of perspectives. As seen in SONY's "LiveAction AR" demo[20], AR presents a unique opportunity to engage with 3D interactive photo-realistic sculptural photography, scenes that we are able to enter, explore, and even alter. Sony's demo shows a 3D female climb out of a 2D poster, seemingly now "in the real world" of the user. The demo shows the ability to walk around the photo-realistic virtual female in 3D, viewing her from multiple angles. The user can also enter the space of the virtual female and take a photograph with her.

This has great potential in altering the way we tell stories, with the narrative of the augmented environment spilling into our physical surroundings. Stylistic motifs will emerge in AR that explore storytelling beyond the limits of the single frame, expanding in multiple directions, puncturing conventional space and no longer confined within a distinct screen. The AR participant and audience will be at the center of this, the space navigating around the user; the user's perception, context and active engagement will dictate and define the illusion.

In his 2005 TED talk, author of *Understanding Comics* artist Scott McCloud discusses post-print comics[21]. He speaks to mixing the visuals of comics with the interactivity, sound, and motion of CD-ROMs. McCloud comments how one of the first things they did was to "take

20 http://youtu.be/2rbTLrrgEaU
21 http://www.ted.com/talks/scott_mccloud_on_comics.html

the comic page as is and transplant it to the monitors, which was a classic McLuhanesque mistake of appropriating the shape of the previous technology as the content of the new technology.” He described the pitfalls of the breaks with continuity in this approach, and questioned if there was a “way to preserve the spatial relationship while still taking advantage of all of the things that digital has to offer us?” McCloud understood very well the importance of time and space in comics to tell a story and as central to the language of comics. These are important questions to consider as content of other mediums is being 'transplanted' to AR and how we can think of AR not just as a screen or monitor, but a reality that expands into our space and is not confined.

In extending comics to an interactive new media form, in the end McCloud proposed that a monitor not be looked at as a page, but rather as a window, creating these comics on an infinite canvas (with examples of circular narratives, x and y axis, and staircases). McCloud states that this is important because all media provide us with a window back into the world we live in. AR does just this; it provides us with various windows into our world, and now an expanded frame that we can also step into and see around, navigating in 360 and multi-directions.

The Méliès Effect

I often refer to filmmaker & magician Georges Méliès in my talks and articles and named him the Patron Saint of AR in a special guest post for The Creator's Project [22](A partnership between Intel and Vice) on what would have been Méliès' 150th birthday last year.

At a time when cinema was about documenting actualities, magician and pioneer filmmaker Méliès extended the medium in incredibly novel ways to conjure impossible realities and define bold new conventions for film. Méliès imagined fantastical worlds in his films, where the marvellous reigned over the mundane, inanimate objects became animate, and forms forever shifted, disappeared and reappeared—nothing was fixed or impossible. Through the medium of film, Méliès created enchanted realities.

Méliès presented stories to embellish his latest effect; the narrative was driven by his toolkit, by the tricks he had at hand. Méliès's stories evolved from his investigation and exploration of the novel technology of cinema and the characteristics of the medium. He was a true explorer: embracing accidents and glitches in the newfound medium of film; he had the capability to look at mistakes and see the creative potential in them, not discard them as bad or wrong. In fact, this is how the stop-trick, also known as double-exposure, technique came to be: Méliès's camera jammed while filming the streets of Paris; upon playing back the film, he observed an omnibus transforming into a hearse. Rather than discounting this as a technical failure, or 'glitch', he utilized it as a technique in his films.

A prolific maker, creating over 500 films, Méliès contributed critical technical advances to the medium (fades, dissolves and animations), yet, what is of equal great importance is how Méliès did not stop at these technical achievements alone; he dedicated himself to

22 http://thecreatorsproject.vice.com/blog/celebrating-georges-m%C3%A9li%C3%A8s-patron-saint-of-augmented-reality

finding ways to use his technique to present compelling content. Perhaps the best way to summarize the ‘Méliès Effect’ in AR, as I’m labelling it, is in the words of John Andrew Berton Jr.: “Even though Méliès’s work was closely involved with the state of the art, he did not let that aspect of his work rule the overall piece. He used his technique to augment his artistic sense, not to create it” (7).

I interpret this as Méliès maintaining an artistry in the medium, being enthused by the possibilities of the technology and allowing the medium to guide his explorations and work, but not overrule it. Méliès serves as an inspiration to my creative practice and work in AR in that the technology inspired stories and the direction of the work, but he also gave himself the freedom of experimentation to move beyond the constraints and invent new ways of applying the technology. As such, Méliès introduced new formal styles, conventions, and techniques specific to the medium of film. This is the task at hand for AR pioneers and makers: to evolve novel styles and establish new conventions towards a language and aesthetics of AR.

Vertov

Dziga Vertov was a pioneer director and cinema theorist who is most famous for his 1929 film, *Man With a Movie Camera.* In *Kino-eye: The Writings of Dziga Vertov*, Vertov writes, “I, a machine, am showing you a world, the likes of which only I can see” (17). For me, the title of contemporary cyborg Dr. Steve Mann's keynote address from 1988, on the topic of wearable wireless camera, *I am a camera: Humanistic Intelligence is the medium; our everyday living is the message,* echoes Vertov's film and famous statement. Vertov's work and ideas are very relevant to the second wave of Augmented Reality (AR) that is emerging.

New media theorist Lev Manovich commences his seminal book *The Language of New Media* with stills from Vertov's *Man With a Movie Camera*. Manovich writes,

> Vertov systematically tried different ways to overcome what he thought were the limits of human vision. He mounted cameras on the roof of a building and a moving automobile; he slowed and sped up film speed; he superimposed a number of images together in time and space (temporal montage and montage within a shot). (xx)

This description reads very much like the attempts of Google Glass and augmented eyewear today inspired by Mann's early work to extend human vision. With Glass and other contemporary AR eyewear we can see superimpositions placed atop reality, using the camera to capture and share video and stills in new ways, from perspectives in motion and hands-free in real-time, that were previously not possible.

In addition to Manovich referring to Vertov's film being “a database of city life in the 1920s” and “a database of film techniques”, Manovich calls the film “a database of new interface operations”(xx). I concur with Manovich; Vertov showed us new ways of interfacing with reality via the camera, which AR is also now doing.

The opening titles in *Man with A Move Camera* read:

> Attention viewers: This film is an experiment in cinematic communication of real events without the help of intertitles, a story, or theatre. This experimental work aims at

> creating a truly international language of cinema based on its absolute separation from the language of theatre and literature.[23]

Unlike filmmaker Georges Méliès, who remediated theatre and stage magic performances in film, Vertov sought to separate film from prior forms. Vertov's intent was to create a new language distinct from theatre and literature, and this is critical as we now too move forward with AR as an emerging medium. In *Kino-eye*, Vertov writes, “As of now, theatrical productions transferred to film are no longer needed”, and I believe the same is true for AR (21).

Vertov states,

> I am kino-eye, I am a mechanical eye. I, a machine, show you the world as only I can see it.
>
> Now and forever, I free myself from human immobility, I am in constant motion, I draw near, then far away from objects, I crawl under, I climb unto them. [...]
>
> Now, I a camera, fling myself along their resultant, maneuvering in the chaos of movement, recording movement, starting with movements composed of the most complex combinations
>
> My path leads to the creation of a fresh perspective of the world. I decipher in a new way a world unknown to you (17).

Throughout the *40 Ideas* we see examples that pertain to Vertov's words above, with the camera and computer 'deciphering' and showing us our world in new ways before unknown to us, 'freed from human mobility', and extending into Artificial Intelligence and machine-learning processes. Like Google's patent for 'Seeing with your hands' (discussed in the section *Point of View: Object*), the camera can 'draw near, then far away' and even 'crawl under' to places previously not accessible to humans. As seen in Glass's promotional materials, Glass's camera can take us to literally new heights, soaring above the clouds in hot air balloons and skydiving, 'maneuvering in the chaos of movement', whereas projects like

23 http://youtu.be/ley9YIbra2U

OpenGlass and OrCam (also discussed in the section *Point of View: Object*) assist the blind to literally see' via crowd-sourcing (other people's eyes) and the eyes of sensors. Now is the time to leave previous medium's behind and enter a bold exploration of the new wave of AR as Vertov did with film.

Thing Theory

Although a genealogy of 'thing' theory can be traced back to Martin Heidegger, the use of Thing theory in this particular context, to invoke the Addams family, references the doctoral research of Sally Applin, Ph.D. candidate at the University of Kent. Here, Thing theory refers to an anticipatory agent that appears at the appropriate time to provide contextually relevant information to each person. In the article *Thing Theory: Connecting Humans to Location-Aware Smart Environments,* Applin and Michael D. Fisher discuss how Thing, the character from the Addams Family television program, is a model for smart agent behaviour and interaction. They describe Thing as managing needs, requirements and desires in the household presenting what “might be needed or desired at the precise moment required, in the precise room or context needed. Thing is not only a ubiquitous agent, but an anticipatory one that migrates within the environment” (1). Thing brings together Artificial Intelligence, machine-learning, calm technology, ubiquitous computing, cognizant computing, and contextual computing. These are all critical elements that will come together in the second wave of AR to define new user experiences that are highly personalized and anticipatory.

Applin and Fischer state,

> Thing learned about and possessed data knowledge of every member of the household, their preferences, needs and desires and was sensing and aware as to what type of contribution it could make to the successful outcome of their actions. It worked with their location and required nothing from them to be able to assist them, outside of their accepting its non-verbal limitation. Thing had sensors, data, and was location-aware. (2)

Thing is a model for the new AR smart agent that is highly aware and predictive, working away independently in the background to intimately understand the user's needs based on her dynamically changing environment, communicating continually with various sensors and contextual data. Applin and Fischer make the suggestion that developers will “have to think

like Thing in order to take into account how to manage the multiplexed communications, needs and messages that come from multiple sensors and actuators at different locations within the environment" (2). I agree that we will need both developers and makers of all kinds in AR, including designers and artists, to comprehend the intricate and sophisticated model Thing presents to create compelling AR experiences.

Applin and Fischer's description of Thing typifies a process of machine-learning. They write,

> Thing operates through observing, reasoning and then taking action. Thing's observations and reasoning are based on knowledge of the family that it has gained over time through understanding and learning what type of tasks they require assistance with on a regular basis. (2)

Thing theory, as applied by Applin and Fischer, is an important contribution to and glimpse into the next wave of AR, which will be focused on contextual experiences where relevant information, content, and experiences are anticipated and delivered in real-time based on a user's needs by closely learning the user: their patterns, likes, and behaviours. Who or what will we entrust to be our smart agent and deliver these experiences seamlessly?

Context-Aware Computing

The 1995 article, *Context-Aware Computing Applications* by Xerox PARC researchers Bill Schilict, Norman Adams, and Roy Want, couldn't be more relevant to where Augmented Reality (AR) is headed today. Gone are the days of gimmicks in AR; the immediate future of AR is in creating contextually relevant experiences. Context is king in AR, and, for me, as a researcher and practitioner, context is one of the central characteristics unique to AR that distinguishes it from prior media forms. Although written 18 years ago, Schilict et al. describe a mobile system that examines and responds to an individual's changing context. The authors note,

> Such context-aware systems adapt according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time. A system with these capabilities can examine the computing environment and react to changes to the environment (85).

The authors describe three important aspects of context, identified as “where you are, who you are with, and what resources are nearby you” (85). Environmental factors like noise levels, lighting, and social situations are also considered. Context-aware computing in AR also needs to take all of these dynamic and changing factors into account, not just location, and adapt to the unique scenario of the user. Schilict et al. describe a “set of places one wants to find out about: restaurants, night clubs, gas stations and stores, or more generically, exits and entrances” as one of at least three kinds or located-objects a user would want to make selections from (86). The authors propose, “Consider an electronic 'yellow pages' directory that instead of the subject divisions of information, sorts represented businesses according to their distance from the reader” (86). Mobile AR apps such as Yelp's Monocle and Layar presented this electronic yellow pages, revealing to users various points of interest including entertainment sites and restaurants in the user's geographic range through GPS.

Such apps only begin to scratch the surface of the possibilities of context-aware computing in AR. Aside from 'sets of places a user would like to find out about', the other two kinds of located-objects Schilit et al. identify are: 1. devices that require physical interactions like printers, displays, speakers, thermostats, etc. (perhaps predicting an Internet of Things) or people in the same room you would like to “beam” a document to. 2. non-physical object and services routinely accessed link bank accounts, menus, and instructions. Context-aware computing in AR will deliver what you need with timely relevance, not limited solely to points of interest.

In the article, *Towards a Blended Reality: Interview with augmented reality pioneer Thad Sterner*, Tom Foremski writes,

> When Google Glass figures out what I need, and when I need it – because it knows my physical context there will be no lag time, I'll get exactly what I need when I need it. I won't even need to go through a process of 'wanting' something, say my supermarket shopping list, because it'll know I'm in the supermarket and it won't let me pass by the tomatoes.[24]

Although Google Glass is not at this level yet, near-future AR devices, hopefully including Glass, will be able to deliver such contextual-aware computing experiences in AR taking into account things such as your your calendar and location, environmental, social and cultural factors, and your likes and preferences and those of your social networks.

24 http://www.zdnet.com/towards-a-blended-reality-interview-with-augmented-reality-pioneer-thad-sterner-7000018627/

Geo-fencing

Geo-fencing is one aspect of context-aware computing that is beginning to appear in Augmented Reality (AR). This is a powerful feature to be harnessed in AR when combined with time and user preferences. Qualcomm's Gimbal[25] platform for Android and iOS offers to deliver timely, personalized, push-notifications to users by combining location, time, and targeted audience profiles. Gimbal includes a geo-fencing feature that creates a virtual perimeter around a physical space. A scenario of a family driving home and past a newly opened pizzeria is used to illustrate how Gimbal works[26]. The mother's smartphone knows she and her family like pizza because of her recent purchase history. Her phone can also sense when she is about two minutes away from the pizzeria with the geo-fencing feature, and as they approach the restaurant, the Gimbal powered app detects the pizzeria and delivers a promotional family discount for her usual pizza order. Further, the deal includes a movie rental coupon inside the pizza box, again knowing the family's preferences and interests, to which she scans the coupon with her app, renting the movie instantly. Gimbal states that consumers will no longer have to deal with the annoyance of being bombarded by irrelevant advertisements.

Roximity[27] is another location-aware retail app that applies geo-fencing and works with Ford Motor Company's SYNC in-car computing system[28]. The Roximity app learns a user's interests and patterns over time, becoming aware of the types of deals and offers the user will find appealing. When connected to SYNC, Roximity can verbally relay deals in the area while driving.

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25 https://www.gimbal.com
26 http://www.youtube.com/watch?v=H-D3tT6TyF0
27 http://beta.roximity.com/

28 http://www.ford.com/technology/sync/

Both apps present coupons and deals in an advertising context to consumers. It is worth considering how else geo-fencing can be incorporated in contextually-aware AR. In regards to storytelling, geo-fencing can perhaps pick up where mobile cinema projects like GPS Film[29] (a movie revealed as the viewer travels through a location, with the story tied to the movement of the user) left off, linked to the viewer's likes and social networks to create an experience that integrates their life and personal reality (in the spirit of *Take This Lollipop*[30] by Jason Zada, an Interactive Live Action Facebook Connect experience).

29http://www.dshessels.com/artworks/gpsfilm/about.html
30http://www.takethislollipop.com/

EEG (Electroencephalography) Brain Computer Interface

To date, Augmented Reality (AR) has been primarily triggered by visual markers or location. But what if anything in the real world was a trigger through a direct brain computer interface? When asked on stage at AWE 2013 what the killer app for AR is, Dr. Steve Mann, father of wearable computing, simply responded, “Reality. It's about making your life better.” A brain computer interface could make 'Augmented Reality' just 'Reality' by using your thoughts directly to trigger an action and interact with and affect your environment. An example of this is a responsive room in which you can control the lights, curtains, and other elements directly with your mind. Companies like Emotiv[31] and Interaxon[32] have consumer based EEG headsets available for sale to the public. In her 2010 TED talk[33], Emotiv founder and CEO Tan Le showcased examples of real life-changing applications such as a mind controlled electric wheelchair. Le states in her talk,

> Our vision is to introduce this whole new realm of human interaction into human-computer interaction so that computers can understand not only what you direct it to do, but it can also respond to your facial expressions and emotional experiences. And what better way to do this than by interpreting the signals naturally produced by our brain, our center for control and experience.

Le demoed live on stage a wireless high-fidelity EEG acquisition system that required no scalp preparation, conductive gel or paste, with the headset costing only a few hundred dollars. The headset also featured cognitive capabilities which allow the user to move objects with his or her mind. While at AWE 2013, I experienced an Emotive EEG headset in conjunction with a demo created by AR company Daqri. I was able to move a virtual spindle in AR with my thoughts using the headset and an iPad with AR software using image detection. The demo, however, was gimmicky and did not represent the true power of EEG in AR.

31 http://emotiv.com
32 http://interaxon.ca
33 http://www.ted.com/talks/tan_le_a_headset_that_reads_your_brainwaves.html

Combining EEG with context-aware computing in AR would be a true feat, one that may await us in the near future.

Invoked Computing

A research group at the University of Tokyo has developed a concept for Augmented Reality called Invoked Computing[34], which can turn everyday objects into communication devices and computer interfaces. By having a gesture invoke the device you wish to use, you can activate any ordinary object to suit your communication needs. The user mimics a specific scenario, like using a telephone. In the demo video[35], the user picks up a banana and brings it close to one's ear; a computer then recognizes and grants the selected real-world object the properties of the tool the user wishes to utilize. A proof of concept has been created where a banana serves as a telephone, and a pizza box functions as a laptop computer.

Invoked Computing presents a scenario where new functions are now layered atop ordinary objects, which do not normally possess those traits. The banana is imagined and activated as a working telephone in one moment, returning to its inanimate state afterwards. *Wired* writer Bruce Sterling comments on how Invoked Computing affords the possibilities for sustainability and no material footprint because you can invoke and access everything[36].

Invoked Computing presents a world that is still rooted in physical objects, they are now just dynamic with changing states. The emphasis is placed on the action and output of the object, as opposed to the qualities of the object itself, which is designed for a specific, often single purpose. An industrial designer's job is to provide access to the completion of a task; how might Invoked Computing reframe and come to change industrial design and designing objects for specific purposes where any object can now perform any desired task? Rather than a collection of various electronics or appliances or tools, will a typical consumer now only need a few objects that could transform into any device as required, dependent on

34 http://www.k2.t.u-tokyo.ac.jp/perception/invokedComputing/
35 http://www.youtube.com/watch?v=ZA6m2fxpxZk#t=0
36 http://www.wired.com/beyond_the_beyond/2011/11/augmented-reality-university-of-tokyo-invoked-computing/

how many tasks they wish to perform simultaneously? Invoked Computing could further be combined with context-aware computing, Artificial Intelligence, and machine-learning to create a predictive and on demand device and interface scenario based on your location and needs.

Buildings That Shift and 4D Printing

The BBC's *Future Thinking* series asks, “What if buildings could adapt their shape and form – without any other input from us?”[37]Architect, computer scientist, and MIT lecturer Skylar Tibbits is profiled in a video interview discussing how 4D printing could make materials that build themselves. Tibbits states, “What if they could assemble themselves – and even change form if they needed to? The emerging technology of 4D printing – where 3D-printed material changes shape over time – means we may be able to build things that can adapt to our use or the environment around them”.

These ideas present a useful scenario for Augmented Reality (AR), one in which context and environment can shift the form and use of a building or object on demand. This concept pertains to Invoked Computing, as discussed previously, where an object can transform into the intended interface as needed on demand, and revert to its previous state when no longer required. Invoked Computing, however, is currently prototyped and conceptualized as a projection-based system. In Tibbits's concept, these functions are built into the object itself to enable it to grow and adapt, as opposed to an outwards projection or overlay.

Tibbits questions, “What if the world was about people, machines and materials that collaborate? Each one has new things to offer and we could have a much more rich conversation between those.” Effective AR will strive to be a real-time two-way conversation with the user's unique surroundings, the resources available in the environment, and the needs and background the user brings. AR will no longer be a gimmicky overlay, but a dynamic, meaningful, thoughtful, and responsive on-demand experience with the user in an ongoing conversation with his or her environment.

37http://www.bbc.com/future/story/20130709-buildings-that-can-make-themselve

Tibbits is also the Director of the MIT Self-Assembly Lab where his team has released something they call “4D printing”. In comparison to 3D printing, where static objects are printed, 4D printing adds the idea of physical parts that can change and adapt over time. He describes the fourth dimension as the idea of responding to time and printing something that is not static, but can evolve, and has a built-in resilience. Tibbits comments, “This is a whole new paradigm for how we make things. And a paradigm for after we make things, how they can be more resilient and adapt on their own.” He suggests we could potentially have more leaner structures that are elegant solutions which react dynamically to environmental activators, as opposed to over-engineered solutions that are extremely rigid.

Again, Tibbits's concepts are very interesting to imagine being integrated into an AR experience with the the ability for objects to have built-in adaptive behaviours, enabling them to grow and adjust as living responsive objects to situational changes. If we imagine this concept applied to architecture, a building could adjust in form, structure, and use, in conversation with the changing environment, including the people occupying and interacting with the building. For instance, the building could adapt in regards to weather, time of day, capacity of people, and social scenarios. Such a 4D printing system could change the way architects and engineers design and manufacture buildings, as 3D printing is now also shifting these practices.

3D Printing

The past several years have seen great advances in 3D printing, the process of printing a three-dimensional physical object from a digital model. Augmented Reality (AR) has the potential to further extend 3D printing in novel ways. In a recent demo video[38], AR hardware company Meta previewed a user sculpting a 3D digital model in open air through hand gestures while wearing the Meta AR Space Glasses. The user was then able to physically print the 3D model with a 3D printer. Such a scenario could enable anyone to be a designer without the need and knowledge of complex digital modelling software. (One would of course require such AR glasses and access to a 3D printer.) This could also create a more natural way to create objects to scale in physical space rather than on a computer screen, and be able to see what an object may actually look like in the environment, virtually, before printing.

AR developer Dekko has built an iOS app that enables users to scan real world objects and bring them into the game Minecraft as 3D digital objects (Minecraft allows players to build constructions out of cubes in a computer generated 3D world). On their website Dekko states, “Why spend months recreating a real world object in Minecraft when you can just scan it with your mobile device?”[39]

Minecraft.Print()[40] is a separate project by Cody Sumter and Jason Boggess in the MIT Media Lab which attempts to create a bridge between Minecraft and the real world using 3D printers. Now what if Dekko's app and Minecraft.Print() were combined in an AR app to scan the real world and print physical 3D models?

38 https://www.youtube.com/watch?v=b7I7JuQXttw
39 http://www.dekko.co/tag/minecraft/

40 http://www.minecraftprint.com

To take this idea further, what if a digital 3D object and a physical printed 3D object could coexist and mirror each other, where the physical object grew and changed with the digital one? Such a concept could become a reality in AR applying the 4D printing method Skylar Tibbits discussed in the section *Buildings That Shift and 4D Printing*, where the 3D printing process is extended to add the idea of parts that can change and adapt over time, in printing something that is not static, but can evolve, and has a built-in resilience. This could have potential uses in fields such as medicine and education for students to monitor how a disease or condition functions, affecting it both virtually and physically.

Synesthesia

Artist Neil Harbisson is a self-proclaimed “Human Eyeborg”. He was born colour-blind with a rare visual condition called achromatopsia, but using a special device attached to his head, he is able to turn colours into audible frequencies. In his 2012 TED talk entitled, *I Listen To Colour*[41]*,* Harbisson discusses how he is able to “hear a symphony of colour” and listen to faces and paintings. He describes how he has never seen colour and has always lived in a greyscale world. Since 2003, he has been able to hear colour instead due to an “electronic eye” developed in collaboration with computer scientist Adam Montandon. This electronic eye is a colour sensor that detects the colour frequency in front of him. The frequency is then sent to a chip installed in the back of Harbisson's head and he 'hears' the colour through bone conduction. He recounts how he at the beginning had to memorize the names and notes for each colour, but after time, “all this information became a perception” and after some more time “this perception became a feeling.” Harbisson began to “dream in colour”, a point in time when he states to have “felt that the software and my brain had united, because in my dreams, it was my brain creating electronic sounds. It wasn't the software, so that's when I started to feel like a cyborg. It's when I started to feel that the cybernetic device was no longer a device. It had become a part of my body, an extension of my senses.”

The Merriam-Webster dictionary defines synesthesia as, “a subjective sensation or image of a sense (as of colour) other than the one (as of sound) being stimulated”. Harbisson describes how hearing colour has changed the way he experiences the world stating such cases as how he now dresses in a way that “sounds good”, and how he has taken on a whole different approach to food (he can eat his “favourite song”). He can hear and compose music with food, stating, “Imagine a restaurant where we can have Lady Gaga songs as main

41 http://www.ted.com/talks/neil_harbisson_i_listen_to_color.html

dishes, and some Bjork or Madonna desserts”. Such a synesthesic approach in Augmented Reality (AR) could radically change the way we tell stories through AR as full sensory experiences the average person has not been able to previously encounter.

Harbisson also describes how he added infrared and ultraviolet to the colour-to-sound-scale so that he may hear colours which the human eye cannot even perceive. (This is reminiscent of Mann's infrared glasses which enabled him to see in spectral bands and making the invisible visible, as described in the section “Augmented Reality Glasses”). Harbisson mentions how a positive aspect of perceiving ultraviolet through sound is due to the fact that ultraviolet is a dangerous colour that can kill and you can hear if it is a good or bad day to sunbathe.

He also states how this has changed the way he perceives beauty because he now hears someone's face. Harbisson describes how someone might look very beautiful, but sound terrible, with the opposite also being true. He comments on how some people that he would never relate sound similar. For instance, Prince Charles has similarities with Nicole Kidman because “they have a similar sound of eyes”.

Harbisson presents a way that cybernetic aids can augment our reality. They can help us to see the world in a whole other way by hearing it and revealing similarities and differences between people and objects that would not otherwise be perceptible to the naked eye. Harbisson poetically exemplifies through his synesthetic experiences how that which is seemingly ordinary can be experienced as extraordinary and revealing further truths to help us see how things are relatable that might not otherwise be obviously so, and in turn seeking to enrich and better our lives through new found knowledge.

Empathy

In the article “Mediated Reality”, in the *Linux Journal,* Dr. Steve Mann describes Mediated Reality and his WearCam eyewear in 1999 as enabling a finely customized visual interpretation of reality unique to the needs of each individual wearer. Dr. Mann describes how these highly personalized experiences could allow for a different interpretation of the same visual reality. He states, “Just as you would not want to wear undergarments or another person’s mouth guard, you may not want to find yourself wearing another person’s computer” (1). Years ago as I read this I often thought, perhaps in the future you will want to filter your reality through someone else’s perspective, be it a friend in a social network, someone you admire or idolize, or perhaps even a complete stranger. By enabling someone to see the world through another’s eyes via Point of View (POV), Augmented Reality (AR) can also be applied as a tool to build empathy, which could serve various benefits from conflict-resolution to design thinking (empathy is a trait of a good designer).

Transcendenz[42] is a conceptual AR video that is driven by creating an empathetic experience for the user in AR. In the video, we see the main character enter the 'Empathy prism', where he is surprised by how everyone quite literally resembles him, taking on his physical appearance. The narration is translated: “It’s amazing how a perfect stranger can suddenly seem so familiar. It’s as if one would project our own life on others and even the most annoying persons [sic] now make us smile.” Transcendenz is depicted as a tool to enable empathy not only towards other human beings, but to nature and our environment as well. Philosopher Immanuel Kant is referenced in the narration, “Empathy is not only about projecting ourselves on our fellows, but also on the world around us.”

42https://vimeo.com/25771444

In his 2005 TED talk, Paul Bennet, Creative Director at IDEO, detailed how his company was asked by a large healthcare system in Minnesota to describe to them what their patient experience was[43]. He recounted how his team showed the client a six minute film of a ceiling, shot by one of his colleagues while laying in a hospital bed, to communicate what it's like to be a hospital patient, by showing a direct point of view. Revealing such perspectives resulted in inspiring empathetic solutions by the hospital.

Empathetic design is central to what IDEO does as a company. IDEO is well known for their approach to design by first empathizing with the end user to step inside their shoes to really understand how the service or product will be used. One can imagine how AR could be a useful design tool in such a process, to actually be able to see the world through someone else's eyes and better understand how they live their daily lives. Google Glass could be one means by recording video of an event, or having a live Google hangout seen directly through a first-person point of view to inspire empathetic design solutions. AR could be used to further layer in real-time what potential design scenarios could look like and how they could be applied.

43 http://www.ted.com/talks/paul_bennett_finds_design_in_the_details.html

Haptics and Touch

To date, Augmented Reality (AR) has focused primarily on the visual, leaving the other senses behind. Incorporating a sense of touch and tactile feedback through haptics in AR can help to greatly heighten the sense of the 'real' when interacting with virtual content and enrich the overall experience. Haptics in AR enables the user to feel a multitude of textures and surfaces that are unique to the context and can also be altered to the individual or scenario.

In August 2011 I had the pleasure of visiting the Magic Vision Lab[44] at the University of South Australia and the opportunity to experience their AR haptics demos. Wearing a head-mounted display (HMD) and using a Phantom Stylus tool, I could feel the scales of a virtual fish which appeared before me. I was able to touch virtual objects and receive tactile feedback, as though these were real, physical objects I was interacting with. This completely threw off my sensibilities of the real, having difficulty distinguishing between what was real and what was virtual. This experience signified an important shift for me in the medium of AR: in the past, the only tactile component of AR was that which physically existed in our environment.

I was fascinated by the sense of touch and tactile feedback paired with AR; however, I was left desiring a more direct interaction in this experience, without the HMD or stylus. Touch technology like Senseg[45] for tablets, which premiered at the Consumer Electronics Show (CES) in 2012, has promise. If we can merge this with AR, I truly think it can be a game changer and help push the medium forward in new important ways that are currently absent. Bring primarily a vision-based medium; we have yet to really augment touch in AR and we can't ignore these other very 'real' senses for much longer.

44 http://www.magicvisionlab.com/
45 http://www.senseg.com/

Dave Rice, Vice President of Senseg, discusses the technology as adding tactile effects to touch screen displays including smart phones, tablet computers, touch pads and gaming devices. He discusses the possibilities for gaming applications (I personally think this would be incredible to apply to storytelling as well) and describes a treasure hunt game in which a treasure chest is hidden and can only be found by feeling around on the screen. Dave says, “There were no visual cues there and that’s pretty exciting because now we can move to the world of feel to complement what you’re seeing, or to work independently from it and really create a new world to explore.”[46]

For me this perfectly describes future possibilities and potential in AR. I think about this last quote and how it applies to my AR Book “Who’s Afraid of Bugs?”[47], the first AR book designed for iPad. For me the next step in this book is to be able to touch and feel the texture of the virtual spider that magically appears. Imagine touching the spider and feeling each tiny hair. Haptics and tactile feedback could change the future of education in AR to enrich the experience and really bring the curriculum alive.

A Brief Rant on the Future of Interaction Design[48], is a very relevant and excellent article in which Bret Victor asks us to aim for a “dynamic medium that we can see, feel, and manipulate”. Bret’s article immediately resonated and I shared it with the AR community at the time as something important we needed to be aware of and really work towards.

Victor emphasizes the use of our hands to feel and manipulate objects. He writes, “The sense of touch is essential to everything that humans have called ‘work’ for millions of years.” “Now, take out your favourite Magical And Revolutionary Technology Device. Use it for a bit.

46 http://youtu.be/FiCqlYKRlAA

47 http://augmentedstories.wordpress.com/2011/06/27/new-work-first-ar-pop-up-book-for-ipad-2-and-iphone-4-using-image-recognition/

48 http://worrydream.com/ABriefRantOnTheFutureOfInteractionDesign/

What did you feel? Did it feel glassy? Did it have no connection whatsoever with the task you were performing?" Victor calls this technology, "Pictures Under Glass", noting that it sacrifices "all the tactile richness of working with our hands".

One example in haptics includes REVEL[49], from Disney Researchers Ivan Poupyrev and Olivier Bau, which applies reverse electrovibration to create the illusion of changing textures as a user sweeps their fingers across a surface. REVEL can provide tactile feedback both on a touchscreen, or, quite wonderfully, on the physical object itself (without the use of a virtual glove or stylus). This haptic technique can even be applied to projections. Also from Disney Research is a project called AIREAL[50], which delivers tactile sensations in the air without having to wear or touch a physical device. This is done by stimulating the user's skin with compressed air pressure fields using air vortices (rings of air) enabling users to both see and feel projected images. Depth image sensors are integrated into the AIREAL design, with the user's hands, head and body tracked in 3D for interaction. For example, a projected 3D butterfly can be displayed hovering on the user's hand. The motion of the user's hand and arm is tracked by AIREAL and the direction of the vortices are adjusted to to match the movement of the butterfly's wings. Early user feedback documented in the paper, *AIREAL: Interactive Tactile Experiences in Free Air*, 2013, indicated that "the interaction provided compelling physical sensations of the virtual butterfly", with one user describing it as, "it feels natural, it feels like a butterfly should feel." (7).

Now, imagine, what would it be like to feel scenes in a projected film? What new tropes and stylistic motifs might emerge in such a genre? Will there be an AR director of our times who will become known for their unique sensibilities and style of touch in haptics? How will haptics help to heighten immediacy in AR and create more realistic experiences?

49 http://www.disneyresearch.com/project/revel-programming-the-sense-of-touch/
50 http://rsodhi.com/?portfolio=aireal-interactive-tactile-experiences-in-free-air

Taste and Smell

Augmented Reality (AR) has primarily focused on the visual and auditory senses to date; however, there have been a few projects exploring olfaction and taste. *Meta Cookie*, from the University of Tokyo[51] combines an interactive olafactory display with plain edible cookies that have AR markers printed on them. The olfactory display is combined with a see-through head-mounted display that allows the user to view various cookie selections in AR (with different cookie textures and colours layered atop the actual cookie ranging from chocolate to strawberry to lemon). Once the desired cookie to be eaten is chosen by the user, the air pump produces a scent of the preferred cookie to the user's nose, creating the effect that the user is eating a flavoured cookie, albeit it is actually plain. Don't like the taste of the cookie you chose? Take another bite and have it transform into another flavour. *Meta Cookie* presents the opportunity for a Mediated Reality, to use Dr. Steve Mann's term, to transform one's environment based on personal preference, in this case by manipulating one's perceptions through a combination of vision and scent, culminating in taste. How can the principles of Meta Cookie's olfactory display be applied to other areas such as entertainment, storytelling, and even hospitality and tourism in AR?

Invented by Hans Laube, *Smell-o-vision*, debuted at the 1939 New York World's Fair. It wasn't until 1960 that the producers of the film, *The Scent of Mystery*, contracted Laube to bring the technology to the movie theatre, releasing scents to individual seats. Ads for the film referring to the progression and innovation of cinematic technology read: “First they moved (1895)! Then they talked (1927)! Now they smell (1960)!”[52] We are just beginning to explore the possibilities of scent in AR's progression to a more fully immersive sensory experience.

51 http://youtu.be/3GnQE9cCf84

52 http://www.wired.com/table_of_malcontents/2006/12/a_brief_history/

The Dead Man's Nose[53], created by Stuart Eve, is a prototype of a smell delivery system in AR that wafts scents to your nose based on your location through GIS data using an Arduino microcontroller. *The Dead Man's Nose* creates smellscapes to augment an archeological experience, combining spatial audio sounds that get louder or quieter depending on the user's location in the settlement paired with various smells as the user walks around the site. Eve describes the experience: “Not only can I walk around the modern day Bronze Age landscape and see the augmented roundhouses, hear the Bronze Age sheep in the distance, I can also smell the fires burning and the dinner cooking as I get closer to the village.” Dead Man's Nose uses scent as a storytelling tool and means to further immerse a user in an environment and recreate a scene through simulation.

Olly The Smelly Robot [54]uses a small fan attached to an Arduino microcontroller and a USB plugged into your computer to trigger scent when you get a social media mention, receive a comment on a post, or any other notification. Different smells can be triggered for different notifications. Although scent can be aggressive to some, Olly can perhaps provide a more gentle notification process than the typical beeps and noises that can interrupt us when we normally receive an alert.

Taste and smell in AR can help to extend a further personally mediated reality ranging from storytelling to notifications in creating an immersive environment that does not rely on vision alone. A scent itself can carry with it memories and built in stories that are highly contextual to each individual. One of the things that AR does well, and distinguishes it from other media, is contextual communication. Scent is an unexplored territory of contextual experiences in AR and perhaps one that we will see evolve in new ways through interactive

53http://www.dead-mens-eyes.org/archaeology-gis-and-smell-and-arduinos/

54http://www.ollyfactory.com

television and AR cinema experiences.

Point of View: Object

Concepts like the *EyeRing*[55] by MIT researchers and Google's patent for 'Seeing With Your Hands' present other means of interacting with Augmented Reality (AR) and computer vision aside from the human eye, and can assist in navigating and conveying information about a specific environment or location. EyeRing can aid the visually impaired to have a form of sight: A camera, worn on the finger as a ring, identifies and recognizes images, colours, and text, transmitting data to a smartphone where an application transforms the collected information into a digital voice. In addition to assistive technology for the blind, the researchers suggest a 'tourist helper' application where the name of a landmark is heard once pointed at with the device. Google's "seeing with your hands" patent[56] describes a glove for gathering and conveying information which enables "a user to 'see' an inaccessible environment" by wearing a device on one's hands (or "other areas of the body" including a foot, hip or back) equipped with "detectors". The device may record a series of images and then display those back to the user.

Although Google Glass is not specifically referenced in the patent, a wearable display that is remote from the glove is mentioned. One can imagine the device being paired with Glass as a possible display. The patent repeatedly refers to predetermined motions, which could serve to combine gesture with AR. One of the motions detailed is a zoom function, which could enable highly magnified views of the user's environment, that might previously have been deemed "inaccessible". In this way, the micro can be transformed into the macro, making better visible that which was prior invisible.

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55 http://youtu.be/e20c6jdTiLc

56 http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/PTO/srchnum.htm&r=1&f=G&l=50&s1=8,248,364.PN.&OS=PN/8,248,364&RS=PN/8,248,364?ystfuv

The Vimeo user Kogonada[57] posted a wonderful series of videos surveying filmmaking tropes in 2012. A montage of stylistic motifs from the oeuvre of various directors are cleverly curated, including one-point perspective from Stanley Kubrick[58], Quentin Tarantino's 'framing from below'[59], and 'shots from above' by Wes Anderson[60]. Kogonada's Breaking Bad's object POV aesthetic[61] is particularly relevant here and is a visual motif in AR that may emerge. This also pertains to the concept of an Internet of Things and responsive objects watching us directly.

DapperVision is a company working on *OpenGlass*, a system of tools and services which can assist visually impaired users in identifying objects via Google Glass and knowing what is in front of them in real-time through crowd-sourcing[62]. There are two primary components that comprise the system: A Question-Answer system which sends photos taken by the user via Glass with a question stated and uploaded to Twitter or Amazon's Mechanical Turk for the public to assist in identifying, and an app called *Memento* that takes video from Glass and uses image matching to identify objects from a database[63]. The information about what the visually impaired Glass wearer "sees" is then read aloud to the user via bone conduction. Another assistive technology for the blind is from an Israeli company called OrCam[64] using a sensor that sees what is in front of you and provides the information through a bone-conduction earpiece. The technology can read any printed text in real-time, recognize objects and people, and help you navigate to a desired location.

Dr. Steve Mann has always said that AR should help us to see better and to live better

57 http://vimeo.com/kogonada
58 http://vimeo.com/48425421
59 http://vimeo.com/37540504
60 http://vimeo.com/35870502
61 http://vimeo.com/34773713
62 http://www.techisforgeeks.com/2013/08/openglass-app-helps-blind-users-see/#ixzz2m4Q9fPRk
63 http://gizmodo.com/two-monumental-ways-google-glass-could-help-the-blind-1001958958
64 http://www.orcam.com

lives; OpenGlass and OrCam clearly have the potential to make a substantial impact on bettering lives by assisting the blind. Other examples noted in these pages have included ways of extending the senses and even going beyond human capabilities. The second wave of AR is pushing beyond vision to help us 'see' and know our environments better, enhancing the way we interact with the world.

Electroreception: Seeing and Hearing With Your Tongue

Gershon Dublon, a doctoral student and Research Assistant at the Responsive Environments Group at the MIT Media Lab, has created the *Tongueduino*, which is an inexpensive three by three electrode pad that rests on your tongue, running through an Arduino controller and connected to environmental sensors. The sensors can register anything that can be converted into an electronic signal such as electromagnetic fields, visual data, sound or ambient movement. By augmenting the body through such senses, such a system could, in theory, allow deaf or blind users to hear or see with their tongues.

In the CHI Conference on Human Factors in Computing Systems paper, *Tongueduino: hackable, high-bandwidth sensory augmentation,* Dublon writes, "Through Tongueduino, we hope to bring electro-tactile sensory substitution beyond the discourse of vision replacement, towards open-ended sensory augmentation that anyone can access." He provides the examples of the system being connected to a magnetometer, to provide "a user with an internal sense of direction, like a migratory bird" as well as being connected to whiskers, which could allow the user to sense orientation and even the lightest touch.

Similar in concept to the Tongueduino, the *BrainPort V100*[65] by Wicab Inc. also incorporates sensor pads on the tongue, but it is connected to a video camera mounted on a pair of sunglasses. The tongue array contains 400 electrodes and is connected to the glasses by cable. White, black, and grey pixels from the camera are felt on the tongue at different stimulation levels as pictures that are painted on the tongue with small bubbles. The BrainPort V100 is an assistive tool that has been tested by individuals with no vision, both congenitally blind and with acquired blindness.

The primary purpose of augmenting such senses via the tongue would be as an

65 http://www.wicab.com/en_us/

assistive tool for the blind or deaf. Such systems would enable extra-human abilities; electroreception is a biological ability to perceive electrical impulses found in the animal kingdom. Dublon asks, “Sharks have electroreception why can't we?” Such systems could be extended to tell new types of stories and experiences that engage senses in AR in extra-human ways.

The Armchair Traveller

In August 2013, Italian beverage brand San Pellegrino partnered with advertising agency Ogilvy NY to allow users to take a quick virtual vacation to Italy, travelling remotely to explore the village of Toarmina, Sicily, in real-time. Users logged in to a Facebook app, which allowed them to access five robots on the ground in Italy from around the world and to drive a robot around the village live-streaming the view of town and interactions with the locals. Each of the robots was equipped with a tablet displaying the user's Facebook profile photo. A two-way translation program with an audio and video connection allowed participants to speak with local residents. Writer Anthea Quay authored an article about the project,*The First Robots That Let You Explore Italy From Your Living Room*[66]*,* of which the title for me recalls the Victorian concept of the 'Armchair Traveller', which the stereoscope popularized. In 1859, American physicist and stereoscope enthusiast Oliver Wendell Holmes wrote about his stereoscopic travels in *The Stereoscope and the Stereograph*, describing a virtual experience of venturing to distance lands without leaving the comfort of his arm-chair:

> I stroll through Rhenish vineyards, I sit under Roman arches, I walk the streets of once buried cities, I look into the chasms of Alpine glaciers, and on the rush of wasteful cataracts. I pass, in a moment, from the banks of the Charles to the ford of Jordan, and leave my outward frame in the arm-chair at my table, while in spirit I am looking down upon Jerusalem from the Mount of Olives. (738)

In the article, *Armchair Traveller On the Ford of Jordan*, media theorist Erkki Huhtamo discusses the stereoscope noting that its “main subject matter was from the beginning the outside world - monuments, picturesque landscapes, well known touristic sites, distant and exotic lands”[67]. Huhtamo also notes that “the stereoscope established a virtual channel delivering the outside world to the inside” referencing the slogan of Underwood & Underwood (a major stereoscopic company), “The Stereoscope becomes the connecting link between

66http://designtaxi.com/news/360024/The-First-Robots-That-Let-You-Explore-Italy-From-Your-Living-Room/
67http://www.mediamatic.net/5910/en/armchair-traveller-on-the-ford-of-jordan

home and the place you wish to see.” Underwood & Underwood even began marketing 'Travel Systems' or 'Tours of the World', which consisted of sets of cards, maps, and guide books, which accompanied the stereoscopic viewers.

The San Pellegrino app certainly echoes and even remediates these early stereoscopic experiences of travelling to distant lands without leaving the comfort of one's home, now improving upon the experience by enabling an interaction beyond a static photograph (like the stereoscope viewings) and allowing one to move through and navigate around the destination in real-time; Augmented Reality (AR) could be used to extend such applications to create contemporary Armchair Traveller experiences.

Human Body as Touchscreen Replacement

Sean Gustafson, Bernhard Rabe, and Patrick Baudisch from the Hasso Plattner Institute in Germany have designed an “imaginary” user interface that is situated within the palm of the user's hand[68]; the User Interface (UI) is "imaginary" as there is nothing beyond the naked hand, such as a projection or visual digital layering. A mobile phone could be fitted onto the user's left hand with a specific mobile function activated as each point on the hand is touched. For the proposed system to work, the computer must know what part of the hand the user is touching and the user also needs to be able to hear the computer via a means such as an earbud. The design is not discussed in regards to Augmented Reality (AR), however this would be an ideal system to integrate into AR eyewear that is equipped with a camera and earbuds or hearing through bone-conduction.

Experiments were conducted by Gustafson and his fellow researchers to determine how well such 'self-touch UI' was used. When tested under normal use, research subjects were shown to be equally fast choosing functions from a regular touchscreen phone and from the palm-based system. It is interesting to note that users who were blindfolded were twice as fast when touching their own hand on the palm-based system as the regular touchscreen phone. The information gathered on non-sighted use is of interest and relevant to accessibility and assistive techniques for the blind as well as scenarios in which users encounter a moment when they are unable to look at their phone, or even don't want to be taken away from what they are doing (having technology interrupt their human interactions).

Researchers Roman Lissermann, Jochen Huber, Aristotelis Hadjakos, and Max Mühlhäuser from the Technical University of Darmstadt in Germany have created a prototype called *EarPut,* which proposes another human body touchscreen replacement other than

68 http://www.nngroup.com/articles/human-body-touch-input/?utm_content=buffer951cb&utm_source=buffer&utm_medium=twitter&utm_campaign=Buffer

touching your hand. The researchers identify possible interactions including: Touching part of the ear surface; Tugging on an earlobe (suited to on-off commands); Sliding your finger up or down the ear (suited to volume control); and cover the ear (suited as a natural gesture for mute). Again, this is a UI that could be connected to an AR device for interaction.

Glass currently uses commands that tap the side of the device. As AR devices become smaller, lighter, and perhaps even embedded within the body through various chips and sensors, using the human body, such as the ear or hand, as a UI touchscreen replacement can bring us closer to a more 'natural' and direct AR experience where our body is more deeper immersed as opposed to being interrupted by a screen, which can act as a barrier (to break the illusion).

Spatial Augmented Reality (SAR) and Projection-based Augmented Reality

In Spatial Augmented Reality (SAR) there is no need for a head-mounted display or Augmented Reality (AR) eyewear as the AR content is rendered and projected directly onto the scene or environment. SAR enables multiple users to experience AR simultaneously in a shared view; all users see the exact same virtual information (whereas with a smart phone or AR glasses, the experience may not be synced between users); AR, for the most part, has been a single-user experience. SAR requires physical objects to project onto, which allows for users to get tactile feedback if interacting with SAR since they are touching an actual object with a digital projection rendered and aligned atop it. The Wearable Computing Lab (WCL) at the University of South Australia in Adelaide, Australia is the primary research lab focusing on SAR, which I had the pleasure of visiting and experiencing their demos first hand in 2011. One of the research projects at WCL looks at how SAR can be applied in the design process of creating a prototype for a device. Complex components, such as dials or buttons are projected directly onto the surface of a blank prototype. The user's fingers can be tracked to allow interaction with any of the components for testing, allowing the user to press virtual buttons, turn virtual dials, and move virtual sliders. SAR enables a collaborative design process in this sense and one that is physically to scale and tactile. Moveable objects can also be projected onto providing there is a tracking system. Further, 3D printing can be combined with SAR to provide the ultimate design process prototype.

WCL lists various examples where SAR can be integrated into design and real-world industrial design projects that the lab is currently working on including: command and control centers on submarines and ships, as well as mining and gas operations, hospital operating theatres, and interior design[69]. Some of the benefits listed in approaching design with SAR

69 http://www.qualcomm.com/media/documents/user-interfaces-spatial-augmented-reality

include: a natural manner for viewing designs, stake-holder buy-in for major decisions, and early ergonomic measurements. In addition to design processes, I can envision SAR being taken one step further with Invoked Computing principles and being able to actually utilize the said product or device on demand.

Dynamic Brand Identities

In April 2013, Fast Company published an article profiling design firm IDEO and the future of brand identities. The article included a query of what a 'responsive identity' would look like in Augmented Reality (AR), asking the reader to imagine 15 years into the future where one is wearing Google Glass 3.0 (offering something much closer to true AR), and commerce has kept apace in this new hybrid world. The question, “What does the logo on that Starbucks look like?” is posed. This is one of the things Michael Hendrix, Director of IDEO's Boston studio, hopes his designers will start to consider for the future. Hendrix states, "We haven’t had to think about responsive identities. We haven’t had to think about time or space. And I think those will all become more important dimensions." I tend to agree; logos and brand identities will no longer be static in this dynamic world of interactive imagery and hybrid multimedia elements in AR.

Hendrix identifies some of the challenges as, “"How do you express a mark physically and digitally? What kind of life does it have? How is it born in that moment, and how does it go away? How does it tell you why it’s there?” Hendrix is getting at something that becomes a living object, at once digital and rooted in the physical world and potentially shape-shifting. These questions, qualities, and challenges also relate to the discussion on Invoked Computing. Perhaps logos and brand identities in AR will be called upon or activated when needed and not tied to a particular object. The question of context is also a very important one. Context is referenced in the article, but it is unfortunately separated from the topic of AR and not tied in where it is of utmost relevance. Hendrix describes the role of context in a brand identity in general stating,

> There’s you, the person, and you have your full identity in yourself, but you know contextually when to wear certain things. You might wear one thing to a funeral, you might wear one thing for a Saturday night. You understand those contexts. And those

> never change your identity, so to speak, but they do start to communicate some kind of intent. And that's what we're trying to figure out right now. How do you create some kind of contextual mirror to create intent?[70]

Creating a contextually adaptive brand identity in AR would be a truly responsive identity that mirrors the environment it appears in and hence becomes more relevant and integrated into the changing context.

70 http://www.fastcodesign.com/1672363/to-create-the-future-of-brand-identity-ideo-looks-inward?utm_source=twitter#1

Ghosting

Eidos[71], created by a team of designers from the Royal College of Art, London, is a prototype mask that uses off-the-shelf sensors and custom software to augment the vision and hearing of its wearers. In addition to the ability to isolate and amplify audio signals of the user's choice, the glasses display “ghosted” images of objects in motion. Clive Smith, one of the Eidos designers, states, “The vision device gives a similar effect to long-exposure photography, revealing otherwise hidden traces of movement, but it does this live.”[72] Smith furthers that this is “remarkable at revealing patterns” one wouldn't normally realize. The Eidos team provides such use examples as sports coaches applying this technology to help players improve their form in real-time rather than post-game, and choreographers adding special effects to their performances.

Eidos ghosting technique echoes photographic innovation from the Victorian era including Eadweard Muybridge's work where he utilized multiple cameras to document motion in stop-action photographs, as well as Étienne-Jules Marey, who developed a means to record several phases of movements in one photo; however, Eidos occurs in real-time, with a ghosting effect and motion layered and viewed directly atop reality. Further, the work is reminiscent of Marcel Duchamp's 1912 painting *Nude Descending a Staircase (No.2)*[73], depicting a figure in some twenty different successive still positions to represent and map the movement of the human body through space (the painting may have been influenced by Muybridge's chronophotograph, *Woman Walking Downstairs,*1887).

Eidos further advances and combines historical and artistic innovations in capturing and representing speed and movement, including the human body, slowing down live motion

71 http://timbouckley.com/work/design/eidos.php
72 http://www.wired.com/design/2013/07/eidos-sensory-enhancement/#slideid-154191
73 http://www.philamuseum.org/collections/permanent/51449.html

in real-time with the possibility of both artistic and practical applications in Augmented Reality (AR).

Non-Traditional Gaming

The concept video for *Transcendenz*[74], as mentioned in the section on Empathy, shows the user entering the Empathy prism through the act of meditation. The program indicates to the user, “You’re too excited to enter the interconsciousness. Try to meditate a bit.” We can think of *Transcendenz* as an Augmented Reality (AR) game in which you enter various levels controlled by your reaction to your environment through a slower pace as opposed to the typical high speed action of video games like first-person shooter games. A couple of references here enter my thoughts. Firstly, non-traditional video games developed at USC’s Game Innovation Lab including Cloud, Journey, Flower[75], and Bill Viola’s The Night Journey[76]. Game designer and lab director Tracey Fullerton describes[77] these experimental games as, “the possibility of a game mechanic that expressed peacefulness, wonder and awe” as well as enlightenment. The core mechanic in Bill Viola’s PlayStation 3 game is described in his artist statement as “the act of traveling and reflecting rather than reaching certain destinations – the trip along a path of enlightenment.” I view this description as parallel to the mechanics and design intent of *Transcendenz*. It is interesting to consider what kind of aesthetic and direction AR games may take on if such a mechanic is followed and applied as opposed to the current direction, which are predominately AR first-person shooter games.

The second reference I think of is Ian Bogost’s latest book, *How to Do Things with Video Games* and his chapter on “Relaxation”, particularly as he refers to lean back and lean forward media in relation to video games. Bogost distinguishes how leaning forward “requires continuous attention, thought and movement” and leaning back is associated with relaxation and passivity (he even mentions gluttony). He writes, “To relax through a game requires

74 https://vimeo.com/25771444
75 http://thatgamecompany.com/games/
76 http://www.thenightjourney.com/statement.htm
77 http://www.tracyfullerton.com/assets/ReflectionsonTheNightJourney_tfullerton.pdf

abandoning the value of leaning forward and focusing on how games can also allow players to achieve satisfaction by leaning back" (167). *Transcendenz* leans back in a state of relaxation and enlightenment, yet simultaneously asks the user to lean forward and not abandon that state, to actively engage with their environment and be present, immersed and interactive. The core mechanics of *Transcendenz*, comparable to Viola's *The Night Journey*, are an exploration, reflection and action through emotional experience to transform the user / player — and, after all, isn't this what designing AR experiences should be about: engaging the viewer in meaningful, contextual, interactive learning experiences which are rooted in the real world?

Journalism

The Fast Company article, *How Vice Hacked Google Glass To Tell Crisis Stories*[78], highlights how Vice reporter Tim Pool uses Glass to tell stories from around the world. Pool identifies Glass as being the biggest change to his reporting toolkit since the iPhone. With Glass, Pool is able to shoot live-streaming footage for Vice.com and share photographs immediately from the thick of volatile demonstrations and other newsworthy events. Glass provides a means of communicating with his producers from thousands of miles away, as well as the ability to speak to locals who don't comprehend English (by means of Glass's translation capabilities). Further, Pool is able to remotely access his desktop while on the ground in action, have necessary files displayed in his field of vision, and bring up any needed files to consult on the background of a story. Pool states that Glasses's Point of View (POV) camera allows him to maintain his focus, “When I'm running, having my hands free is particularly important. When things get intense with plastic bullets, I don't want to stare at a camera, I just hit record.” Pool's public photos taken with Glass are instantly posted to his Google+ account, which in turn makes it easier for the Vice team to assemble articles.

Looking at Augmented Reality (AR) as a useful tool to enable storytellers to document, share, and report on events is a new approach as AR until now has largely focused on outputs (like video overlays in newspapers or magazine) as opposed to an actual process to produce and generate content and as a means to create professional work. Manufacturing, instructional guides, and repair have been clear arenas for AR as tool for annotation, with cases for Journalism beginning to emerge.

Pool's account of Glass and usefulness is mainly attributed to the hands-free camera and ease of documenting and sharing photos and data, as opposed to any real AR

78 http://www.fastcolabs.com/3015109/how-vice-hacked-google-glass-to-tell-crisis-stories#1

capabilities, aside from the real-time language translation aspect. What other AR aspects could be added to Glass and other AR eyewear to create a strong reporting toolkit and process? Tapping into location, context, voice, and facial recognition could further assist journalists's productivity and thoroughness, allowing for a richer story to be unveiled.

Memory

How will Augmented Reality (AR) come to affect human memory?

In July 2013, researchers at the RIKEN-MIT Center for Neural Circuit Genetics and MIT's Picower Institute for Learning and Memory incepted false memories into mice[79]. In previous work, The researchers had detected a single memory in the brain in previous work and genetically tagged the brain cells housing that memory with a light-sensitive protein. Pulses of light were flickered to "turn on" the memory at any moment. The most recent work expands on this by tinkering with that memory to change its contents, essentially creating a false memory.

Will we begin to replace our memories with the memories of other people? Will first-person perspectives we see via AR become part of our memories and be remembered as first-person experiences of our own? For example, will empathy experiences in AR, and seeing the world through someone else's eyes, become imbued in our own memories as though they were our personal experiences, our personal realties? Will we be able to delete or replace memories we no longer wish to hold on to through some sort of procedure in AR, in the spirit of Michel Gondry's film *Eternal Sunshine of the Spotless Mind*?

How will augmented life-logging devices such as smart cameras like Memoto (now called Narrative)[80], a wearable, automatic camera and app that gives you a searchable and shareable photographic memory, come to impact human memory? Will our memories be completely stored digitally, with the ability to recall an exact moment with actually documented photographic evidence of the event as opposed to our mental recollection? How will this come to impact what we mentally store? Will facial recognition and other memory aiding technology

79 http://www.riken.jp/en/pr/press/2013/20130726_1/

80 http://getnarrative.com

in AR lessen our human capacity to remember and store and retrieve information?

A Second Self for Self-Improvement

In an IEEE Spectrum interview from March 2013 entitled, *Steve Mann's Better Version of Reality*,[81] Dr. Mann recounts an experience about being able to see himself from multiple viewpoints and how it resulted in self-improvement and a 'better' self. Mann shares a story of setting up a protocol where one Augmented Reality (AR) eyewear device recognizes another, specifically, in this case, while sitting around a table. He describes how as a result he was able to watch himself eat from several different viewpoints of all of the other people. Dr. Mann states, "And one thing I found is it really helped me improve my table manners; all those things my mother used to tell me when I was a child about eating in a dignified manner suddenly made sense, because I could see how dignified or undignified I looked from other vantage points." He furthers, "And I think this will really change society if we have this constant sensibility of seeing the world from different viewpoints." In addition to begging the question, if we are in a panopticon setting where we feel we are constantly being watched, 'will we behave better?', Mann's example also speaks to the ability to observe a second-self from multiple documented perspectives to witness our behaviours and act upon the things we wish to change. In a way, it's about stepping outside of one's self to see how we (actually) appear to others.

Ghost Runner is a concept app for AR glasses by Portland startup company OnTheGo Platforms that is an interactive training tool for runners and endurance athletes which records your route, time, and distance and provides analytics in realtime[82]. The next time you run your recorded route, a 'ghost runner' appears in pace with your old time, running exactly where you

81 http://spectrum.ieee.org/podcast/geek-life/profiles/steve-manns-better-version-of-reality

82 http://www.katu.com/news/business/stumptown-startups/Race-a-ghost-of-yourself-with-Portland-startups-upcoming-software-190234331.html?m=y&smobile=y

ran before (this is viewed as an overlay through AR glasses) to help challenge you; you are essentially running against yourself and your best time.

Aside from improving table manners, or run-time, the ability to see one's self through AR could also help foster empathy for one's self, versus self-criticism, towards better emotional self-care. Although not executed in AR, a recent Dove campaign named, *Dove Real Beauty Sketches*[83], presented a scenario comparing portraits done by a forensic artist based on the way women described themselves and how strangers described these same women[84]. The resulting portraits of the women who described themselves to the artist appeared much harsher than the portraits of the women described to the artist by the strangers, which were no where near as critical as the women were of themselves. By being able to see one's self through the eyes of another, be it a stranger, a family member, or a friend, AR could also assist with self-improvement by aiding to gain self-confidence and remove negative self-talk.

83 http://www.youtube.com/watch?v=XpaOjMXyJGk
84 http://youtu.be/XpaOjMXyJGk

Facial Recognition, Detection, and Analysis

Facial Recognition in Augmented Reality (AR) is not a new phenomenon. Pioneer Dr. Steve Mann had facial recognition running on his AR eyewear in the late 90s. Dr. Mann's 1996 article *Wearable Tetherless Computer-Mediated Reality: WearCam as a wearable face-recognizer, and other applications for the disabled*, describes a variety of implementations in researching the best form of the ’wearable face recognizer’. Dr. Mann details these as ranging from storing the database of candidate faces on the WearCam apparatus (which was worn on the body), to connecting remotely from the apparatus to the database (with WearCam being connected to the Internet, any database was accessible from the Internet and could, in principle, be used). Dr. Mann identified the ’wearable face recognizer’ as being in either 'free running’, or in ’query mode’. In the former, the system captures images continuously and attempts to prompt the wearer, (with a name inserted into the reality stream); the wearer initiates each query in the latter. We are beginning to see concepts and prototypes for facial-recognition on Google Glass today, which operate in a similar manner.

A pilot computer program created by a team of researchers from Tilburg University in the Netherlands watches and analyzes a child's face to reveal how difficult a child finds a math problem. Researchers Marije Van Amelsvoort et al. describe the study as aspiring to a math game in the future with built-in face-reading technology that would adjust itself to an individual child's ability. This could be an example of context-aware computing through facial-detection and analysis being combined with education in AR.

An example of facial analysis being used in health includes virtual psychotherapy. Darpa’s research teams are hoping to combine 3-D rendered simulated therapists with sensitive analysis software that can actually detect psychological symptoms “by analyzing facial expressions, body gestures and speech,” states Dr. Albert Rizzo, who is leading the

project.[85] SIM Sensei, an initiative funded by DARPA, is a 3-D rendered simulated therapist that is being designed for use at military medical clinics. A collaboration between the University of Southern California's Institute for Creative Technologies (ICT) and Cogito Health (a spin-off company developed by MIT researchers), the project utilizes Kinect-like hardware for motion sensing, a webcam and a microphone with the computer's software taking note of how a patient moved and how they spoke. A soldier could enter the clinic and use a private kiosk to log on to a computer to interact with his or her personal simulated therapist.

SIM Sensei isn't intended to replace human clinicians, rather supplement them and assist military clinics to prioritize patients. If SIM detects "red flags" in an individual's behaviour, such as vocal patterns that signal depression, the patient could be scheduled by SIM to see a doctor immediately. Rather than shying away from face-to-face mental health treatment, the virtual option can provide a more anonymous alternative. Rizzo and his colleagues eventually hope to see SIM Sensei available for soldiers within the comforts of their own home.

Facial recognition, analysis, and detection systems in AR could be applied across a broad range of uses from education, healthcare, and even everyday memory in assistive ways.

85 http://www.wired.com/dangerroom/2012/04/darpa-virtual-therapy/

Non-Facial Recognition Alternatives

A Google-funded app called *InSight* being developed by students at Duke University and the University of South Carolina will enable Glass to recognize people in a crowd based on the clothes and accessories they wear[86](based on the premise that it is unlikely that someone in a crowd will be looking straight at an Augmented Reality (AR) headset's camera). InSight takes a “fashion fingerprint” by analyzing a person's clothes and accessories. A “spatiogram” is built which contains the spatial distribution of colours, textures and patterns of the clothes the individual is wearing. This unique combination of texture, pattern analysis, and colour can make someone easier to identify over long distances or at odd viewing angles. The spatiogram of the person you are seeking is compared with other spatiograms of people in Glass's field of view while the application is running. The system is dependent on the consent of the user who wishes, or does not wish, to be identified. The spatiogram file is built in the background by snapping photos while the user is on the phone. The user can then choose to share the spatiogram file with others.

The application could perhaps also assist people with a condition known as face blindness, which is a neurological disorder that makes it impossible to recognize others. Further, the application could also support anonymity to protect an individual's privacy as the fingerprint changes each time you change your clothing, enabling you to be anonymous again when you wish. Srihari Nelakuditi, one of the InSight developers, states, "A person's visual fingerprint is only temporary, say for a day or an evening".[87]

Another non-facial based recognition system created by Extreme Reality[88] uses a 2D camera, and patented software technology to capture full-body 3D motion which recognizes

86http://www.androidauthority.com/google-glass-insight-recognize-people-167112/
87http://www.newscientist.com/article/mg21729075.600-google-glass-app-identifies-you-by-your-fashion-sense.html#.Ufx2s1NQ2Bg
88http://www.xtr3d.com

an individual's gait as a unique biometric signature. Dor Givon, Chief Technology Officer (CTO) and co-founder of Extreme Reality, states, "Face-recognition technology is very limited. You have to be in a similar position every time for analysis. If someone wants to avoid face recognition they can just put on sunglasses or a beard. The way people walk is hard to change." [89]

Extreme Reality's technology could also be applied to context-aware computing with AR devices. Givon notes, "We can change the environment from the moment you wake up in morning. The room knows it's you and can enhance the environment with augmented reality elements that let you control them with your body in the most natural way."

89 http://news.cnet.com/8301-11386_3-57595555-76/extreme-reality-turns-skeletons-into-biometric-signatures/

Emotion Analytics

Emotional Analytics is an emerging field which seeks to measure an individual's moods, attitudes, and tonalities, introducing a whole new dimension of understanding and human-computer interaction in Augmented Reality (AR). An individual's voice is analyzed to extract a full set of emotions and character traits in real-time as they speak in any language. The company Beyond Verbal[90] has patented this technology and has released a Beta web application, called *Moodies,* to record and analyze 20 seconds of a user's voice.

Translation apps in AR, like *Word Lens,* offer a direct translation of printed words or typography, such as signs or menus in foreign languages; Emotion Analysis provides a complex translation of human emotion which is language agnostic. Beyond Verbal's current application is intended for human use, however, one can imagine how such software could be integrated with Artificial Intelligence (A.I.) systems and machine learning via smart agents to facilitate interactions between humans and computers through an understanding of emotion. Emotional Analytics could also be combined with context-aware computing to add another level of environmental awareness and a potentially deeper understanding of an individual's specific needs at the time based on their mood and attitude.

The second wave of AR presents new means of better comprehending, navigating, and translating our world: Emotion Analytics will be another layer of recognition and understanding in this process, adding to the delivery of relevant and user-centred experiences in AR that are context driven.

90http://www.beyondverbal.com

Eye-tracking

Eye-tracking offers new possibilities for ways to interact with Augmented Reality (AR) enabled devices such as smartphones, tablets, and in the near future AR glasses. Although eye-tracking has been around for years, manufacturers can now implement the technology in smaller devices such as laptops, smartphones, and tablets.

Eye-tracking technology by companies like Tobii[91] seeks to create more intuitive interfaces using natural eye movements. In an interview with *Venture Beat*, Carl Korobkin, Tobii's Vice President of Business Development states, “With smartphones now, you’re touching the screen, but you’re already touching the screen with your eyes. Why reach out and touch something if I’ve already looked at it? You really don’t need that mechanical process anymore.”[92]

The *Venture Beat* piece suggests imagining a digital e-reader app, such as Amazon's Kindle app, which follows your vision as you read, highlighting words, or a game designed to make characters appear where you are directing your gaze. A more simple example proposed is a scenario in which you could close dialog boxes with a mere look as opposed to a click.

Incorporated into AR glasses, eye-tracking could be used to select, trigger, and manipulate virtual objects in your AR field of view. Eye-tracking could be further extended to work with gesture tracking to remove the need for a tangible interface such as a smartphone, tablet, or mouse.

Technology like Tobii's can also assist people with disabilities to communicate. *EyeWriter*[93] is a an open-source, low-cost device that allows ALS (Lou Gehrig's disease)

91 http://www.tobii.com

92 http://venturebeat.com/2013/07/17/tobii-eye-tracking-laptop/

93 http://www.fastcocreate.com/1679433/getting-up-how-a-locked-in-graffiti-artist-inspired-the-impossible

sufferers to control a computer with their eye movements. It was named one of Time Magazine's top 50 inventions of 2010. The EyeWriter was created and designed by Members of Free Art and Technology (FAT), OpenFrameworks, the Graffiti Research Lab, The Ebeling Group communities and the Not Impossible Foundation to enable Los Angeles graffiti artist Tempt One to be able to draw and communicate with his eyes after being left almost completely physically paralyzed, except for his eyes. When paired with AR, such technology can enable new modes of assistive technology and communication for those who may not otherwise have a voice.

Augmented Reality (AR) Eyewear

Google Glass has popularized the possibility of Augmented Reality (AR) eyewear for a mass consumer audience. AR eyewear is not new; Dr. Steve Mann has been wearing AR glasses since the 70s. In the IEEE Spectrum article, *Why Smart Glasses Might Not Make You Smarter*[94]*,* Dr. Mann discusses how he came up with what he calls "a generation-one glass" in 1978 that included a camera and a display, and is similar to the products we are seeing on the market now like Google Glass. Spectrum interviewer Elise Ackerman asked Dr. Mann if it is realistic to think that eyewear like Glass will make people smarter, to which Dr. Mann responded, "If it's done right, it'll make you smarter and more situationally aware, in the sense that you see things clearer." He gives the example of how he created a face recognizer 15 years ago that identified faces and superimposed virtual name tags on top of reality, visible through AR glasses. Another example he notes is creating glasses that allowed him to "see in different spectral bands", where people had walked recently because the ground was still warm, and which cars had recently parked in a parking lot because the engine was still hot. Dr. Mann states, "I had made the infrared visible—I saw in a broader spectrum."

AR glasses have the potential to help make the invisible visible in an effort to help us see better. Dr. Mann proclaims, "Potential benefits are immense if these products are done right." He recounts how a person who is legally blind was able to read while wearing a generation-four glass he created. In fact, Dr. Mann discusses how he originally built his first prototypes as a seeing aid[95], commenting, "The vision I had was that you would download your prescription over the Internet into the glass. The prescription would automatically get stronger if your eyes were tired. If you were reading a newspaper, it would adapt to your field

94http://spectrum.ieee.org/consumer-electronics/gadgets/why-smart-glasses-might-not-make-you-smarter

95http://wearcam.org/industrial_design/

of view.”

AR glasses like Meta's Space Glasses (of which Dr. Mann is also involved with, serving as Meta's Chief Scientist) seek to combine eyewear with gesture. Meta's CEO Meron Gribetz describes Google Glass as a basic “notification machine” and as an accessory for a smart phone”. He states, “Meta will replace these things” and refers to what Meta is developing as a “natural machine”. At Augmented World Expo (AWE) 2013, Gribetz described Meta as bringing your whole world into code by tracking (projected 3D images) with your hands. Gribetz's vision for Meta is different from VR glasses like the Oculus Rift[96], which he referred to at AWE 2013 as a “Matrix Machine” where you're wearing a “large bucket on your head to immerse yourself in an alternate reality of simulations”. In such an example, Gribetz describes you “leaving your friends and reality behind”, whereas Meta engages with the real world and uses “intuitive natural metaphors that bring back the world we seem to have lost in the past few years”.

Will we regain the physical, tangible world we've lost, as Gribetz states, or will we enter a whole new world that brings the *Matrix* into ours? How will AR glasses enhance our reality and allow us to truly see better, having real-world engaging experiences with our friends?

96http://www.oculusvr.com

Motion Control

A motion controlled future that is intuitive and ties in more naturally to how we interact with the world is rapidly approaching and will be integrated into Augmented Reality (AR) devices and software, beyond traditional peripherals like the keyboard and mouse.

Engadget reported on a recent panel on the future of gesture and motion controls at Expand NY, which featured Samsung's Shoneel Kolhatkar, Leap Motion's Avinash Dabir, and Pelican Imaging's Paul Gallagher[97]. The panel reflected on how a new generation is growing up with touch, voice, and gesture controlled interfaces. Motion also already plays a significant and natural role in human communication and how we naturally interact with the world, such as a person's conversational gesturing for example. Interaction needs to be natural and predictive for a future of motion control to work, with gestures being efficient, simple, and immersive.

Devices overall will become smarter and come to anticipate our intentions. Samsung's Smart Scroll is a good example in which it will stop playing video when the device knows you are no longer looking at the screen. Gallagher explained, “What we're talking about is how to have a system interact with you and be able to understand your intent.” Just as a person knows they are being addressed by eye contact or body language, devices too will become smarter and recognize when you are communicating with them. The panel commented on how, for now, industry is focusing on special use cases such as providing an interface for surgeons who, in the middle of an operation, need to access files and don't want to break sterility. Dabir commented, "I think it'll start in these specialized use cases and trickle down into everyday workflows," finding a home in consumer devices eventually.

With the new AR heading towards a direction of machine-learning, Artificial Intelligence

97http://www.engadget.com/2013/11/10/motion-gesture-expand/

(A.I.), and contextual computing to anticipate a user's needs, I believe we will see motion controlled interfaces integrated in AR eyewear and devices en route to how consumers interact with computers and AR on a daily basis. AR is shifting from an experience in front of a desktop computer with keyboard and mouse, and even smartphone and tablet with touch screen, to one where we interact in real-space naturally and intuitively. The future of this will include combining gesture and motion controlled interfaces in AR with tactile feedback through haptics.

Neo-Baroque space: The User at the Center

In the article, *Architectures of the Senses: Neo-baroque Entertainment Spectacles*, 2003, Angela Ndalianis writes, “The baroque’s difference from classical systems lies in the refusal to respect the limits of the frame. Instead, it intends to invade spaces in every direction, to perforate it, to become as one with all its possibilities” (Ndalianis 360).

This description of the baroque aligns with Augmented Reality (AR) blending into and permeating our reality and physical environment re-orienting our visual understanding of conventional space.

Ndalianis identifies Pietro da Corona’s ceiling painting *The Glorification of Urban VIII* (Rome, 1633-1639) in the Palazzo Barberini as baroque, where “the narrative from one panel literally spills into the narrative of another” and “the impression is such that, in order to spill into the next visual and narrative space the figures and objects perceptually appear to enter into our own space within the Palazzo Barberini” (361). In contrast she notes, “A strictly classically aligned composition would, instead, have enclosed and kept discrete the separate narrative borders.” (361). AR enters into “our own space”, with the narrative of the augmented environment spilling into our physical surroundings.

Ndalianis discusses how the spectator is central in (neo)baroque space and vision. She writes,

> With borders continually being rewritten, (neo)baroque vision provides models of perception that suggest worlds of infinity that lose the center that is traditionally associated with classically ordered space. Rather the center is to be found in the position of the spectator, with the representational center changing depending on the spectator’s focus. Given that (neo)baroque spectacle provides polycentric and multiple shifting centers, the spectator, in a sense, remains the only element in the image/viewer scenario that remains centered and stable. It is the audience’s perception and active engagement with the image that orders the illusion (358).

With AR, the position of the spectator is the center, with the possibility of changing the AR

experience depending on the spectator's focus, position, and context. Just as Ndalianis writes, it is the spectator's "perception and active engagement", with AR, "that orders the illusion." "Active engagement" in AR will make the spectator's context, interests, and motivations even more central to ordering and defining "the illusion" or virtual representation atop the user's physical environment.

Google Glass has the potential to contribute to a (neo)baroque style in AR where the spectator, through customized eyewear, will really be at the center in a new ordered visual space. The possibilities for capturing first-person perspective photography and video directly via the eyewear may come to help define a new set of aesthetics and stylistic tendencies. I am intrigued to see how the current 2D images and video will expand beyond the frame once Glass is fully AR enabled, to quote Ndalianis again, extending "space in every direction, to perforate it, to become as one with all its possibilities."

The future of AR shall not be limited to strictly a visual experience, it must be fully sensorial as we push ahead as an industry and community of researchers to grow the medium. Ndalianis writes, "When discussing the neo-baroque we also need to consider an architecture and regime that engages the sensorium" (367). She refers to "haptic, gustatory, olfactory, to the auditory and the visual", all of which AR as a new medium needs to experiment with and extend into, beyond computer vision and tracking. Adrian Cheok's keynote at ISMAR 2011 in Basel, Switzerland addressed the critical need for AR to engage the other senses and move beyond AR being strictly about computer vision. With projects exploring taste and smell in AR, like Meta Cookie[98] from the University of Tokyo, and work being done in AR haptics, such as at the Magic Vision Lab[99], University of South Australia, AR will continue to expand in new ways, beyond visual frames and into the full human sensorium,

98 http://www.youtube.com/watch?v=3GnQE9cCf84&feature=youtu.be
99 http://www.magicvisionlab.com/

to truly become “one with all its possibilities”.

Subversive Augmented Reality

In Augmented Reality (AR), virtual content is added to a real environment; in Mediated Reality, virtual content is also added to a real environment, but it is now modified by a visual filter in real-time. Mediated Reality presents a framework for a highly customized experience. In the article “Mediated Reality” in *Linux Journal*, Dr. Steve Mann describes WearComp as “a wearable computational device that provides the user with a self-created personal space. The most fundamental issue of WearComp is that of personal empowerment”[100]. WearComp was created in response to intrusive advertising, which Dr. Mann identifies as consuming our visual attention. He writes,

> A solution to this problem may be obtained through something I call mediated reality. Mediated Reality differs from virtual reality or augmented reality in the sense that it allows us to filter out things we do not wish to have thrust upon us against our will… Just as a Sony Walkman allows us to drown out Muzak with our own choice of music, Mediated Reality allows us to implement a ‘visual filter’.[101]

In Mediated Reality, then, the individual is in control of their mediated experience, personalizing this experience via a filter, with content substituted at their choosing as opposed to ‘against one’s will’. Dr. Mann notes, “Mediated Reality can help us reclaim solitude in personal spaces. By wearing special sunglasses in which a visual filter is implemented, it is possible to filter out offensive advertising”. He suggests that in place of the invading advertisement, a “calming image of a waterfall” could be substituted. Dr. Mann has utilized Mediated Reality to substitute personal notes and directions in place of advertisements, with WearComp’s communication capabilities also allowing for multiple users to “share a common visual reality”.

Artist Julian Oliver’s Mediated Reality project, *The Artvertiser*, 2009,[102] credits Dr.

100 http://www.linuxjournal.com/node/3265/print
101 Ibid.
102 http://www.theartvertiser.com/

Mann's research as an inspiration. Oliver defines 'artvertising' as the idea of taking advertising, intercepting those advertisements before they hit the visual cortex and substituting them for art. Oliver prefers to use the term "Improved Reality" in place of Mediated Reality to describe the *Artvertiser*. The *Artvertiser* utilizes computer software to recognize advertisements, which it then replaces with art, viewed through a pair of customized binoculars Oliver refers to as the 'billboard interception prototype'. Oliver describes the advertisements becoming "a virtual 'canvas' on which an artist can exhibit images or video when viewed through the hand-held device". Critical to the project's premise, "The Artvertiser situates the 'read-only' proprietary imagery of our public spaces as a 'read-write' platform for the presentation of non-proprietary and critically engaging content".

The *Artvertiser* recalls Marshall McLuhan's statement in *The Relation of Environment to Anti-Environment,* "The artist provides us with anti-environments that enable us to see the environments" (18). Applying the *Artvertiser* as a means to intercept advertisements, and replacing them with art further echoes McLuhan's perspective, "One of the peculiarities of art is to serve as an anti-environment, a probe that makes the environments visible" (17). This can be tied to Jay Bolter and Richard Grusin's theory of hypermediacy as making the medium apparent and drawing attention to it. The *Artvertiser* makes the viewer aware of the medium of advertising through the medium of Mediated Reality. In *Remediation*, Bolter and Grusin write, "Sometimes hypermediacy has adopted a playful or subversive attitude both acknowledging and undercutting the desire for immediacy" (34). The *Artvertiser* applies a subversive approach to reveal, or intercept, the mediated environment dominated by advertising, made visible only through the technological visualization of Mediated Reality. Whose Mediated Reality will we be privy to and what visual filters or tools for interception may come to exist? Will we be part of a read-write environment, or read-only? Who will author and

authorize these realities?

Translation

A dominant practical use-case emerging in Augmented Reality (AR) is translation. AR technology can assist a user to better understand and translate the world around him. Emotional Analytics is a more advanced means of interpreting one's environment through AR, as discussed previously. Google Glass can translate any phrase into another language with a spoken translation heard along with an English phonetic spelling appearing before the user. Prior to Google Glass, the smartphone app *Word Lens* translated text in real-time with an overlay of the translation into another language layered directly atop the text such as a street sign. The Word Lens application was recently integrated into Glass's applications.

A particularly fascinating new example of translation possible in AR is a prototype scientists at Microsoft Research Asia have developed in collaboration with the Chinese Academy of Sciences and Beijing Union University, which enables the Kinect to read and translate sign language in real-time. Named the *Kinect Sign Language Translator*, the system can provide a written and spoken translation based on a person signing, and can also take speech and turn it into signs on screen at conversational speeds[103]. The *Kinect Sign Language Translator* can empower a signer to communicate independently with a non-signer without the need of an interpreter. AR is beginning to expand in an incredible direction of assistive technologies to help improve lives. This is a significant move away from gimmickry AR, towards enabling people to live richer lives, more in tune with and better connected to their environments.

The Kinect was originally developed for gaming, using sensors to read a user's body movements and position in space. Microsoft's second generation of the Kinect sensor

103 http://www.dailymail.co.uk/sciencetech/article-2481515/Microsoft-Kinect-sensor-converts-sign-language-speech-text.html?ITO=1490&ns_mchannel=rss&ns_campaign=1490

includes a heart-rate monitor and an increased field of view, allowing up to six skeletons to be read at once, as well as track eye movements and detect expressions. I believe we can anticipate seeing more AR translation type tools using the Kinect sensor applying these features in the very near future.

Cognizant Computing and Digital Devices as Personal Assistants

In a short video entitled, “What Will Personal Computing Look Like in 2020?”[104], Dr. Genevieve Bell, Director of Interaction and Experience Research at Intel, reflects on the future of computing. Bell comments on a world where technology will come to anticipate our needs and we will enter a much more reciprocal relationship with computers where technology begins to look after us and do things on our behalves. These views are mirrored in Gartner Inc.'s Research Vice President Carolina Milanesi's statement[105] on the future of smart devices and how, by 2017, your smartphone will be smarter than you. Milanesi states, “If there is heavy traffic, it will wake you up early for a meeting with your boss, or simply send an apology if it is a meeting with your colleague. The smartphone will gather contextual information from its calendar, its sensors, the user’s location and personal data.”

Gartner's research claims this will work with initial services being performed "automatically" to assist generally with menial tasks that are significantly time consuming such as time-bound events, like calendaring, or responding to mundane email messages. A gradual confidence will be built in the outsourcing of menial tasks to the smartphone with an expectation that consumers will become more accustomed to smartphone apps and services taking control of other aspects of their lives. Gartner calls this the era of cognizant computing.

Gartner identifies the four stages of cognizant computing as: Sync Me; See Me; Know Me; Be Me. Sync Me and See Me are currently occurring, with Know Me and Be Me just ahead. Sync Me stores copies of your digital assets, which are kept in sync across all contexts and end points. See Me knows where you are currently and where you have been in both the real world and on the Internet, as well as understanding your mood and context to

104http://www.youtube.com/watch?v=zcvjlyMC0cs
105http://www.gartner.com/newsroom/id/2621915

best provide services. Know Me understands what you need and want and presents it proactively to you. Be Me acts on your behalf based on learning and rules you set.

Milanesi states, “Phones will become our secret digital agent, but only if we are willing to provide the information they require.” Privacy issues will certainly come into play, and a user's level of comfort in sharing information. Dr. Bell observes that we will go beyond “an interaction” with technology to entering a trusting “relationship” with our devices. She reflects that a great deal of work goes into 'getting goodness” out of our computing technology and that we “have to tell it a tremendous amount.” She continues that in 10 years from now, our devices will know us in a very different way by being intuitive about who we are, “where they might anticipate what we are doing and deliberately do things on our behalves.”

The next wave of Augmented Reality (AR) is context driven in an era of cognizant computing that will include, but not be limited to our smartphones. We will enter a deeper more trusted relationship with our digital devices where they will know us intimately and will act on our behalves within our daily lives dynamically adjusting to our continually changing context and environment to predict our needs and deliver relevant and timely experiences.

A few examples of current smartphone apps that are a step in the direction of cognizant computing and a digital personal assistant include *Google Now*[106], *Tempo*[107], and *24me*[108]. Leading this field is *Google Now* claiming to bring you the things you want when you need them as communicated with their slogan, "Just the right information at just the right time". *Now* enables things like customized suggestions and information on nearby events, traffic information and routes, weather forecasts, set reminders, real-time sports scores,

106http://www.google.ca/landing/now/

107 http://www.tempo.ai

108http://www.twentyfour.me/

tracking of online-orders and packages. Soon, *Now* will integrate crowdsourced Waze traffic updates in real-time, with alerts relevant to your specific commute highlighted[109].

Nuance Communications' *Project Wintermute*, cleverly named after the Intelligent Agent in William Gibson's classic science fiction novel *Neuromancer*, claims to move across devices and platforms, rather than just being limited to a smartphone. I believe that this is the future of cognizant agents in Augmented Reality, where your context will dictate the most relevant display with a seamless experience across all of your digital devices; the congnizant personal assistant will always be with you, knowing you very well, and continually predicting and catering to your wants and needs.

109 http://www.engadget.com/2013/11/13/google-now-news-tv-waze-websites/

Responsive Clothing

Dominic Wilcox's functioning GPS shoe prototype, *No Place Like Home*[110], guides the wearer to the destination of their choice. Inspired by the *Wizard of Oz* and how Dorothy could click her heels to go home, the shoes integrate custom mapping software, a USB cable, and GPS embedded in the heel and activated by a heel click. Once you upload your desired destination to the shoes, a ring of LED lights point the wearer in the right direction. The shoes with the GPS communicates wirelessly with the right shoe which shows how close you are to your destination via a progress bar of lights.

Created by the Australian-based company Wearable Experiments, *The Navigate Jacket*[111] also uses a built-in GPS system and LED lights, with integrated haptic feedback through vibrations to direct the wearer to their destination. Co-founder Kelly Whitehouse states, "We are transforming the art of travel into a hands-free application." The jacket allows wearers to walk to their destination without the need to hold or look at a map on their smart device or otherwise. Instead, the directions are visualzed on the sleeves. The LED lights indicated how far the next turn ahead is and the total progress of their journey with the vibrations notifying the wearer which way to turn and when by feeling a tap on the shoulder.

Responsive clothing is adding to the ecosytem of Augmented Reality (AR) (sensor-based) devices that will communicate with and respond to your context and environment. Smart apparel like *The Navigate Jacket* and *No Place Like Home* are examples of a shift to a more natural and human-centered experience with technology not interrupting or getting in the way of life (see Calm Computing section). GPS is a common feature in these types of responsive garments, however there is the possibility to integrate far more sensors working in

110http://dominicwilcox.com/portfolio/gpsshoe/

111http://wearableexperiments.com/navigate/

the background into apparel including biometrics to monitor, your heart rate, breathing, calories, and activity connected to an application on your smart phone. Om Signal[112] is a Montreal-based company that is doing just that offering real-time and trackable insights for consumers, patients and medical practitioners.

Aside from real-world uses such as health and navigation, designer Daan Roosegaarde asks what "what kind of new protocol or rituals will we have" if wearables become part of our daily lives?[113] Roosegaarde's concept garment, the Intimacy 2.0[114]dress, transforms from an opaque state to various degrees of transparency triggered by proximity and heart-rate. Roosegaarde views wearable computers as an extension of the human mechanics of the body like sweating or blushing. He states, “Some elements of your body, although it’s your body, are out of your control as a human being." Roosegaarde continues, "When you stop breathing, you will faint, but after a while the body takes over again, so to speak. I like these kind of mechanisms, which are inside you.”

Roosegarde comments on how he would like to have wearables react in different ways based on when a certain person is present, with neutral behaviours when others are around. He describes this as, "In the same way when you talk to your boyfriend, you have a different conversation than you would with me. It’s both English, we are both guys, but you tell different stories." He also queries what it would be like if your clothing began to make suggestions. He refers to Amazon as an example when you buy a book, and other books you may wish to purchase based on your likes and those of your friends. Roosegarde's suggestions are hinting at a cognizant computing in AR from the previous section where your personal

112http://www.omsignal.com/

113http://www.fastcolabs.com/3007681/open-company/why-clothing-next-frontier-responsive-computing

114http://vimeo.com/29952304

assistant is not limited to your smartphone, yet now omnipresent and also embedded in your apparel.

Body Implants & Superhuman Capabilities

A step beyond responsive clothing is having wearables embedded in our bodies and under our skin with various implants. The ears serve as a natural progression of implants into the body for augmentation; It will likely be the first fairly non-invasive step, as we are already accustomed to placing things into our ears like earbuds, Bluetooth wireless headsets, and hearing aids. In the *Bloomberg* article, "Ears Follow Eyes as Target in $1.84 Billion Wearable Boom", Olga Kharif also suggests that this very factor could possibly help ear-based computing devices to enter the mainstream faster."[115] In the article, Kharif reports on the company iRiver releasing a headset in the U.S. with a "Tic-Tac-sized sensor" which is able to track a user's biometrics including heart-rate, calories burned, and speed and distance travelled, all by shining a light into the ear. For example, a runner can insert the iRiver's ON headset[116] into her ears and connect to her smartphone; during the run, the device captures her biometrics while playing music through the headphones. A voice-feedback system on the device speaks into the user's ears to notify her of the heart-rate zone she is in and whether calories goals have been reached. The real-time data is sent to a smartphone app for later review.

Kharif points out how such "ear-based gadgets" are different from devices like Google Glass "because they can be almost invisible, an attribute that might appeal to people who don't want their devices to draw attention." John Edson, president of design consultancy Lunar commented on this stating, "The current trend is to hide the technology. The ear is a nice place to hide electronics." Founder of wearable camera company Looxcie[117], Romulus

115 http://www.bloomberg.com/news/2013-11-18/ears-follow-eyes-as-target-in-1-84-billion-wearable-boom.html
116 http://www.iriverinc.com/product/productOverView.asp?pn=iriveron

117 http://www.looxcie.com

Pereira states, “Life requires both hands, frequently. Glasses and the wrist have become the poster child for exploring wearability. Behind this poster child is a whole population of things.” And these other "things" will come as sensors and computers get smaller and faster and get closer and closer to the body, to potentially the point where they are embedded in our bodies and beneath our skin.

In the CNET article *Surgically Implanted Headphones Are Literally 'In-Ear'*[118], Leslie Katz reports on how 'would be cyborgs' like Richard Lee are modifying their bodies to implant devices. Lee is experimenting with surgically implanted headphones that use magnetic speakers in his ears. Lee is one of a growing number of "Grinders", people who get surgical implants to push the limits of human capabilities. Further to the points in Kharif's article considering issues of devices appearing less noticeable, Katz writes, "Lee's implants are undetectable to the naked eye, with only a tiny scar visible on the tragus, and he can easily conceal the coil necklace under his shirt so nobody sees that either." Lee comments on ways of extending his implanted headphones beyond listening to music stating, "I can see myself using it with the GPS on my smartphone to navigate city streets on foot."

Lee is losing his sight in his right-eye and intends on further practical uses of the in-ear implants. He intends to connect his new system to an ultrasonic rangefinder to have the ability to hear "hums when objects get closer or further away, thus (hopefully) making his hearing more bat-like". Lee states that echolocation is something he will begin practicing with and that, “The implant is going to allow for a lot of new senses."

Lee is one of said "Grinders" who is seeking to aquire super human abilities through body modifications and implants. In a related CNET article, *Hacking Humans: Building a*

118http://news.cnet.com/8301-17938_105-57591584-1/surgically-implanted-headphones-are-literally-in-ear/

Better You[119], Seth Rosenblatt reports on contemporary efforts to 're-engineer the body' and the pioneers who aim to push the capabilities of the human body. Dr. Daniel Kraft, Executive Director for FutureMed and the Medicine and Neuroscience Chair at Singularity University states, "I think one way to frame this is how 'hacking' is moving from enabling the disabled to becoming super-enabled". Trevor Prideaux is an amputee who added a smartphone to his prosthetic arm; he can hold his arm to his ear to place and receive calls. Wafaa Bilal is an arts professor who implanted a digital camera in the back of his head to be able to take photos of what was going on his back.

There is a rising trend in modern "medical augmentation", which Kraft states is, "generally riding exponential trends of smaller devices, connected computing, and big data". Augmented Reality (AR) is also integrating these trends Kraft lists, but how will it integrate bio-implants and medical augmentation? Will AR truly make us super-enabled and superhuman?

In the Huffingtonpost article, *Man or Cyborg: Does Google Glass Mark the End of True Humanity?*[120] Cassie Goldring poses these questions commenting on the blurring of technological extensions of humans, specifically in regards to the potential impact of Glass on human capabilities. Goldring identifies a choice, with which I agree; she writes,

> We can choose to view these technological advancements as an eventual threat to our humanity, or we can see them as devices that help us become more human. As long as we maintain a strong humanistic perspective in the midst of technological advancement, and acknowledge that these technologies are extensions of us and not the reverse, our humanity will always prevail.

Human-centric experiences will be at the heart of the second wave of AR and this will include the integration of devices that extend our natural abilities. I believe Goldring summarizes

119 http://news.cnet.com/8301-17938_105-57496940-1/hacking-humans-building-a-better-you/
120 http://www.huffingtonpost.com/cassie-goldring/man-or-cyborg-does-google_b_3635068.html

these pending issues and possibilities ahead quite well by stating, "We must look at devices such as Google Glass not as a desperate attempt to become superhuman, but instead, as an attempt to reach our full potential as humans, connect us in new ways, and ultimately gain a deeper understanding of one another".

Artificial Intelligence and Machine Learning

Linked to the discipline of Computer Science, Artificial Intelligence (A.I.) is "the study and design of intelligent agents", also referred to as computational intelligence (Poole et al., 1). An intelligent agent is a system which acts intelligently according to set circumstances and defined goals, maintains a flexibility to changing environments and changing goals, learns from experience, and makes appropriate choices within given limitations (1). At any point, the intelligent agent has, "Prior knowledge about the world, past experience that it can learn from, goals that it must try to achieve or values about what is important, and observations about the current environment and itself" (7). Machine-learning is a branch of A.I. which uses computational methods to learn tasks automatically based on past observations (learning by example) and improve performance without human intervention, such as making accurate predictions. A common example of machine learning is spam filtering in which the computer will devise its own program to do so based on examples provided. A.I. and machine-learning will be central to the second wave of Augmented Reality (AR) in understanding and learning our behaviours to make predictions, knowing us very well, and even acting on our behalves.

In the CNET article, *Google's Project Glass: You ain't seen nothin' yet,*[121] Martin LaMonica reports on how Glass offers a glimpse into Google's ambitions with A.I. He makes the observation that the hope for A.I. software is it will present targeted information as needed, while processing information in the background, which to me, is a process that is very remniscent of calm technology (discussed in the next section). LaMonica provides shopping as an example explaining, "the A.I. system would sift through lots of data to come up with very granular and personalized recommendations, rather than recommendations based on past purchases as computers do today." I completely agree with this; computers will

121 http://news.cnet.com/8301-11386_3-57410443-76/googles-project-glass-you-aint-seen-nothin-yet/

quite intelligently aggregate various data sources, including information pulled from social media, personal calendars, and locations frequented, to identify what is important, paired with observations about the current environment, in order to anticipate behaviours and make smart, highly relevant real-time suggestions to the user in AR via A.I. and machine-learning.

Ubiquitous Computing and Calm Technology

> Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives.[122] --Mark Weiser, 1996

Mark Weiser became known as the father of ubiquitous computing, a concept he first proposed in 1988 at Xerox PARC. On his ubiquitous computing webpage, Weiser wrote in 1996, “Ubiquitous computing is roughly the opposite of virtual reality. Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people.”[123] Wiser seems to be describing Augmented Reality (AR) and at the time predicted that it would be 20 years before we saw the second path of ubiquitous computing, which is “invisible” with its highest ideal “to make a computer so embedded, so fitting, so natural, that we use it without even thinking about it” coming to dominate. By Wiser's predictions, this is now only a few years away in 2016.

Also in 1996, Weiser wrote the critical paper *The Coming Age of Calm Technology* with John Seely Brown at Xerox PARC[124]. Calm technology can be summarized as invisible and natural to use, it doesn't interrupt or get in the way of life, it happens in the background, and it appears when you need it. This is where I personally see the second wave of AR beginning to head.

In the introduction to *Understanding New Media, Augmented Knowledge and Culture* (2006), Kim H. Veltmann writes,

> Within the next two decades the computer will become invisible. Herein lies a first paradox. Computers are about making things visible. They help us visualize processes, concepts and many things, which we cannot see. Yet, as they develop, computers are becoming part of the furniture, disappearing into the woodwork. When the technology

122 http://www.ubiq.com/hypertext/weiser/UbiHome.html
123 Ibid.
124 http://homes.di.unimi.it/~boccignone/GiuseppeBoccignone_webpage/IUM2_files/weiser-calm.pdf

is mature, our chief means of rendering things visible will be invisible” (xxiii).

I agree with Veltmann's viewpoints. The first wave of AR was about making the invisible visible, in a way that focused primarily on a 2D and 3D layering or annotation atop the real world. The second wave of AR will also be about making the visible now invisible through interactions and modes like calm computing and ubiquitous computing; AR experiences will be more human-centric, with technology receding into the background and a focus on more natural experiences.

User Experience (UX)

The best Augmented Reality (AR) experiences and the best AR designers will cater to context, which includes the user's location, social scenario, time of day, interests and needs, all with a great awareness of resources available in the user's current and dynamically changing environment. Context also includes a user's devices and wearables; great UX AR designers will need to design for a connectivity of devices to deliver the best experience on the most suitable output be it AR glasses, a smart phone, smart watch, or other device.

UX in AR will have a major focus on human-centred design. Technology thought leader the late Red Burns said it best: The world is "a place that people live in — you are designing for people, not machines."[125] The new breed of UX AR designers will tap into the unique qualities of AR to create contextually rich and memorable human experiences that help us to better engage with the world we live in.

In a blog post on *Augmented Experience*[126], Nate Clinton writes, “Let’s be honest: Google Glass looks pretty silly. Its appearance is *out of time*, futuristic, and obnoxiously so. And it’s *out of place* in daily life—a strange accessory with mysterious purpose, as if someone were to walk around all day with a skateboard on a leash.”

Clinton, however, points to the possibilities of AR's future and “a vast new frontier for the practice of interaction design” that the UX community will shape. He writes, “we will determine it’s character, and the impact it will have on people’s lives.” I agree with Clinton and the urgency for makers to create and define these new AR user experiences. I see my own practice and research shifting from one of experiments in storytelling in AR to one that now looks at how AR will come to impact and improve people's lives with new forms of user

125 http://www.wired.com/opinion/2013/09/focus-on-people-not-tech-and-other-impt-lessons-for-interaction-design-and-life/

126 http://www.cooper.com/journal/2013/11/augmented-experience

experiences.

Clinton writes,

> To paraphrase a recent piece by Don Norman[127], it all depends on how we design and develop augmented reality applications. If we manage to create useful and utility-producing applications with wearable technologies like Google Glass, people will benefit. This seems at first more like a truism than truth. But the obviousness of the statement belies the underlying premise, which is that Google Glass and its future iterations are simply a canvas on which we can write the future of our "augmented" everyday experience. So let's not leave it all up to Google, shall we?"

Again, I fully agree with Clinton. AR is shifting to a wave of meaningful, and useful applications that will benefit people in their daily lives. If we want to live in a read-write, rather than a strictly read culture in AR, as makers and users, we must contribute and help define the types of experiences we want to have in AR.

Clinton describes a process of remediation in writing,

> The first attempts to harness the power of Glass-like technology will be "ports," shoe-horning old functionality into a new form factor. Text and email messages will appear, caller ID will notify you of a phone call, the front-facing camera will take a picture or video on command. But none of these use cases address new *goals*. They simply make achieving old goals incrementally faster or more convenient. I don't have to lift my phone and look at the screen to see a text message or know who's calling. I don't have to lift my camera and press a button to take a picture. The difference in my experience enabled by porting functionality from my phone to Glass is a difference of degree, not a difference in kind.

In remediation, the new media form refashions the old, appearing to improve upon the prior medium. In the case of Glass, Clinton highlights how "old goals" are achieved in a more convenient way. Now is the time as we enter the second wave of AR to leave the old behind and address "new goals". As Steven Holtzman argues in *Remediation*, approaches of repurposing "don't exploit the special qualities" of a medium, and that "it's those unique qualities that will ultimately define entirely new languages of expression"(49). He describes repurposing as a "transitional step" that permits "a secure footing on unfamiliar terrain", but

127http://www.technologyreview.com/news/517346/the-paradox-of-wearable-technologies/

we must now “transcend the old” and create the new with AR. The onus is on us to address what we can achieve in AR that we could not previously, beyond just an improvement of prior media. Clinton addresses, “Part of our challenge and calling as a UX community is to think deeply about what an augmented experience feels like, and how it shapes people’s lives. As you would with any user experience, let unmet user goals guide your design.” This is sound advice and I couldn't agree more. This is the path we must take and where the *40 Ideas* concludes, looking now to the makers, the thinkers, and the dreamers to build these concepts into a new reality waiting to be experienced.

Epilogue



Fig.1-2: Clear kayak design, actual product

In my 2013 Augmented World Expo (AWE) presentation in Silicon Valley, I gave a talk about Augmented Reality (AR) without showing any actual examples of AR. Instead, I used images from outside of the field to help refresh and reframe the community's and industry's perspective on where we currently were at the time and where we needed (and still need) to go. One of my slides included the design of a clear kayak. The transparent kayak allows for a more immersed experience for the kayaker and a direct relationship with the kayaker's environment. The clear kayak provides an invisible barrier that permits an entryway: the kayaker is able to access a view and experience that was not accessible before with an ordinary opaque kayak.

To return to media theorist Matthew Lombard, who defines presence as “the illusion of non-mediation”, the clear kayak functions as “a large open window, with the medium user and the medium content (objects and entities) sharing the same physical environment” (8). Connecting this to Jay David Bolter and Richard Gruisin's definition of immediacy in

Remediation where “the medium itself should disappear and leave us in the presence of the thing represented” (6), the clear kayak does just this, giving the illusion of 'disappearing' with the kayaker left in the direct presence of the environment. This clear kayak is significant and symbolic of the new AR that is emerging where the user will be more deeply immersed and directly engaged. We've already witnessed the shift from a magic-mirror approach in AR to a direct sight-line over the environment (as noted in *The Top 10 Ideas That Have Already Changed AR*). This sense of immersion will further progress with AR glasses, however, it will not only be hardware and device reliant, engagement will be enriched with personalized experiences driven by context where the user is at the center.

The *40 Ideas* intentionally closed with User Experience (UX) as the final idea. What's missing in AR and where we need the most direction to accompany technological advancements and achievements is the design question of how can AR be more responsive to the user and to human needs to move beyond gimmick-driven experiences. How can AR be used to enhance our lives and the way we engage with the world around us? As I have stated, the second wave of AR signifies an “entryway”; AR can no longer just be an “overlay” and something that is superficially placed on top of reality, it needs to be meaningful, relevant, contextual, and human-centered.

The second wave of AR will be an exploration of extending our human capacities to understand, engage with, and experience our world in new ways. Driven by the one thing that is central and unique to AR – context – our devices will be highly cognizant of our constantly changing environments continually deciphering, translating, analyzing, and navigating to anticipate our specific needs, predicting and delivering personalized solutions with highly relevant content and experiences. This next wave is adaptive; it is live and always on, working quietly in the background, presenting itself when necessary with the user forever at the

center. It works for you, and you alone. It knows you very well, your behaviours, your likes, dislikes, your family and friends, even your vital statistics. The world is now filled with AR markers, no longer clearly distinguishable as black and white fiducials; the world itself and everything in it is now one giant trackable: people, faces, emotions, voices, eye-movement, gesture, heart-rate, and more.

The second wave of AR presents a brave new digital frontier, where the objects in our world are shape-shifting, invoked, and on-demand. This era will see one of new interaction designs and user experiences in AR, towards natural user interfaces with heightened immediacy; we will be in the presence of the 'thing', more deeply immersed, yet simultaneously with both feet rooted in reality. Our devices will not only get smaller and faster, and closer to, and perhaps even become implanted inside our bodies, they will be smarter in how they connect with and speak to each other and other sensors to present a multi-modal AR experience across all devices; dependant on your context, content will be delivered to the most suitable device. There will be multiple access points to AR experiences: we will be able to now touch, smell, and taste the visual digital illusion, being immersed in it, no longer simply looking at, previously left hungry for more. We will have new ways of knowing and being in our world entirely.

When I began this work, my platform in the community and industry focused on storytelling and AR. I gave numerous talks globally on the topic, designed and presented creative work and prototypes, and became known as an evangelist for AR as a new medium. I am still greatly passionate about AR nearly a decade later, and as I have watched AR change and grow, I too have changed and grown as a researcher and practitioner, and my focus has shifted. I can very clearly now see the rapid advancement of AR into this next wave, having lived through and been actively involved in the first wave, creating work like the AR Book in

that period of AR, and I can see that this is where the new work, challenges, and opportunities rest. AR wants to be more, and it can and will be. Storytelling is still an important aspect of AR, and it will now also partly be about telling the story of AR itself, of this first and second wave. Storytelling in AR has changed to one that will be defined by context, it will become the highly personalized story of you. AR will need storytellers who will understand things like machine-learning, Artificial Intelligence, cognizant computing, sensors, wearables, and be able to weave all of these things together to tell one grand, continually updating story.

I see my role in all of this continuing as I share my insights and knowledge gained and continue to make work, write, and critically reflect on where we are going. The first wave of gimmick-driven AR will linger for a while, but it will dwindle, and be replaced by the power and promise of the new generation of AR in the age of context. And so, like Alice, I find myself now on the other side of *The Looking-Glass* with the journey continuing as I seek to find, and hopefully design, that transparent kayak.

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