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The Emergence of Augmented Reality (AR) as a Storytelling Medium in Journalism

John V. Pavlik[1] and Frank Bridges[2]

Abstract

Digital technology holds the potential to transform journalism and the media in several beneficial ways, including new forms of storytelling that might better engage citizens and provide more context, nuance, and texture to reported events and issues. However, the extent to which these benefits have been realized is mixed and subject to debate. In this monograph, we examine how digital technology might transform the content of journalism through augmented reality (AR). The significance of digital storytelling through AR is manifest in its potential to engage a citizenry increasingly disengaged from traditional news and to provide more contextualized information.

Keywords

augmented reality, journalism, storytelling, media, digital

Journalism and the media have been drastically changed in large part by digital technology, the Internet, and mobile media. Other forces that affect shifts in the media landscape include economic turmoil, political transition, and cultural shifts on a national and international scale. Although there are several significant implications of the technological forces that transform the journalism and media landscape, this monograph focuses on one area in particular. The focus here is on the development and utilization of a form of technology known as augmented reality (AR) in journalism,

[1]Northwestern University in Qatar, Doha, Qatar
[2]Rutgers, the State University of New Jersey, New Brunswick, NJ, USA

Corresponding Author:
John V. Pavlik, Associate Dean for Research, Northwestern University in Qatar, 2020 Ridge Avenue, NW University M/S 1801Q, Evanston, IL 60208, USA
Email: jvpavlik@gmail.com

with a particular emphasis on the implications of AR as a storytelling medium in journalism. We use a case study method that examines AR through the lens of the situated documentary, a new form of immersive storytelling unique to journalism and grounded in the use of the locative or geographically coded media capabilities of AR.

Technological forces influence journalism and media in at least four fundamental ways. First, they transform how journalists and other media professionals do their work—that includes how they gather, edit, and produce the news and has the potential to improve productivity, efficiency, and access to information. Second, technological change transforms news and media organizations and business practices and models. Digital technology can restructure the delivery of news, greatly reducing the cost of delivering news, and thereby transform the news business model. Third, the relationship between media and their publics is redefined as audiences move from passive receivers to active producers of news and other social media. This transformation has the potential to improve the relationship among journalists, news organizations, and their publics by increasing the interaction among citizens, news, and journalists.

The extent to which these benefits have been realized is mixed and is subject to much debate. In many ways, these shifts have led to a decline in the role and influence of traditional news media in society, especially newspapers, which have been replaced by social media and other digital communication such as mobile media. As noted communication scholar James E. Katz observed, "It does appear that the special role that the newspaper has traditionally played in societies is likely to be substantially diminished."[1]

A fourth area in which technological forces influence journalism and media is the principal focus of this article. Technological change presents a fundamental challenge to notions and models of news and media content and storytelling. The significance of this content transformation is that it has the potential to engage journalism audiences and the media. Audiences have become disengaged from traditional news forms and have turned to social media and mobile communications to learn about their world.

Transforming the Content of Journalism and the Media

News content and its various attributes (e.g., sources, accuracy, timeliness, and ethics) are the core of the journalistic and media enterprise and are largely what separates journalism and the media from other endeavors. The convergence of digital technologies, the Internet, and mobile media dramatically transform the content and storytelling possibilities of journalism and other media forms.

Unique storytelling forms emerge in this convergent environment. The focus in this monograph is the innovative ways stories are told through the emergent technology known as augmented reality. We begin with a discussion of the theoretical considerations of AR, storytelling, and the diffusion of innovation in the context of journalism and media. Against this background, we examine a case study of the situated documentary, a form of journalistic storytelling uniquely possible in an AR-enabled media environment. Following this case study, we extend our analysis to the broader

development of AR as a potential form of storytelling in mainstream journalism, as well as other potential applications of AR in journalism and media. We do this analysis through the lens of a series of in-depth interviews with leading editors who have experimented with AR and technologists who have been on the forefront of AR development. We also draw on the results of a roundtable discussion with journalists and educators.

The situated documentary is based on the convergent technologies of mobile AR developed by John Pavlik and his computer science colleagues at the Columbia University Computer Graphics and User Interfaces Laboratory—Professor Steven Feiner, Tobias Höllerer, and Professor Bradford Garton of the Columbia Computer Music Center.[2]

Although AR is related to virtual reality, it enhances a user's interaction with reality through a computer-generated environment. AR allows a user to continue to see and hear the surrounding world but with additional sights and sounds that are synchronized to the exact location relative to a user's three-dimensional (3-D) orientation to a geographic locale.

In this monograph we define journalism by its function to survey matters of public importance as well as to interpret those events within a larger social context. Also included in journalism is the opinion and editorial function in which journalists and journalism organizations provide guidance to the public on matters of importance to a community or society at large. We define news as a principal subset of journalism, but one that focuses on the delivery of information. AR is central to journalism in that it serves the same essential function as news—it augments the user's experience with the real-world, natural environment. In the same way that no individual can survey his or her entire community, society, or world events on all matters of public importance, AR acts as an enhanced digital system of user interaction. This monograph explores this system of augmentation when employed by journalism for storytelling. Such a notion is in many ways a direct descendant of the theoretical work of Harold Innis and Marshall McLuhan, who suggested that the communication media act as extensions of the human senses. Just as journalism allows citizens to come to know, for instance, candidates for political office without ever meeting them, AR takes this function to an entirely new level.[3]

The concept of the situated documentary is based on the application of a mobile augmented reality system (MARS). AR has been in development for about two decades. It was initially not designed as a mobile platform. Preston Thomas Caudell developed the idea and coined the phrase *augmented reality* in 1990 while working for Boeing, where factory workers used AR to sort aircraft parts.[4] Consequently, many early developments were military and flight-oriented. L. B. Rosenberg created one of the earliest working AR systems, dubbed the Virtual Fixture, at the U.S. Air Force Research Laboratory.[5] This system illustrated the potential of AR to improve human performance, at least in the context of flight.

We propose here that AR has entered a third stage of development with a growing set of journalism and media applications. These three stages are outlined in Figure 1.

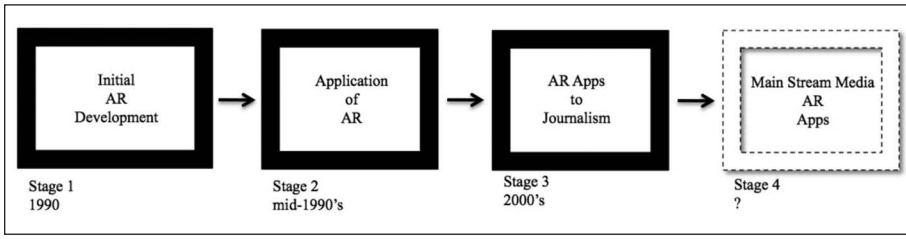


Figure 1. Stages of augmented reality (AR) development

The first stage is characterized by the initial research design and development of AR technology completely outside the realm of journalism and media fields. At this time, Caudell and others developed AR as a set of convergent technologies to aid in human performance in the field of aerospace engineering.[6] Caudell found inspiration in a 1937 lecture by Sir Charles Sherrington, who said the brain was like a "cosmic dance." Caudell explained that his interest in AR derived from wanting "to be able to visualize brain-like circuits." Ronald Azuma soon provided an expanded definition of AR.[7] He wrote that AR meant the augmentation of the user's experience of the real world that provided virtual information to improve an individual's senses and skills. This first AR stage of development lasted from 1990 for about four years.

The second stage in the development of AR involved the early evolution of AR into a form that could be applied to other fields of human endeavor. For example, AR was applied to a wide array of human activities that included medicine, media, and the arts. In 1994, for instance, self-described AR artist Julie Martin created an "Augmented Reality Theater production" dubbed "Dancing In Cyberspace," which featured dancers and acrobats who controlled body–sized virtual objects in real time as they were displayed simultaneously onto the same physical and performance space.[8] This period lasted about eight years. During this period, AR was still largely a research technology and reserved mainly for laboratories and expensive to use with some systems that often cost up to hundreds of thousands of dollars. Although the first mobile AR systems were developed during this time, most systems were often cumbersome and impractical and weighed about fifty pounds. However, early prototypes for journalism and media could be tested, as projects by Höllerer, Feiner, and Pavlik illustrate.[9]

The third stage of AR development emerges with an array of journalism and media applications, particularly in a mobile context with spatial orientation features.[10] The third stage is characterized by several important qualities. Among these are the miniaturization of AR technologies, the commercialization of AR, the availability of AR on mobile devices, such technologies as broadband wireless infrastructure, AR applications, or "apps" (mostly free and relatively easy to use), and geographic information systems (GIS). Consequently, there was a groundswell of journalism and media organizations that began to adopt and utilize AR technologies for journalism and strategic communication purposes.

We anticipate a fourth stage of development will occur, although its inception will be hard to predict. This stage is vital, however, to the effective utilization of AR in journalism and media organizations for several reasons. First, journalism and media organizations will fully integrate AR as a storytelling medium. Consequently, AR will be increasingly employed in stories on matters of civic importance such as investigative reporting, public affairs, and political corruption. Second, this is the stage in which AR will be widely integrated as a routine tool in news organizations, much as photography and informational graphics.

The Wireless Foundation of AR

Mobile AR technology relies on a unique invention from the days leading up to World War II. It is based partly on the design of player pianos in which the rolls of paper with perforations controlled the notes that the instrument would play, and partly on the genius of its inventor. Not only this technology design inspiration but also its developer were unlikely.

Born in 1913 as Hedwig Eva Maria Kiesler in Vienna, Austria, actress Hedy Lamarr became a prominent Hollywood movie star for Metro-Goldwyn-Mayer during the 1940s and for Cecil B. DeMille and others in the late 1940s and early 1950s. When her acting career was beginning to take off during the mid-1930s, she married her first husband, Friedrich Mandl, a Viennese arms manufacturer.[11] Mandl was not happy with her movie career, especially her on-screen nudity and passionate love scenes in the 1933 Czechoslovak film *Ecstasy*. As a result, he tried to curtail her career by taking her to meetings with technicians and business partners and often forced her to stay at their castle, the Schloss Schwarzenau. It was at these meetings where the mathematically talented and beautiful Kiesler, or Lamarr as the world would soon come to know her, learned about military technology and had her first exposure to the weapons manufacturing process.

In the late 1930s, Lamarr left Austria and divorced Mandl, making her way to the United States. There, she began to spend time with her acquaintance, George Antheil, an avant-garde American music composer from New Jersey. Together, they began work on what led to a patented "secret communication system" for the two in 1942. Antheil recollected to Lamarr how he had once envisioned a score that incorporated a series of synchronized player pianos along with various other instruments that would perform together like a machine, not just an orchestra. Though he was never able to realize his original composition, Lamarr adapted the theory behind it to solve a serious problem of World War II for the U.S. Navy—the detection or jamming of radio-guided torpedoes by enemy radar. By using the technology that Lamarr and Antheil patented in 1942, which incorporated a series of synchronized piano player rolls shifting among eighty-eight frequencies, torpedo communication was able to "hop" from frequency to frequency in an apparently random pattern, making it extremely difficult for the torpedoes to be detected after launch. Lamarr dubbed this process "frequency hopping." Lamarr's invention proved to be decades ahead of its practical realization, and the

U.S. military rejected it at the time. Lamarr's invention was not employed until the 1962 U.S. naval blockade of Cuba.[12]

Today, Lamarr's technological innovation is an important foundation for the modern spread-spectrum communication technology—cellular communications, Bluetooth, and Wi-Fi—that is a key to mobile AR technology.[13] Lamarr has been widely recognized for her contributions to the field of mobile communication. In 1997, she received the Pioneer Award from the Electronic Frontier Foundation.[14]

In the context of journalism and the media, AR involves layering data such as audio, graphics, photos, video, and animation over live video displayed (or presented) on a handheld or wearable display (or speakers), synchronized to specific locations in the context of the individual's exact geographic position and orientation. Among the most common current AR media applications are sports and hand-held video games, such as the Sony PS Vita AR hand-held video game introduced in 2012.[15] In sports telecasts, AR is often seen in television broadcasts of U.S. football games where a yellow line shows viewers the position of the first-down marker and a blue line marks the line of scrimmage. These virtual lines help fans see where the offense needs to advance the ball to get a new first down and keep possession of the football. The real-world elements on the screen include the players and the actual football field, but the yellow and blue lines are virtual, augmented forms of reality seen only on television and are added digitally. In various other sports, such as ice hockey, a similar AR colored trail shows the location and direction of the puck. Swimming telecasts sometimes include AR lines to mark the position of a current record holder and whether a swimmer in a race is on pace to set a new record. On rugby or soccer fields, televised AR displays of virtual advertisements sometimes change throughout the matches. However, these applications are limited forms of AR in that they are not interactive with the viewers. They are only displayed on the screen.

Mobile AR layers traditional forms of data using geo-tagged content on smartphones or head-worn displays. This technology could also be used to aid those with disabilities. For example, tactile (haptic) and aroma media forms, as used in games, would offer intriguing, interactive storytelling capabilities, as well as creative tools to develop an AR media interface for persons with disabilities.[16] Pavlik, Avrahami, and Pineda have studied the potential of a related technology, video as input (VAI), as a medium for communication for persons with disabilities.[17] Although hand-held AR applications have also entered the commercial marketplace, research by Feiner suggests there is still much development needed to make these systems effective.[18]

VAI is an emerging tool for interacting with a digital device. In the late 1990s, Pavlik et al. proposed it as a hands-free interface for interacting with or controlling a computer. Rather than using the keyboard or mouse as the means of inputting information, VAI "treats the camera (a proxy for the eye) plus the PC (a proxy for the brain) as an intelligent input device, rather than a simple streaming device." Results from a series of user studies (three focus group interviews) indicate that the response to VAI applications for storytelling is encouraging. Although there are important questions that arise, the response from three different user groups was uniformly positive to the concept of applying VAI to storytelling, for both journalism and education generally.

First, in a VAI interface, much as in AR, users see themselves in the story, both literally and figuratively, which fosters a feeling of greater empathy for what and whom they encounter in the story. By seeing themselves in the story (i.e., a first-person narrative model, as in an AR storytelling narrative model), they get a fuller sense of the context for an event or occurrence. VAI gives the user an opportunity to learn by doing. Of importance, VAI gives the user a form of "natural control" over the development of a story. It enables him or her to interact with the story, its characters, and the narrative through physical movements. A user practices a behavior and gets reinforcement from an avatar programmed to recognize particular actions (e.g., a gesture, a movement, a tilt of the head). Because of the avatar's ability to respond to particular user behaviors, the user may get a psychological boost from the feeling of interaction.

Second, VAI addresses issues of computer literacy because of its more natural user interface. VAI provides greater accessibility to stories for persons with disabilities, persons who may not have sophisticated keyboard skills, including prekindergarten to second grade students, and international audiences.

Third, VAI has the potential through multiuser, networked applications to bring multiple users into a shared story environment where learning can be enhanced through user interaction.

Commercial applications of VAI technology have entered the consumer marketplace with various games such as the family-oriented "Double Fine Happy Action Theater" for the Xbox Live Kinect.[19] The downloadable Happy Action Theater employs the Kinect camera to capture an image of the user's room and then places the user, his or her family, and the surroundings into the game. The users see themselves and their furniture in the game, but everything has been altered. They can react to hot lava flowing into the room, play with virtual snow, or respond to a school of fish swimming in a digital ocean.

AR is a part of a broader emerging field known as computational journalism (CJ). CJ is emerging from the convergence of traditional journalism and media and computer and information science. Hamilton and Turner note that CJ scholars "use their convening power to draw together university researchers to focus on CJ tools . . . drawing together journalists, communication scholars, and computer scientists to work on a suite of reporting tools."[20] CJ also represents an opportunity for innovation in news organizations.[21] Online journalist Geoff McGhee, who received 2009–2010 John S. Knight Journalism Fellowship at Stanford University, developed a video report on databased visualizations as a storytelling medium for journalism.[22] Web inventor Sir Tim Berners-Lee is convinced mining data is critical to the success of journalism in the twenty-first century. "Data-driven journalism is the future," he insists.[23]

Rogers's Diffusion Model

Underlying the introduction of AR in journalism and media is the theoretical work of pioneering social science scholar Everett M. Rogers, who established a considerable

body of work on the adoption and diffusion of innovations. Like many other influential scholars, Rogers built on the ideas and investigations of researchers before him and made it much of his life's work to study and write about the adoption and diffusion of innovation. In his seminal work, *Diffusion of Innovations*, now in its fifth edition, Rogers outlined the process that innovations (both products and ideas) must go through before they are ultimately adopted, or rejected, by individuals or organizations.[24] Rogers's research delineated five stages in the process of adoption of an innovation. These stages are (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation.

In the knowledge stage, an innovation becomes known but there is insufficient information. In the persuasion stage, potential users become interested in the innovation and seek more information. In the decision stage, the innovation is evaluated with advantages or disadvantages listed that help to adopt or reject it. If the innovation is adopted, the implementation stage involves a trial of the innovation in which the overall usefulness of the innovation and whether it should be used on a larger scale are assessed. Finally, the confirmation stage involves the adoption of the innovation to its fullest potential.

Rogers's theoretical work on adoption and diffusion of innovations applies in at least two ways to AR and journalism and media organizations. First, it applies to the news and media organizations themselves. News and media organizations need to go through these five stages, first learning about AR and its application to journalism and storytelling, following through the other four stages, persuasion, decision, implementation, and confirmation. At the same time, the public must go through these five stages as well for AR to become a technology utilized by news consumers.

Rogers's research also shows that the rate of adoption of an innovation is influenced by at least five factors, including (1) the perceived relative advantage of the innovation, (2) compatibility, (3) complexity or simplicity, (4) trialability, and (5) observability. For AR to diffuse relatively rapidly among journalism and media organizations, as well as be adopted for use by news consumers, these five factors will all come into play. The relative advantage of AR as a storytelling tool will influence the use of AR by journalists and editors. News consumers' perceptions of the relative advantage of AR-enhanced stories will also influence their likely adoption of the use of AR in media applications. If AR is seen as simpler to use, it will likely be adopted more rapidly. If AR is easy to try and if it is apparent that others are using AR, the rate of adoption of AR in journalism and media will increase.

Rogers also identified five categories of adopters of new technologies, or innovations.[25] In general, as shown in Figure 2, the earliest adopters of a new technology, or innovators, represent about 2.5 percent of all potential adopters of an innovation. These individuals, or organizations, if they connected with an innovation, Rogers suggests in *Diffusion of Innovations*, will also become advocates for it. So-called early adopters represent about 13.5 percent of the population, while the early majority represents about one-third, or 34 percent. The late majority represents another one-third, or about 34 percent. Laggards, or late adopters, represent the final 16 percent.

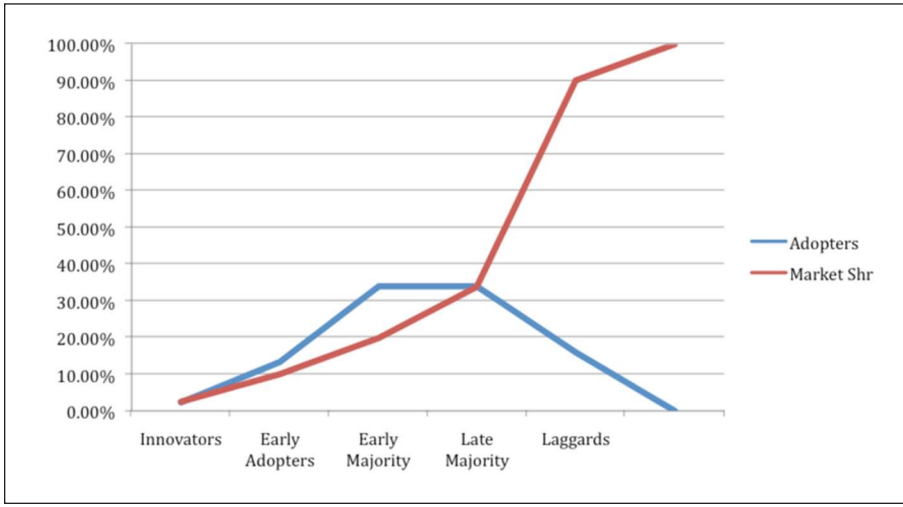


Figure 2. Adopters of innovations according to Rogers's model

In applying Rogers's model to journalism, research suggests it is only the leading 2.5 percent of news organizations, or innovators, that have adopted locative media, particularly in the form of AR, as of 2012. Among the earliest adopters of AR in newspapers are the *New York Times, USA Today*, the *Wall Street Journal*, and the *Boston Globe* in the United States and the *Financial Times* and other leading news organizations such as the BBC internationally.

Two of the commercial AR technologies most widely adopted by news media at this writing are Junaio and Aurasma.[26] The free downloadable application from the iTunes store is called Aurasma Lite. Aurasma has been identified in research as a powerful commercial AR technology for a mobile platform experience. Among those news organizations to introduce the use of Aurasma in 2011 are the *New York Times*, the *Wall Street Journal*, and the BBC. The *Wall Street Journal* and the *New York Times* have utilized Aurasma as a tool for integrating mobile media with the printed newspaper product, or potentially for a mobile AR news experience. Research indicates that this convergence is a mechanism for engaging digital media consumers into closer contact with traditional media and for longer periods of exposure.

Junaio was introduced before Aurasma. It was used in 2010 by several news organizations, among the earliest media adopters of AR, including *USA Today* and the *Boston Globe*. Junaio proved to have limited technical capability, however.

Via Aurasma, a camera-equipped smartphone or tablet pointed at a newspaper or magazine can recognize a two-dimensional image and then recall and overlay a prerecorded video or 3-D object onto that image, potentially adding audio as well. By pointing an iPhone or iPad at a newspaper article with a photograph of presidential candidate Mitt Romney, for example, video of a speech by Romney could begin

Figure 3. Sample view of augmented reality (AR) embedded in a newspaper

playing on the mobile device synchronized over the newspaper photo. Shown in Figure 3 is a sample of what such AR-enhanced content embedded into a newspaper article might look like. Illustrated here is a YouTube video clip from a lecture by the senior author embedded into a column he wrote as department chair for a recent issue of the Rutgers student publication, *Alum-Knights*, and made accessible via a mobile device running the Aurasma app.[27]

AR has not been fully integrated into newspapers or magazines as a news storytelling or reporting experience, as of this writing. Rather, news and media organizations have employed Aurasma, Junaio, and other commercial AR applications in an experimental fashion as a marketing tool as well as for some cultural and sports reporting, such as to virtually tour a football stadium or to provide citizens a guide to local cultural events. The *New York Times*, for instance, has used Aurasma as a tool to enable readers to engage interactively with the masthead of the newspaper. Readers who have installed Aurasma on their smartphone or tablet computer could point the camera at the masthead of the newspaper and the Aurasma software would recognize an embedded AR multimedia experience and activate it. For example, on March 1, 2012, that AR experience was a Harry Potter *Daily Prophet*–like interactive animation of the *New York Times* banner that became 3-D type that shortly transitioned into a 3-D animation of New York City, simultaneously playing the theme song from the 1977 Martin Scorsese film *New York, New York*, with an unidentified male crooner singing, "Start spreading the news . . . I'm leaving today." On another day, November 12, 2011, the Aurasma Lite AR enhanced *Times* masthead featured an animated virtual South African actress Charlize Theron.

Despite the obvious gimmick approaches to AR, these marketing applications may have significant implications for journalism, journalists, and their parent news organizations. In an age when newspapers and other news media have struggled to reinvent their business model for the Internet and the mobile and global media marketplace, AR and other locative forms of media content can present significant marketing opportunities. Not only can news media utilize AR for promotional purposes, but also AR can be an effective advertising medium.

AR is already beginning to transform the retail business.[28] Retailers use AR applications to enable consumers to shop at home, create virtual changing rooms for consumers in their own living rooms, let shoppers try on a variety of virtual wardrobes, and see themselves on-screen in various clothing styles, colors, and combinations. Using printed images of products held in front of their computer or other web-enabled cameras, consumers can virtually interact with those products. Combined with a 3-D printer, consumers can use AR to not only try out a product at home but actually buy, download, and print it out.[29]

In the past, there have been exceptional examples of innovations that have transformed the storytelling nature of journalism. The advent of photography in the early nineteenth century is one illustration. This technology was quickly seen as significant by Samuel F. B. Morse, an innovator most known for his role in the invention of the electromagnetic telegraph.[30] Morse introduced American newspapers to the budding technology of photography after a visit to France where he had seen the daguerreotype, an early form of photography invented by French artist and chemist Louis J. M. Daguerre and his collaborator, Joseph Nicéphore Niépce.[31] Morse had visited Paris in 1839, and on his return to New York he wrote his own description of the daguerreotype. Morse observed that it was "one of the most beautiful discoveries of the age." His description was published in the *New York Observer* on April 20, 1839.

Likewise, Walt Whitman, the celebrated American poet and former editor of the *Brooklyn Daily Eagle*, published on July 2, 1846, in his newspaper these words of praise for the daguerreotype: "In whatever direction you turn your peering gaze, you see naught but human faces! There they stretch, from floor to ceiling—hundreds of them. Ah! What tales might those pictures tell if their mute lips had the power of speech! How romance then, would be infinitely outdone by fact."[32] Whitman's words foreshadow the twentieth-century invention of television or cinema with sound.

Within a few years, newspapers across the United States began publishing daguerreotype images, transforming the storytelling abilities of the newspaper medium. An early news photograph taken in 1853 that used daguerreotype technology is available online at the website of the U.S. Library of Congress.[33] It illustrates a boating tragedy on the Niagara River in New York where three men in a small boat were overwhelmed by the river's current and crashed into a rock. As the Library of Congress notes, "The current carried two men immediately over the Falls to their deaths. The daguerreotype shows the third man, stranded on a log, which had jammed between two rocks. He weathered the current for eighteen hours before succumbing to the river."

AR is poised to transform the storytelling of twenty-first-century journalism in perhaps the same fashion as photography of 150 years before. What may be needed today is a modern-day Walt Whitman or Samuel Morse who can see the potential in a new and novel technology whose potential is perhaps best captured in poetic verse. Where is this digital wordsmith, the journalist of augmented storytelling vision?

Research shows that adopting innovations can pose a dilemma for incumbent news organizations because the cost of the investment in new technologies for incumbents may be higher than for newer entrants.[34] Meanwhile, to not adapt may be a death knell. News executives are thus increasingly placing a greater emphasis on flexible work environments and research and innovative use of technology, if not investment.[35] Research also suggests that early adopters of a technology "receive less of a benefit than later adopters do."[36]

Part of the newsroom innovation problem may be organizational. An increasing amount of research suggests that creativity is stimulated by conflict. "It is the human friction that makes the spark," writes Jonah Lehrer.[37] He dispels the myth of brainstorming, popularized in the late 1940s by Madison Avenue executive Alex Osborn of the advertising firm BBDO and a former newspaper executive. In his book *Your Creative Power*, he outlined his theory for innovative thinking which became a staple in corporate America and in university classrooms. He proposed that groups could brainstorm more imaginative ideas in less time than individuals working alone, but the key was that there should not be any criticism voiced during the group brainstorming sessions. Creativity was too fragile, he believed. Criticism would cause those criticized to say nothing at all.

However, research showed that Osborn was wrong. Yale social scientists and others demonstrated the same number of individuals working on the same assignment for the same amount of time produced more and better solutions, as judged by a panel of independent experts, than a brainstorming group that consisted of the same number of individuals who worked for the same amount of time on the same assignment.[38] The problem for brainstorming groups is they start to think alike. Conflict may be uncomfortable at times, but it forces self-reflection and stimulates critical thinking. It yields more and better ideas. News organizations and their management may draw important lessons from this growing body of research about how to structure and design their organizational culture to stimulate creativity and innovative thinking and problem solving at this critical, technologically driven juncture in the twenty-first century.

Research indicates much of the innovation in the digital age has been occurring outside the realm of news organizations.[39] Large organizations such as Google and Apple as well as smaller operations such as ChicagoCrime and Everyblock.com often prove to be the most innovative in their use of emerging digital, online, and mobile technologies. Established news organizations have not been always at the forefront of digital innovation, although there have been occasional exceptions. Furthermore, research reported in early 2012 by the Project for Excellence in Journalism (PEJ) indicates that technology intermediaries such as Google, Facebook, and Apple "now

control the future of news."[40] Moreover, the PEJ study suggests that unless news organizations innovate now and in dramatic fashion, the problem may get worse. "The gap between the news and technology industries is widening." PEJ warns, "In the last year a small number of technology giants began rapidly moving to consolidate their power by becoming makers of 'everything' in our digital lives." These digital giants are "maneuvering to make the hardware people use, the operating systems that run those devices, the browsers on which people navigate, the e-mail services on which they communicate, the social networks on which they share and the web platforms on which they shop and play. And all of this will provide these companies with detailed personal data about each consumer." News media are being left out of the equation—an equation in which they once were factored in a central position.

For much of the twentieth century, journalism, especially in the United States, enjoyed a relatively comfortable economic position. Consequently, there was something of an economic disincentive to innovate, despite an erosion of market position in the latter half of the twentieth century. U.S. newspaper companies produced double-digit profit margins for much of the twentieth century, as did many American television news operations while they utilized free use of the public airwaves. With the digital revolution at the end of the twentieth century and the emergence of what has come to be known as "new media" (although this term had been used at least as early as the 1960s to describe earlier emerging technologies for teaching and learning), more entrepreneurial individuals and organizations outside traditional journalism saw opportunities to use digital technologies in creative and efficient means to variously tap markets and financial resources once the basis of the news industry.[41]

Companies such as Google, Yahoo!, Craigslist, and eBay developed online advertising and auction services that were highly targeted and efficient. The rise of social media, particularly Facebook, YouTube, and Twitter, drew advertisers to the more than one billion individuals who subscribed to these services and were interactively utilizing these services and actively engaging in clicking on advertisements placed on them. These various innovative nonjournalism organizations facilitated a dramatic decline in the revenues of traditional news organizations, especially newspaper companies that had not innovated aggressively in recent decades.

Such news media innovation is rare, however, in the digital age. When it does occur it can bring about dramatic change. Research shows, as Carey and Elton report, "the Holy Grail in new media adoption is stunning innovation—a device or service that not only meets but dazzles people through its creativity, user interface design and appealing content. It is a worthy but rarely achieved goal."[42] "Apple's iPad, introduced in 2001, is an example of a stunning innovation." The innovator behind this stunning innovation, however, was not a journalist or journalism leader but rather Steve Jobs, a pioneer of the digital age, whose leadership helped transform a recalcitrant music industry, reluctant to enter the world of online music distribution. Jobs proved that digital music distribution was viable and profitable, and the problems of intellectual property rights, royalties, and digital rights management and piracy were not insurmountable.

Marketing opportunities with AR are interesting and may be useful from a business point of view for journalism, but they have limited potential, at least in terms of the role of journalism as a cornerstone of democratic society. Storytelling represents a far more substantial opportunity for journalism, and a means to engage readers in a meaningful way with content or stories in a deep fashion. Consider a case in point.[43] On October 25, 2011, the *New York Times* published a fascinating report about the late influential American comedian George Carlin who not only made people laugh but also challenged them to think and shook up their politics in the process. Among his most provocative comedic performances was Carlin's famous "seven words" routine. In this routine, Carlin identified and spoke seven English words that he claimed could not be said on radio or television, at least not without penalty by the Federal Communications Commission (FCC, the federal body the regulates broadcasting in the United States). These seven words were considered obscene, Carlin claimed, to great humorous effect, and also much social commentary.[44] The words were almost certainly inspired by another controversial comic, Lenny Bruce, who in 1966 offered a performance that included those same seven words plus two.[45] Bruce reported he was arrested for saying those nine words. Carlin's routine was released on an album in 1972, and then he performed a similar routine titled "Filthy Words" in 1973, and it was broadcast on the Pacifica radio station WBAI-FM, uncensored on October 30 of that year.[46] John Douglas, a member of an organization called Morality in Media, said he heard the broadcast with his fifteen-year-old son and filed a complaint to the FCC, which took action against Pacifica.[47] Douglas said that the material was inappropriate for the time of day it was broadcast. The case eventually made its way to the U.S. Supreme Court. Ironically, in 2012, the Supreme Court again considered the matter of obscenity and broadcast standards in U.S. television in the age of media convergence.[48]

With Carlin's passing, residents of West 121st Street on the Upper West Side of New York City where Carlin grew up have started an initiative to have the block between Broadway and Amsterdam, where Carlin lived, renamed in honor of the legendary comedian.[49]

Although residents have signed a petition to rename the street, the block also has opponents to the renaming, among them the Rev. Raymond Rafferty, pastor at Corpus Christi Church. Carlin attended Corpus Christi School, which is located on the block of West 121st street, through the eighth grade. But as reported in the *New York Times*, Rafferty says of Carlin, "His early comedy made mockery of Corpus Christi parish and its priests."[50] For this reason (and perhaps others), Rafferty is opposed to renaming the street in the late comic's honor.

The reporting and storytelling in the *New York Times* about the renaming is useful but missed a compelling opportunity to utilize the potential of AR. With Aurasma, the newspaper could have fully engaged a wider range of media and attracted a more youthful, mobile audience. In the October 15 report on Carlin, the *Times* provided a photograph of Carlin standing in front of Corpus Christi school. The newspaper could have embedded into the picture of Carlin an AR video link to Carlin's seven words monologue.[51] This video would provide for readers unfamiliar with Carlin's work the

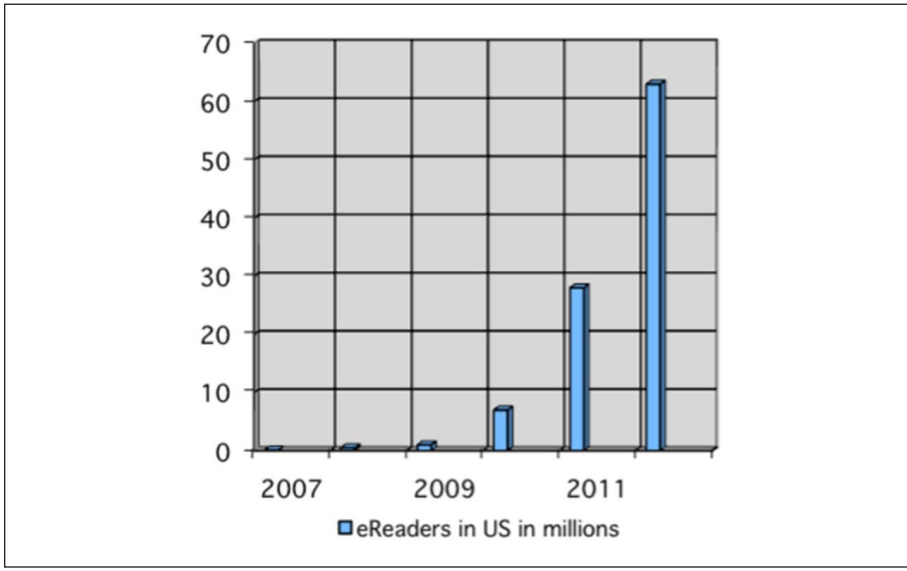


Figure 4. eReaders in the United States in Millions

context to better understand the historical context of the controversy of renaming the street in his memory. In such a possible AR application, it would be most effective to embed an icon of some sort into the white space adjacent to the photo indicating to the reader that an AR experience is available. This would permit readers to efficiently recognize when in a newspaper (or other printed product) there is an AR-mobile convergence experience available.

For AR experiences to be effective requires a significantly installed base of smartphones and tablet devices and necessary software. These requirements are increasingly being met in the United States and much of the developed world.[52] In the United States the installed base of these smartphones and tablets is more than 165 million.[53] The installed base of tablet devices alone exceeded 65 million in the United States as of 2012, as shown in Figure 4. Apple reported selling more than three million iPad tablets in the first three days of its launch on March 16, 2012.[54] Furthermore, as reported by the Pew Center's PEJ, "In 2011, the digital revolution entered a new era. The age of mobile, in which people are connected to the web wherever they are, arrived in earnest. More than four in ten American adults now own a smartphone. One in five owns a tablet. New cars are manufactured with Internet built in."[55]

Second, an app such as the free Aurasma Lite needs to be installed on the device. As of July 11, 2011, more than one million users had installed Aurasma onto their smart phones or tablet devices, making it the most widely used AR mobile platform.[56]

Beyond embedding an AR experience into media content in a printed product, AR can be effectively integrated into the real world for citizens using their mobile devices. Consider the case of persons who visit West 121st street in New York City.

Storytelling can be available to those traveling down the street, past Corpus Christi school and church, visiting the places where Carlin used to live, play, and go to school. Anyone with a smartphone could retrieve stories in a variety of formats that news, media organizations, or citizens have made available. For instance, a video interview with Rev. Rafferty, the pastor at Corpus Christi Church, could be linked directly to the site of the church. A copy of the petition could be linked to the street sign on the corner along with a video interview with a resident on the street who signed the petition.[57] A link could be made available on a variety of locations along the street to various Carlin monologs, including his seven words bit, as well as a link to the U.S. Supreme Court case it ultimately led to, not to mention the FCC ruling on the Pacifica broadcast. AR-enabled content could also be embedded into Google Earth to provide locative media storytelling that would eliminate the need for users to travel to distant locations to access that content.[58]

Applications of AR for hard news or political reporting will probably not be the first areas where mainstream news or media organizations express innovative storytelling techniques. More likely are entertainment-related venues, including sports and travel, as suggested by the authors' interviews with editors at forward-thinking newspapers and magazines that have already used AR. These domains also lend themselves to the visual storytelling capabilities of AR. Moreover, the fifth stage of Rogers's diffusion model, observability, has implications here. Editors who are in the early adopter stage of Rogers's model and have considered the use of AR will probably notice other early adopters of AR who use this innovation for sports and travel reporting. Consequently, they are more likely to follow their lead. *Sports Illustrated*, for instance, in its February 17, 2012, annual Swimsuit Issue, featured AR enhancements for anyone who subscribed to the magazine or purchased a copy.[59] With the appropriately installed AR app (a special SI Swim Viewer for various mobile devices), magazine readers could download videos of the swimsuit models pictured in the magazine by pointing their smartphone camera at the appropriately tagged model as depicted in the issue.

Travel reporting, given its geographic basis and the mobile requirements for the traveler is also a natural AR application. *National Geographic* in late 2011 reported on how the marriage of GPS and Internet access with digital photography, maps, social networking, language-translation software, and AR will bring a transformation of the mobile media experience in 2012 for travelers.[60] Via this combination, AR embeds useful information into an individual's surroundings and permits travelers to "visit" a new foreign destination and quickly identify that location, obtain relevant historical information, and then, via related news sites, acquire recent or archival news stories.

Consider the case of one international story from March 24, 2012, the sixty-eighth anniversary of the so-called "great escape" from the WWII prisoner of war camp known as Stalag Luft III.[61] Located near the western Polish city of Zagan, two hundred kilometers southeast of Berlin, the camp and its story were immortalized in the 1963 Hollywood film, *The Great Escape* starred Steve McQueen. Imagine being able to virtually retrace the tunnels nicknamed "Harry" and "George" dug by the Royal Air Force fliers, explore the sixty-acre site constructed by the Germans to serve as a prison

for the estimated ten thousand captured fliers, or come to grips with the retribution the Nazis exacted following the escape as they executed seventy-three of the seventy-six escapers they eventually recaptured.[62]

This story could be told via AR in at least three ways. It could be explored by visitors to Zagan via their mobile devices with the AR experience and content embedded fully on their smartphone, integrated and told in a convergence of print and mobile device, and experienced virtually by persons located anywhere in the world with Internet access.

Method

This monograph is based on the use of a multimethod research approach. The cornerstone of this research is a case study of the use of a new type of documentary developed by the senior author and his colleagues in computer science and computer music at Columbia University. Known as the situated documentary, this form of documentary that uses AR was developed as a proof-of-concept prototype to evaluate the viability of AR as a storytelling medium for journalism. This monograph examines the case study in detail.

In addition, in-depth interviews with a series of leading editors from innovative newspapers and magazines were conducted. Interviews were conducted with senior editors and those in decision-making positions on the use of AR in those media. The editors are identified in this monograph, as are their media outlets. Interviews were made via a combination of telephone and email follow-up formats. Questions were nonstructured and open-ended. Supplemental to these editor interviews were in-depth interviews with senior technologists at companies with commercial AR applications. These interviews were conducted to obtain information about current and future developments in the AR field. These interviews were conducted via telephone and email follow-up.

Finally, a roundtable discussion with thirteen journalists and journalism, media, and communication educators was employed. Participants were recruited by the authors and based in the New Jersey–New York region. They were not reimbursed for their expenses for participating in the roundtable, but they were provided a free lunch at the outset of the discussion. The participants were audio-recorded for an accurate record. All of them were told in advance of the purposes of the roundtable and that the meeting would be recorded. A list of participants is provided in Table 1.

The authors obtained a waiver for this research from the Rutgers Institutional Review Board for human subjects rights in research.

The Situated Documentary: A Case Study in AR Storytelling

The situated documentary is a form of immersive storytelling based on a theoretical model derived in large part from the same conceptual framework as the VAI model

Table 1. Roundtable participants

	Position	Organization
Journalism and communication educators		
Ron Miskoff	Associate director, faculty	JRI, SC&I, Rutgers
Anselm Spoerri	Faculty	SC&I, Rutgers
Matthew Weber	Faculty	SC&I, Rutgers
Jon Oliver	Assistant dean	SC&I, Rutgers
Andy Mudrak	IT systems architect	SC&I, Rutgers
Robert Montemayor	Faculty, director	Latino Information Network, SC&I, Rutgers
Steve Garwood	Instructional design and technology specialist	SC&I, Rutgers
Robb Crocker	Part-time lecturer	SC&I, Rutgers
Journalists		
Heather Taylor	Staff	New Jersey Online News Resource Group
Jennifer Bradshaw	Editor	Patch
Hank Kalet	Regional editor	Patch
Garry Pierre-Pierre	Publisher, faculty	*Haitian Times*, CUNY Graduate School of Journalism
Michael Turton	Editor at large	philipstown.info

outlined above. In a situated documentary, a user experiences past news events while he or she wears a head-worn display and visits and walks or otherwise travels through the location where those events took place. The user's experience is somewhat analogous to a museum audio tour. However, instead of an indoor venue, a situated documentary can take place anywhere in the world with geo-tagged multimedia enhancements. The idea is to tell stories where the events took place via interactive and immersive multimedia presentations embedded in the real world. AR enriches an individual's experience with the real world. In many ways, this format is a natural extension of what place-based journalism has historically done best—stories are put in a local context and act as a supplement to a citizen's direct experience with the world. An artifact of this style is evident in the first part of any story in a newspaper—the dateline that identifies the location where a story was reported. In the analog age of news and media, this is the extent of precision possible. In the digital age, with global positioning systems (GPS) capable of measuring locational information within inches, precision can be much greater than a mere dateline. The location of stories, including those reported in situated documentaries, can be much more precise with every fact (or source) geo-tagged to the exact location where it was reported, observed, or gathered. This information is provided to a user and woven into a narrative. This technology brings the story to life in a 3-D, interactive form that allows the user a level of participation impossible in traditional, analog media.

The situated documentary allows us to examine the emerging transformation of the storytelling model of journalism from the analog to the digital age. In the traditional model of analog journalism, storytelling is dominated by a linear presentation of facts, typically from beginning to end. The audience experiences the story in a passive—almost voyeuristic—mode. Stories tend to have a single or sometimes dual modality of media forms (e.g., text, or text combined with photographs, infographics, audio, and video). A story is published and fixed in time. Corrections might be published later as an afterthought. Stories tend to be based on events and, as such, are episodic rather than contextual. The voice of a typical story is that of a third-person narrative, perhaps best characterized by legendary *CBS Evening News* anchor Walter Cronkite's signature sign-off, "And that's the way it is."

The new media storytelling model is nonlinear. The storyteller conceptualizes the audience member not as a consumer of the story engaged in a third-person narrative, but rather as a participant engaged in a first-person narrative. The storyteller invites the participant to explore the story in a variety of ways, perhaps beginning in the middle, moving across time, or space, or by topic. Nonlinear storytelling may come as a bit of a shock to some traditional journalists, but it is possible to adapt to new technology without sacrificing quality and integrity.

One of the greatest of all storytellers, Pete Seeger, writes in his book *Pete Seeger's Storytelling Book*, "Not long ago I thought every good story needed a beginning, a middle, and an end. Then my grandson Kitama came along."[63] Kitama is a young journalist working in the digital age. One day Pete asked him, "Kitama, do you ever finish your stories?" "No," he answered. "I just start them." In many ways, that answer is an essential difference between a traditional news story and a situated documentary. Situated documentaries are dynamic and continue to evolve as events in the real world evolve. They encourage the reader to interpret and bring meaning to a story.

Another key difference between the two forms is that with situated documentaries, stories are more contextualized and placed within a broader environment of events, trends, and issues.[64] Rather than presenting a story in isolation, a situated documentary associates the story with other related events. Consequently, an individual can see where the story fits into a broader pattern.

In a situated documentary, the story is also interactive and engages multiple modalities that include tactile and other sensory input. The story can be dynamic over time and can continually evolve as additional reporting through citizen input by social media is encountered. A situated documentary is immersive. It places the user into a compelling 360-degree AR 3-D environment. For individuals, the narrative is experienced from a first-person point of view where they are more of a participant of past events rather than simply observers or readers of them. This model is similar to a video game or the experience of creating and engaging in social media websites such as YouTube or Facebook, rather than a newspaper or evening newscast on television.

To create the first situated documentary, as well experience one, involved the design of an early prototype of the Mobile Journalist Workstation (MJW), circa 1996.[65] The components of the 1996 model include a variety of convergent technologies such as a backpack computer that weighed about fifty pounds, a differential GPS that was

Figure 5. Augmented reality (AR) view of Columbia University campus
Source: © 1999, T. Höllerer, S. Feiner, and J. Pavlik, "Situated Documentaries: Embedding Multimedia Presentations in the Real World," in *Proc. ISWC '99: IEEE International Symposium on Wearable Computers* (San Francisco: IEEE, 1999), 79–86.

accurate within half an inch, and a head-worn display with orientation tracker. The combination of technologies permits the user to navigate and select objects in the field of view by simply looking at an object for half a second rather than moving a virtual cursor over that object and clicking a virtual mouse on it. Research suggests that this is a more intuitive user interface in a hands-free field setting.[66] Also included in the MJW are Wi-Fi access, a handheld computer, a GIS, three software systems for 3-D modeling (MJW3D, Coterie, and Java 3D), and a 360-degree camera/microphone for omnidirectional audio and video captures. In the years since the early prototype, there have been a variety of important advances. Significant miniaturization and more powerful communications and computing improved graphics and video that greatly enhanced mobility.

Although current cellular technology makes simplified AR applications possible, the full-situated documentary requires a wearable display. Shown in Figure 5 is a view of the Columbia University Morningside Heights campus on the upper west side of Manhattan at West 116th Street via MJW. The 3-D virtual flags denote points of interest. In the "VisualSelect" mode, the user selects objects by gaze. This feature is significant in that it allows a user to operate in a hands-free mode for a more intuitive interface as well as a more efficient interface control. A green cone snaps onto the flag in the user's gaze. The flag gently waves and changes color to indicate the user has

Figure 6. Augmented reality (AR) view of Low Library, where student protesters occupied the university president's office in 1968
Source: © 1999, S. Guven and S. Feiner, "A Hypermedia Authoring Tool for Augmented and Virtual Reality," *New Review of Hypermedia and Multimedia* 9, no. 1 (2003): 89–116.

selected it. The initial color denotes the story—red for revolt, blue for tunnels, green for asylum, and pink for the invention of FM radio.

Pavlik and Feiner's students produced a series of situated documentary prototypes. Among these prototypes is the 1968 Columbia Revolt, which includes several hours of multimedia place-based content.

Among the locations where important story elements can be experienced are Morningside Park, where student protesters clashed with police, and Low Library, where student protesters occupied the university president's office, as depicted in Figure 6. The user can explore and experience in multimedia form what the protesters found in former Columbia University President Grayson L. Kirk's office and better understand the protesters' motivations for the strike. In Fayerweather, visitors can re-experience a wedding performed by the campus chaplain during the strike, as shown in Figure 7. Pavlik and Feiner's students not only found archival footage of the wedding but also reinterviewed the former student bride, who was still living in New York. Her husband had recently died.

Visitors can explore virtually by tele-immersion the mile of tunnels that honeycombed beneath the campus. First built to connect buildings for the Bloomingdale Insane Asylum, the tunnels predate the campus. Geo-synchronized, superimposed 3-D imagery brings the asylum to life, and a user-controlled app allows the visitor to

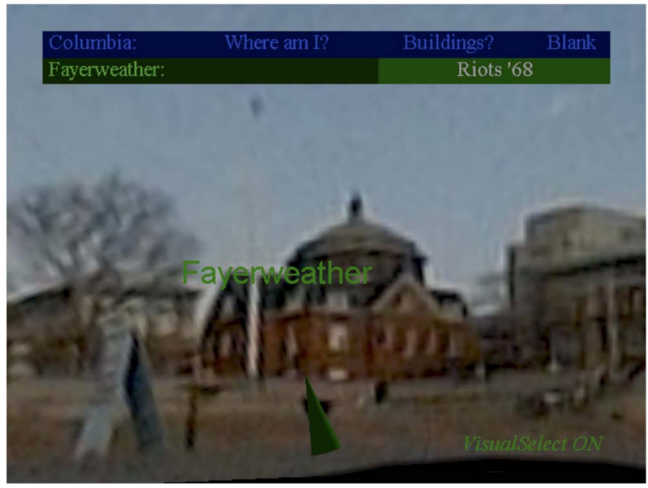


Figure 7. AR view of Fayerweather Hall, where campus chaplain married two student protesters.
Source: © 1999, T. Höllerer, S. Feiner, and J. Pavlik, "Situated Documentaries: Embedding Multimedia Presentations in the Real World," in *Proc. ISWC '99: IEEE International Symposium on Wearable Computers* (San Francisco: IEEE, 1999), 79–86.

virtually time travel by selecting the year of choice and seeing the campus transformed instantly into that bygone time. After the university expanded the tunnels for the college campus, students used them during the 1968 student protest. Physicist Enrico Fermi also used the tunnels when he began building a nuclear pile in the basement of a Columbia building in the years leading up to World War II. He enlisted the Columbia football team to haul radioactive material via the tunnels to the pile.[67]

By 2007, there were a variety of commercial versions of MARS applications that included handheld cell phone virtual mapping field trials from Nokia 6680 and Japan's Geovector.

By 2008, MARS technology had become lightweight, compact, and more powerful. Devices could fit in one's pocket and cost less than $5,000. By 2009, AR had become not only unobtrusive and lightweight, but also fashionable. See-through eyewear from SBG Labs had a miniature projector in its frame. Holographic optics could generate an overlay image, such as a map, news story, or advertisement to the wearer's destination. Professor Babak A. Parviz's University of Washington research team has taken this idea a step further by creating an AR contact lens.[68] This technology may soon interface with a smartphone or tablet so that widespread consumer use of mobile AR will become the norm.

Such innovations are rapidly disseminating in the United States and internationally. In the United States, e-readers (including primarily the Amazon Kindle Fire HD) have

grown from an installed base of virtually zero in 2006 to an estimated fifty-five million users in 2012 (see Figure 4). The installed base is expected to reach sixty-four million by the end of 2012. Worldwide, the numbers have doubled between the two time frames.[69] The iPad alone has earned the distinction of being the most rapidly adopted nonphone electronic product since the DVD player.[70] Though the previous fact is impressive, the iPad represents a new line of mobile devices—tablet computers (Motorola Xoom, Samsung Galaxy Tab, and the Microsoft Surface)—that have made an enormous impact in the mobile computer marketplace. Apple sold three million iPads in the first eighty days after its April 2010 release (despite occurring during an economic recession). Comparatively, the first DVD player sold 350,000 units in its first year. It is estimated that tablet computer sales will reach 70.8 million by the end of 2012.[71]

Drawing Lessons from Traditional Documentary Storytelling

Situated documentaries and AR-enhanced storytelling draw on many of the best practices of traditional documentary filmmaking. Documentary filmmaking often involves new, timely, and controversial subject matter. To explore such topics, documentary makers often employ interviews and archival footage to explicate various points of view that allow audience members to draw their own conclusions regarding particular issues and perspectives presented in the piece.

Documentary filmmaking has taken on many forms in the digital age. It incorporates not only reenactments and historical footage, but also animation and 3-D graphics. One of the limitations of the traditional documentary linear format and requirements of broadcast television distribution is there are certain run-time standards. Usually these are either 86.40 minutes or 56.40 minutes, to accommodate the needs of television, particularly public television or cable TV network channels.[72]

However, with all the ways to tell a story, standards have changed significantly in this age of digital production and online distribution. Various formats for digital, online, and on-demand display are available. These innovations have implications for AR-enhanced storytelling, as well. Through stunning filming and in-depth historical information, audience members can immerse themselves in the narrative experience and even feel as though they are present at a location. To enhance the interactive experience, a documentary maker can give audience members a call to action via a website, mailing or email address, or phone number provided at the conclusion of a documentary.

In the digital age, by using converging and emerging technologies, documentary makers can pursue the boundaries of what might be considered documentary filmmaking. At the Sundance Film Festival, perhaps the preeminent U.S. venue for creativity in filmmaking, festival organizers have recognized this trend and instituted a new area they call New Frontier. On the 2012 New Frontier webpage, the first year that they introduced this section, the organizers state,

> Highlighting work that pushes the boundaries of storytelling and the moving image, New Frontier celebrates the convergence of film, art, and new media technologies as a hotbed for cinematic innovation. New Frontier presents media installations, multimedia performances, transmedia experiences, panel discussions, feature films, and more.[73]

Among the most creative foreshadowing of what is possible and yet to come with the use of AR concepts and ideas is *Bear 71*.[74] Directors Jeremy Mendes and Leanne Allison created their twenty-minute documentary from the millions of images captured by trail cameras throughout the Banff National Park in Alberta, Canada. The subject of the documentary is a grizzly bear that is radio tagged at the age of three and tracked for the next five years. Actress Mia Kirshner narrates the story as the voice of Bear 71. Video footage is sometimes shown to further illustrate her story. For most of the documentary a map is shown with various elements on it that represent other tagged animals, trail cameras, and humans who are "wandering" through the park. These persons are actually views of the documentary, and if using a computer equipped with a camera and microphone, they can be observed as well. Throughout the documentary, viewers learn about the movements of people and how they affect the bear and other animals by their encroachment on their territory. The film concludes with a dramatic ending and message of the environmental impact of the human imprint on the wilderness of the west. The story is one that can be told and experienced only in the manner that the directors have set out to do through the metaphor of AR and place-based storytelling.

Mainstream Commercial AR Applications: What Interviews Tell Us

Complementing the situated documentary AR case study, the authors conducted a series of six in-depth interviews with leading media editors who use AR in their media products as well as technologists whose companies have developed commercial AR media products. A discussion of the results of those interviews follows. This discussion is placed in the context of how these pioneering media companies have utilized AR to best understand the strategies for innovation employed by AR media editors and technologists.

By 2009, commercial media began to develop early AR applications. *Esquire* magazine published its "Best and Brightest" AR issue that featured an interactive version of actor Robert Downey, Jr.[75] After downloading free proprietary software, readers could hold the cover of the magazine up to a webcam on their computer and see a still photo of Downey become an animated character. The camera read a graphic called a quick response (QR) code just below Downey's cover photograph. Software recognized the graphic that triggered a Downey AR sequence that allowed the user to see the animated actor stand, walk, and talk about *Esquire* magazine's interactive issue.

Figure 8. Quick response (QR) code generated for *Journalism and Communication Monographs*

The magazine offered several more AR sequences inside, each one featured additional interactive content not included in the printed magazine.

QR codes are a relatively limited form of AR technology developed in 1994 for the automotive industry.[76] Toyota subsidiary Denso Wave developed the QR code, a matrix barcode or two-dimensional code, to track vehicles during the manufacturing and production process.[77] It is designed to allow high-speed scans. To illustrate, the authors created a sample QR code for this article for the web site of the journal *Journalism and Communication Monographs* (*JCM*), http://jcmonographs.org. Using the free QR code generator (at http://qrcode.kaywa.com/), the authors created the QR code shown in Figure 8.

This QR code can be scanned with a smartphone or other mobile device equipped with a QR code reader, and it will automatically open the *JCM* website. QR codes are increasingly in wide use.

The *New York Times* first utilized QR codes in its *m*agazine on December 19, 2010, when it ran a full QR code cover for its tenth anniversary special issue.[78] The QR graphic was called the "Balloon Code" because it consisted of original balloon art. The creation of the QR code cover was an extraordinary undertaking. A behind-the-scenes

video of the making of the Balloon Code is available online.[79] When the issue was published, QR codes were a relative novelty to most newspaper readers. The sight of a full-cover color QR code on the cover of the magazine was eye-catching and effective. QR codes are useful because they can function indefinitely and the content they are directed to can be updated.

Though difficult to measure, reader response to the *Esquire* AR issue was considerable, as indicated by the number of software downloads required to interact with the issue. David Granger, editor in chief of *Esquire*, explains that while "*Esquire* has a circulation of 720,000, we ended up with 70,000 downloads of the software to have the AR experience."[80] This figure represents nearly 10 percent of the magazine's circulation. "That's actually a fantastic response," said Granger. "At least 70,000 readers downloaded the software to try and play with the AR application. Then it spread like wildfire. Lots of people watched the video." Because of the success of this AR experience, Granger anticipates the possibility of further experimentation with AR in *Esquire*. "We would like to take advantage of the next generation of AR technology. But, we aren't interested in doing what everyone else does. Mobile phones and AR is an interesting opportunity. We've had a couple conversations with developers. Now that the iPad has cameras, there are possibilities we'd like to explore. But we like to do exclusive projects."

For Granger, AR technology is not used for the sake of showcasing the novelty of the new emerging technology. He is also looking to expand on the content of the existing magazine by making it more complex. However, such innovations should not be done at the sacrifice of the print version, the core of their readership. "We're trying to take advantage of the capabilities of the medium and use them. We're not just putting the magazine on the device. We want to enhance the entertainment experience. We do a lot of experimentation." Granger admits that innovation "begins with impatience with formula. I hate templates. Every story is an opportunity to do something new. Try to find ways to stir the pot. We question every assumption that magazines make. For instance, does a magazine have to have margins? Does it have to be in print? Then, it helps to have a reputation for doing new and crazy things. People will start to come to you with interesting and new ideas."

In early 2010, *USA Today* introduced its first use of AR.[81] In collaboration with Universal Studios, the newspaper printed a two-dimensional map of the world of the fictional character Harry Potter for the upcoming opening of "The Wizarding World of Harry Potter" theme park in Orlando, Florida.[82] When held in front of a webcam with Internet connection running Shockwave software, the map would come to virtual life as an interactive, 3-D form on the viewer's screen. This feature particularly appealed to fans of Harry Potter, the youthful audience that historically had been a tough draw to newspapers. Recent research by Nielsen shows that Americans ages twelve to thirty-four spend an increasing amount of time using various digital media, including the Internet, social networks, mobile phones, and video games, and less time watching traditional television sets and reading printed newspapers.[83] For newspapers and other news media, AR presents an opportunity to reengage these younger audiences.[84]

Veronica Stoddart, deputy managing editor for travel for *USA Today*, described in an interview the newspaper's experience with the Harry Potter project.[85] "The story had more than 60,000 page views. And the instructional video about how to use the map had a total of 34,000 video streams on the first day, which was more than 19 percent of the overall video traffic for the paper that day. News of the map was widely picked up by 100 media outlets, including Potter fan sites, technology sites, theme-park attraction sites, social media, and mainstream media."[86]

In an interview with Jim Welch, content editor at *USA Today*, he discussed the newspaper's continuing use of AR.[87] *USA Today* also developed an AR application for Super Bowl XLV held on February 6, 2011, at Cowboys Stadium in Arlington, Texas. The newspaper's Super Bowl application used the free Junaio browser (available for the Apple iOS and Google Android platforms) and included an AR tour of Cowboys Stadium, a Monday play-of-the-game feature, and other AR capabilities. Welch explains, "The Super Bowl effort was considered a success—for our audience, sponsors and staff." It was successful in terms of a variety of indicators. "There were more than 5,000 downloads of the Junaio app between Friday and Monday," before and after the Super Bowl. "The Cowboys Stadium tour drew 15,000 clicks on Friday, 12,000 on Saturday and 10,000 on Sunday." Fans also used the Monday play-of-the-game feature. It drew 33,700 clicks, with 114 clicks per minute at its peak. "Much of what we were doing," Welch notes, "was to try to educate the user with the idea that we would aim for a more-regular series of AR efforts."

USA Today's Jim Welch brings up one of the main hurdles of AR—"educating the user." An interview with Trak Lord, social marketing manager for Metaio, Inc., an AR software development company and developer of the Junaio browser used by *USA Today*, echoes Welch's sentiments.[88] "Adoption and education is a huge goal for us." Lord adds that as far as the consumer market goes, AR has yet to see the one killer app or experience that sparks massive adoption. "Using QR codes is still new for consumers." So to educate the market and help the adoption process, Metaio developed the Junaio browser, which is available as a free download. "Junaio is more of an open development platform that allows developers, agencies, and brands to easily publish AR content in a cloud-based environment," Lord explains. Metaio also works directly with clients to develop AR concepts. The more AR applications that are encountered in everyday life, the better educated consumers become about the availability of AR and its real-world application.

As an example, Metaio has developed a software application and hardware interface for Lego that incorporates a kiosk in all of the Lego stores that can detect when a Lego set is scanned and then provides a 3-D image of the completed set. For instance, if the Lego Grand Carousel merry-go-round set is scanned at the kiosk, the box is displayed on the screen in real time and an assembled image of the set is displayed on the box. The box can be rotated to show the various angles and features of the assembled set. In addition, the image of the merry-go-round also revolves on its own with figures that are animated and walk about the completed set. Lord sums up the AR tool with, "It's a unique point-of-sale experience that engages consumers in a cool, interactive way."

As predicted by Rogers's diffusion of innovations model, which suggests that the earliest adopters of a new technology who connect innovation will become advocates for it, Mike Mozart, an independent toy reviewer who broadcasts his reviews on YouTube, uploaded a video of the AR kiosks at the Lego store at the Rockefeller Center location in New York City.[89] The video showed Mozart scanning various Lego sets. The video generated more than fifteen thousand views, and the store saw a marked spike in traffic. Furthermore, there are several other videos on YouTube that feature the Lego AR kiosk from various stores in cities around the United States. These videos have garnered several thousand views each. For example, the video for the Downtown Disney Lego store in Orlando has more than a quarter of a million views.[90] These presentations acted as mini viral videos to educate the local population about AR. This education then allows for the next step of the diffusion of the innovation, which is that the individual will seek out more information on the technology. In the case of the Lego kiosk videos, individuals will then look for stores in their area where they can see this innovation firsthand. Lego has made it easy for customers to find this technology since they installed a kiosk in every one of their retail stores. This way, no matter which store a customer seeks out, they will find this use of AR technology.

Though AR has made a considerable leap, Trak Lord suggests the next step in user experience could be fully integrated eyewear. Metaio announced a collaborative partnership in April 2011 with Vuzix, a developer of consumer video display glasses, commercial and defense micro-display goggles, and AR glasses that display both video and audio through integrated ear-bud headphones. Lord confirms, "Wearable computing could be on the horizon, enabling immersive and more intuitive experiences."

Lord explains that this type of hardware allows users to see and use their immediate environment. He notes, "According to a 2011 Q3 Nielsen report, 62 percent of Americans ages 25-34 own a smartphone. We've devoted a lot of research and effort to mobile AR, and whether massive consumer-ready glasses are in the near future, we'll continue to make our mobile technology better and better."

By leveraging the mobile technology that is vastly available, and the burgeoning knowledge of AR, companies can develop applications through software such as Metaio's SDK and available hardware such as Vuzix's STAR 1200 that are clear glasses with integrated video capability. These products allow hands-free AR.

The drawback is that AR eyewear is expensive, with a manufactured list price of $5,000. Yet the fact that the glasses are available, at least in a first generation, illustrates the trajectory of the growth of wearable AR technology.[91] Because of the mainstream success of the use of AR by the *New York Times*, *Esquire*, and *USA Today* and their commitment to future projects, convergent technologies can drive situated documentary from academic monographs to mass-market reality.

Jon Voss, founder of LookBackMaps, a website and mobile-based application that allows users to upload photographs, geo-tag them, and add personal information, described methods for the facilitation of the adoption rate of AR.[92] Voss said, "The novelty factor is big, but what's making them [consumers] come back?" He responds

by saying that his company tries to bring to AR "a gaming experience to engage the user." Interactivity, social networking, and geo-location are key features that drive consumer demand for this technology.

This type of gaming experience can be seen in geo-location applications such as Foursquare, Gowalla, and Facebook's "places" feature. By visiting certain locations and "checking in" through the mobile application, users gain points while their rankings with friends are displayed. They also have the ability to earn badges and "mayorships" to locations that are displayed prominently for not only the user but also other members of the community to see. These aspects of game play create a sense of competition and engagement among users.

Lord's company, Metaio, also uses the proliferation of tablet computers as a conduit to educate users about AR. In 2011, Metaio issued a press release at the Augmented Reality Event conference in Santa Clara, California, that declared their focused commitment to tablet computers for their AR development and revised their mobile AR SDK to maximize the large screen size of the tablets. Though they are still supporting mobile smartphones, they believe that the size of the tablets creates a much better AR experience.

Ultimately, storytelling is the unique opportunity AR presents for journalism and the media. An interview with Dana Dansereau, interactive producer for the documentary *Bear 71* and a member of the National Film Board (NFB) of Canada, underscored the emerging value of AR in documentary film.[93]

Dansereau says he sees two things about AR: an advancement of technology and a merger of technologies where the whole is greater than the sum of the parts. Though Dansereau and his team refer to their final product as "augmented reality lite," they have taken advantage of advances in several other technologies to better execute the animated characters within the AR world they have created. These additional digital technologies include Flash animation, QR codes, various compact still and video cameras, and a unique computer application of their own creation. In addition, they relied on audiences' ownership of mobile devices, especially Apple's iPad, to allow filmgoers to "see through the lens of technology."

Viewers can experience *Bear 71* in three different ways: in a theater-type setting, at a kiosk installation, as at Sundance's New Frontiers, and from desktop computers or mobile devices anywhere in the world.

For the theater experience, the entire audience watches the interactive documentary for the same twenty-one minutes, but how each member experiences it can be completely different. Dansereau explained that because the design of the documentary encouraged viewers to engage with the film through a smartphone or tablet app while they watched the piece, it answered two questions. "One, it answered a question of when you held the iPad to the screen could it give each audience member a unique way to view the film?" said Dansereau. "And second," continued Dansereau, "it was a technological answer to what we wanted to do as documentary creators."

At Sundance, the *Bear 71* design team set up an installation with a large projected park map. Visitors could point their mobile devices and engage in the AR functions at

their own pace, but in the company of other people. The experience could be continued as willing participants were "tracked" throughout their stay at the festival. To further authenticate the installation, a "rubbing tree" was situated to represent the parallels of animals in the wild "checking in" to their environments much as humans do with social media such as Facebook and the location-based Foursquare.

Finally, for those who saw *Bear 71* through an Internet-connected computer or mobile device, it was an experience that was unique not only from a content standpoint, but also for the film's duration. "The online version allows for a non-linear, multi-user world, where individuals can wander around," explains Dansereau. "In the theater the experience is very linear. Everyone gets the same story, but the visuals can be radically different. With the online experience, you inhabit the space, and play in the universe of Bear 71."

As one might expect with a cutting-edge project like *Bear 71*, the online feedback was positive and allowed the producers to have a large data set of analytics to improve the product. Dansereau recollected that when an article came out late one evening praising *Bear 71*, could watch traffic first spike in China and India on the *Bear 71* website, and then watch the usage "cascade around the planet."

Roundtable Discussion: Implications of AR for Journalism

On February 1, 2012, the authors hosted a roundtable discussion of AR and its implications for journalism and storytelling. Held at Rutgers University's Journalism Research Institute (JRI), the roundtable featured thirteen participants, including professional journalists and journalism, media, and communication educators with an interest in AR. The authors recruited participants based on their potential knowledge of an interest in AR and its implications for journalism and the media as well as their proximity to the Rutgers campus.

The structure of the roundtable included a light lunch to open the gathering with an opportunity for participants to meet. The senior author then provided a brief twenty-minute overview of the current state of AR related to journalism and its possibilities for storytelling based in part on the interviews the two study authors had previously conducted as well as the situated documentary AR case study. This was followed by a group discussion moderated by the senior author.

The first topic discussed was the general reaction of the journalists and educators to the overall notion of AR as applied to journalism, particularly as a storytelling tool. Participants offered a variety of perspectives on this and other topics during the roundtable. An overarching theme of most of the topics discussed dealt with uncertainty for the future as it relates to both the technology of AR as well as the potential consumer embrace of this emerging new technology. It is not surprising, especially in the state of professional journalism in 2012, that the future of the news industry is a profound and looming question for most journalists, and it goes hand in hand with uncertainty about any emerging technology, including AR. Concerns about

uncertainty were expected to some degree by the authors. Not surprisingly, many of the topics that came up during the course of the roundtable confirmed issues and matters previously identified in this monograph, particularly in the interviews with editor innovators. It is productive to review the specific questions and concerns that emerged from the roundtable to see both how they fit into the larger picture of journalistic storytelling through AR as well as to better understand the challenges media may face in the adoption and diffusion of this innovation.

Roundtable participants identified five areas of particular concern about the potential utilization of AR as a storytelling tool (or otherwise) in journalism:

1. A perceived relatively low or slow adoption rate among consumers
2. Technological limitations of current AR applications
3. Their own understanding of the potential capabilities of and strategies for using AR in journalism
4. Content implications of AR for journalism
5. The business implications of AR for journalism

Participants acknowledged there are many news articles on the web and in print reporting on the virtues, or lack thereof, of AR. However, participants also expressed concern about what they see as relatively little evidence of widespread public adoption of AR technology. Roundtable participants acknowledge that QR codes are widely seen and used by the public and may represent the beginning of public adoption of AR.

Roundtable participant Matt Weber, a faculty member in the Communication Department at the School of Communication and Information and an expert in media innovation, pointed out that research shows that as of 2012 only 5 to 10 percent of American consumers were knowledgeable about QR technology. Considering that small awareness rate (the first step in Rogers's diffusion model), consumer adoption of AR would be limited, roundtable participants noted. Moreover, they added, an individual from that small group would also need to have a digital device that is equipped with an AR reader. This requirement reduces an already small percentage of potential AR consumers willing to use the technology down even further, participants said. In addition, since this subset of consumers would more than likely make up only the early adopters of AR technology, their population demographics likely would be somewhat narrow—more than likely affluent, well-educated, and young, participants said, although research shows that Asian Americans and Latino Americans are among the demographic groups with the highest adoption rate of tablet devices.[94] Weber added, "I think there's a lot of potential, but the education component is significant."

Confounding the limited consumer adoption of AR, said roundtable participants, is the fact there are numerous choices available for consumers. The Apple iTunes store, for example, has more than one thousand applications listed under "augmented reality" for both the iPhone and iPad.

Coupled with the lack of users adopting AR, another concern that came out of the roundtable was the technological hurdles faced to use AR technology. This

challenge was experienced firsthand by participants during the opening presentation on the use of AR in journalism. Access to an AR-enhanced website failed to initially load via the university's Wi-Fi connection. The senior author pointed out that connection problems sometimes plague normal cell phone use, so a requirement of a longer connection time or high bandwidth, as is the case with some AR applications, can be even more troublesome for those considering adopting this emerging technology. This requirement can not only cause a negative opinion of AR technology, but also lead to reinforcement of users' negative evaluation of the technology, as per the third stage of Rogers's diffusion model. For those innovators using QR codes in early 2012, in which the potential adopter assesses the merits of the innovation, potential technological hurdles could be a major factor in deciding whether to adopt the new technology.

Another AR-related question discussed by roundtable participants focused on issues pertaining to the display of QR codes. QR codes can be seen with a variety of media that include newspapers, magazines, and television commercials. In the context of QR codes displayed in print media, consumers have a relatively simple, unconstrained opportunity to use their mobile device to scan the code, roundtable participants noted. However, if a QR code is shown during a television commercial, the fleeting nature of the display of the QR code would potentially restrict the consumers' opportunity to engage with the QR or AR application, roundtable participants noted.

During Super Bowl XLVI (February 5, 2012), Go Daddy, a web hosting company, ran the first Super Bowl television commercial that featured a QR code.[95] Go Daddy claims that the ad "accounted for a tremendous Internet spike during the game."[96] How much of this spike was the result of the insertion of the QR code is unclear. Yet research shows that 60 percent of viewers watched Super Bowl XLVI while holding a smartphone. Unless viewers were recording the telecast of the game, roundtable participants observed, there was only a thirty-second window during the commercial for viewers to recognize the code, activate their mobile device, and attempt to scan the code.[97] However, viewers could go to the Go Daddy website after the game and scan the code.

As Rogers's diffusion model suggests, it is advantageous for news media innovators to have other sources using AR technology, such as QR codes, as a form of "observable" innovators. As roundtable participants noted, this process helps to educate the public on the use of AR and reinforces its use. For example, the Home Shopping Network uses QR codes as a communication vehicle for its audience.[98]

Participant Anselm Spoerri, a faculty member in library and information science at Rutgers's School of Communication and Information (SC&I) noted, "If you look at what's happening in terms of shopping, the stores are starting to embed those codes so that you will be walking through the supermarket or wherever you are and you will use your cell phone in order to get additional information such as the barcode or other types of code. So newspapers won't have to be the ones to basically educate the audience. It will be other forces to do that for you."[99]

Conversation at the roundtable then moved to content origination, as it concerns journalist. There has been a trend in the past decade for the development of the "mojo,"

or mobile journalism. Participants saw AR as part of the mojo phenomenon, or at least related to it because of its advanced use of mobile and location-based technology. Reporters are expected not only to report a story but also to take pictures and video. They then work the content together from a laptop while in the field and after the story is completed upload it to a newspaper's server. For reporters, photojournalists, and editors who have traditionally reported, edited, and designed the news on computers at the office, mojo offers a radical shift in job descriptions. In addition, reporters are expected to include story details within different social media news steams such as Facebook, Twitter, and YouTube. They must also know basic software coding and design so that stories can be included on a website, such as CNN's iReport section.[100] There is concern that older reporters might not be able to adapt to the series of technological advancements that have been put on the journalism industry.

Conversely, the digital tools required to produce AR, as well as the other mojo materials for twenty-first-century journalists, can be taught, and are taught at journalism programs such as Rutgers. Robert Montemayor, the director of the Rutgers's Latino Information Network and a part-time lecturer at SC&I and Pulitzer Prize–winning journalist, reflected to the rest of the roundtable participants about a recent interview he had given. "I had a student come in a couple of months ago and she wanted some comments from me as the head of the Latino Information Network. She thought I would have something to say about voting, which I did, so she started interviewing me like a pro while filming on her iPhone, and in a matter of less than 15 minutes she was in, she was out, and she was gone. The next thing I know it's on *Huffington Post*. She's got the story, she's got the video, she's got it all in a cycle."[101]

Keeping up with continuing and fast-paced technological changes associated with AR will be a major challenge for news organizations, roundtable participants noted. Moreover, they added a question about how higher educational institutions involved in journalism education will be able to keep up with the changes mandated by the rapidly evolving state of AR, and how these programs will be able to properly train students to be prepared for the new skills needed. Veteran newspaper reporter and Patch Media regional editor Hank Kalet noted that some recent editorial interviewees have been underprepared and not able to take on the new demands of the journalism business. Kalet said, "Our best bet is to find people who are comfortable working in a variety of platforms."

The final topic of the roundtable was the business side of the news business and what might be the implications of AR. News reporting businesses are expected to maintain an enormous amount of information that is generated by digital forms of journalism. In the digital environment, a news article does not run in isolation. With Internet technology, almost all stories are supplemented by extensive and interactive multimedia materials, including longer web-versions of the article, photo albums, supporting audio and video, and social media. Curation of this vast amount of material is an imperative for news reporting institutions. This complexity requires not only hardware such as servers and greater web presence, but also employees who can handle programming and knowledge management needs. Cloud computing that supports such

activities as well as mobile applications aid in the transition. For roundtable participants, the implications of AR were a significant area of discussion on the same level as questions of how newsroom managers and business decisions would be affected by the use of AR. How could AR be integrated into journalism as a resource for marketing and advertising? Would such utilization affect positively or negatively the traditional wall that separates news and business in the newspaper enterprise?

Roundtable participants also asked, what does a successful business model look like for news media that utilize AR or other convergent mobile media? For a company that launches a new media product featuring AR-based content, building a content management system with AR and revenue streams fully integrated may be relatively straightforward, if not viable. However, participants noted, what a legacy newspaper does to maintain its viability while adapting to the use of AR while generating supporting revenue streams is perhaps even less clear. Though legacy papers might have more finances in reserve for change, they also have inertia and established business patterns with which to contend. Participants noted that if these legacy companies make the wrong choice, it could spell the end of their business. The U.S. daily newspaper industry is littered with cases of failed twenty-first-century adaptation. Papers that died before they had the chance to innovate with the use of AR include the *Rocky Mountain News*, the *Cincinnati Post*, and the *Tucson Citizen*.[102]

Although the AR roundtable highlighted many general points about the changes within the business of journalism and specific implications of AR for enhanced storytelling, it also generated thoughts and discussion for the future of the news media. One point is a concern about the need to educate the public about the availability of AR for both consumers and journalists. AR technology is widely available and has promising capabilities; however, the public and media professionals need to know that most AR usage is free and requires only downloading an app for a device they already have. Roundtable participants noted that training journalism and media students in not only AR technology but also its use in storytelling will be key to developing students who can adapt to the future and possess the skills that make them employable in twenty-first-century news organizations. Participants observed that journalists have a reputation for a reluctance to change and adapt to new technologies, particularly when it means a change in how they report and tell stories.

Participants noted that it is vital that journalistic institutions continue to recognize the ongoing state of dramatic technological change that transforms the news industry, as represented by AR. As participants pointed out, QR codes and other AR technologies may have several drawbacks, but mobile applications such as Aurasma are rapidly making AR easier to use, more reliable, more widely available, and known to both the public and journalistic communities. Driven by emergent technologies, significant change is in store for journalism in the future, but this roundtable helped uncover some of the issues critical to the adoption and diffusion of AR in journalism as a storytelling tool today.

AR and Journalism: The Next Generation

Both the interviews and the roundtable discussion supported the adoption and diffusion of AR as a storytelling form for journalism. In terms of Rogers's diffusion model, the first three factors of it are perhaps most relevant to AR: (1) the perceived relative advantage of the innovation, (2) its compatibility with existing journalistic norms and practices, (3) and its complexity or simplicity.

A variety of emerging technological developments are poised to transform the capabilities of AR for storytelling. In the process they will facilitate the adoption and diffusion of AR in news organizations by potentially influencing all three of the above diffusion factors. A Google innovation could help propel AR for journalism. GPS is limited to exterior venues because most locational databases are normally restricted to the outdoors. Consequently, applications for media AR-based storytelling are confined to exterior applications. In 2012, Google introduced an addition to its popular maps feature—a 360 degree "Street View" for interiors.[103] Although this feature raises issues about privacy and terrorism, there are many potentially positive uses. Travelers could use such applications at airports to locate a restaurant or shoppers could use the information in large indoor malls to find a particular store. Journalists could use the AR display to allow smartphone users to retrace an indoor crime scene or as a way to locate sources for stories. Google's innovation could influence the rate of adoption of AR by newsroom staffs as it would be compatible with existing journalistic norms and practices.

One of the most intriguing AR storytelling applications to emerge in 2011 was a musical exploration of New York's Central Park. "Central Park (Listen to the Light)" is a site-specific entertainment app that produces music customized to a user's location.[104] Created by Bluebrain brothers Ryan and Hays Holladay, it is one in a series of site-specific albums the group has produced that began with "The National Mall" in Washington, D.C. A virtual version of "Central Park (Listen to the Light)" can be experienced online at http://vimeo.com/26700564. The full experience requires the program's app, at least an iPhone4 or iPad, and presence in Central Park. The application provides a rich, original musical experience customized to dozens of locations throughout the park. For example, a jazz piano piece welcomes the listener who visits the Metropolitan Museum and a pastoral theme is heard when one walks across the Sheep Meadow.

As illustrated in Figure 9, the Bluebrain site-specific musical production begins to suggest innovative ways to engage the human senses to tell stories via a combination of modalities that were unavailable to mediated storytellers. These advances give journalists new methods to represent the world and to help citizens better understand a changing and more complex reality. AR has the potential to become a viable storytelling format with a diverse range of options that engage citizens through sight, sound, or haptic experiences.[105] Reports suggest that future developments will introduce tablet devices that feature advanced, AR-enabled tactile touch-screen interfaces.[106] For example, such a screen may enable a picture of a rock to actually feel rough to a user's

Figure 9. A Bluebrain view of "Central Park (Listen to the Light)"
Source: © 2012, permission provided by BluebrainMusic.

touch. Silk will feel smooth. A user could feel an object move about by touching it when displayed on the screen. How might a journalist use this capability in AR-enhanced storytelling? Such technology could enable vast advances in storytelling in the realms of science, health, or medical reporting.

The case of Bluebrain is noteworthy because it represents in many ways the increasingly intuitive nature of AR as a storytelling medium. For users to accept AR, they will need to become comfortable with the AR experience and interface. This trait of human nature emphasizes the third factor in the Rogers's diffusion model—the simpler an innovation, the greater its rate of adoption. In the case of AR, an intuitive interface suggests a simpler user experience with a potentially greater comfort level that will facilitate the adoption of AR as a storytelling form in journalism.

Another emerging tool for utilizing AR in a mobile media environment is Google's Goggles, a visual search tool that enables users to take photographs of objects with their smartphones or tablets and identify those them through a visually based search engine. To use Goggles on a smartphone, the user first visits the Goggles website, http://www.google.com/mobile/goggles/#text and sends a text message to his or her mobile device.

Objects might take the form of text, such as street signs or menu items. Goggles can also translate text from one language to another. Other objects Goggles can easily and quickly identify include landmarks, books, contact information, artwork, wine, and logos. For example, if one takes a picture of a painting of the artist Frida Kahlo, Goggles instantly identifies the painting and opens links to several websites that provide information about the painting.

For journalism, the question is how to utilize Goggles for storytelling. The implications and possibilities are far-reaching and intriguing. Goggles would enable a news

site to support a user-centered approach to storytelling, much as social media have supported the growth of citizen journalism or user-generated content. News organizations could be more aggressive in populating search engines with their news content, or at least with entry points to their content. As a result, when a user conducts a Goggles visual search for any visual object near a news event, among the first sources identified could be news and journalistic sites. Goggles at the scene of a breaking news story could help confirm facts and allow users to contribute photographs, text, and video reports to help advance the reporting on that story. During a protest or other event, such dynamic use of this visually based search technology, particularly in concert with social media, could prove extremely powerful as a reporting and storytelling tool.

Nick Bilton reports in the *New York Times* that Google is set to provide journalists and other media professionals or other citizen storytellers interested in the use of AR a potentially bold leap forward with the likely introduction by 2013 of inexpensive Google AR eye glasses or a head-worn display using Goggles.[107]

In April 2012 Google demonstrated the first prototype of the AR glasses. Dubbed "Project Glass," the Google heads-up display (HUD) wearable AR system utilizes both artificial intelligence and voice command.[108] These glasses project geographically overlaid and synchronized information via the Goggles technology against a real-world backdrop. They provide the wearer the ability to access information about the world around him or her with virtual data that includes 3-D objects, animations, graphics, text, video, audio, or other formats. The information may be about products, advertising, news, games, navigational information, or even individual people.

The Google AR glasses will be equipped with GPS and motion sensors, a camera, and audio input and output. The expected price for the Goggles eyewear is not more than $500, comparable to a smartphone or other digital device such as an e-reader or tablet computer. With Goggles software, the glasses could use facial recognition tools to identity a person's identity with links to news sources and social networks. The Project Glass website features a video demonstrating the functionality of the prototype HUD system.[109] However, questions have emerged as to whether the AR glasses, at least in the near term, can actually deliver all that Google promises in its promotional video.[110]

How journalists could use these wearable AR glasses for storytelling is to be determined. One option is the development of the situated documentary as in the MJW prototype discussed earlier. However, with the Google Goggles eyewear, the situated documentary could be fully implemented as a mainstream AR storytelling form for journalism.

Also important to the diffusion of AR in journalism is the introduction of the Wikitude World Browser, the first AR web browser for mobile devices, including Android, iPhone, and Blackberry smartphones.[111] In 2012, a Wikitude World Browser for Windows Phone was released. The browser is simple to use and widely available. These additions are key factors in the diffusion of the AR innovation, as delineated in Rogers's diffusion model.

The Wikitude World Browser features more than 2,500 AR "content worlds." A content world is an AR experience for a mobile phone that features a specific place or location, such as San Francisco's Golden Gate Bridge, a Starbucks coffeehouse, or a public library. Wikitude reports that "these aggregated content datasets add up to more than 150 million points of interest such as sights, restaurants, mobile coupons, cafes and Wi-Fi hotspots around the globe." When users employ Wikitude to investigate their surroundings by simply panning the phone in a 360-degree motion, the browser scans the environment and displays on the phone's screen places of interest. The Wikitude World Browser scans the user's surroundings for "geo-referenced content using the camera and the mobile device's sensors. The object's information is displayed in the camera right where the real object is located."[112] Wikitude allows mobile phone users to customize their home screen according to their lifestyle or preferences.

The Wikitude Browser also links to social media. Users are able to search through content and points of interest from social media sources such as Wikipedia, YouTube, Twitter, and Flickr. The user can search for specific places of interest. For instance, if the user types "hospital" into Wikitude's search box and holds up his or her phone, the device will display the nearest hospital.

Among the Wikitude worlds are "Volcanoes of the World," created courtesy of the Smithsonian Institution, the Antonine Wall, built in ancient times by the Romans in central Scotland, with forts and artifacts along the route, and the Forbidden City, Beijing, with its numerous gates, temples, and pavilions tagged with historic information describing various uses in each dynasty of ancient China. AR worlds are available in more than a dozen categories, including architecture, art, culture, the environment, events, history, nature, real estate, shopping, transportation, and travel. Journalists could use the Wikitude World Browser to report current local news, feature stories, or accounts from the past. News AR worlds would enable anyone to engage the information through their smartphones in multimedia story formats from wherever they are located.

Summary of AR Uses in Journalism

In this monograph we have examined the implications of the emerging technology of AR for journalism, particularly in the realm of how journalists tell stories. We have studied how storytelling may be transformed into a more interactive, first-person participatory form utilizing the location-based, geographically anchored nature of AR. Coupled with the increasingly mobile and developing wearable (eye wear, ear bud) AR technologies, these storytelling qualities may develop more along the lines of the situated documentary as discussed in the case study presented earlier.

The opportunities and challenges of news and other media innovation identified in the interviews and roundtable discussion presented a set of at least five topics. These intersected in particular with Rogers's diffusion model. In particular, the technological development of AR as it evolves toward a simpler, more robust technology with more

Table 2. Quick Response (QR) Code Apps

QR code app	On system	News media	App free or paid
Bakodo	iOS		Free
AT&T Code Scanner	iOS, Android		Free
QR Reader	iOS, Android		Free
Microsoft Tag Reader	iOS, Android	*USA Today*	Free
ScanLife Barcode & QR Reader	iOS, Android	*National Post* (Canada)	Free

readily apparent comparative advantages will likely drive its adoption rate both in newsrooms and among consumers and citizen journalists in the United States and internationally.

There are other AR journalism applications beyond storytelling:

- Overlaid interactive, geo-tagged graphics
- Embedded geo-synchronized photographs and video to provide additional context to news and information
- The use of QR codes to direct citizens easily and quickly via mobile devices to additional content, text, video, and websites for further detail
- The use of social media via location-based social networking (e.g., http://tagwhat.tumblr.com/)
- The utilization of location information available via AR or social media to identify potential sources for stories

As shown in Table 2, there are a wide number of QR code applications available for journalism and media at no cost. These applications are available for both production and distribution of QR codes, for use on mobile devices, and for citizen use for QR code readers. The wide availability of these QR code readers will facilitate the adoption of this technology by news organizations.

Similarly, as shown in Table 3, there are also a wide variety of free AR code apps available for journalism and media. As a result, they have been used by a growing number of news organizations in the United States and internationally, including the *New York Times* and the BBC. These apps are available for many smartphone brands and are robust, reliable, and easy to use as production tools for journalists and for consumers to download, install, and use in scanning AR-enhanced content. Consequently, the ubiquitous availability of these AR apps will facilitate the adoption of this technology by news organizations and consumers.

In 2012, the *Philadelphia Inquirer* joined the growing ranks of newspapers adopting AR as a vehicle for storytelling when it introduced via Aurasma Lite a series of embedded videos and other forms of hidden content throughout the newspaper. Readers use iPhones, iPads, or Android smartphones or tablets to install the *Inquirer*'s version of the app, InquirerAR, available for free via Apple's App Store or Google

Table 3. Augmented Reality (AR) Apps

AR app	On system	News media	App free or paid
Aurasma	iOS	*Financial Times, New York Times, Los Angeles Times, Philadelphia Inquirer*, Sky News, BBC	Free
Layar	iOS, Android		Free
Wikitude World Browser	iOS, Android, Windows, Blackberry		Free
Junaio	iOS, Android	*Boston Globe, USA Today*	Free
Blippar	iOS	*Metro Herald*	Free

Play. For its launch, the paper tagged several photographs and advertisements in a special twenty-four-page section about the relocation of a famed local arts organization, the Barnes Foundation, featuring the art of Albert C. Barnes. The pictures and ads were labeled with a miniature version of the *Inquirer*'s Old English–type *I*. In one case, pointing the reader's digital device at a photo of Albert C. Barnes activated a video about the art scholar and collector who created the arts institution. In another case, pointing a tablet or smartphone at a photo of the west wall of Room 23 in the Collection Galleries activated a panoramic video in the center of which is Henri Rousseau's "Unpleasant Surprise." In the coming months, the *Inquirer* expects to expand its use of AR and reports that a growing number of news organizations will adopt Aurasma-based AR as a storytelling tool.[113] Aurasma anticipates one day generating revenue from its partnerships with organizations such as the *Inquirer* through AR ad click-throughs. News organizations may see AR-related revenue streams as well.

Seven Steps in Creating AR-Enhanced News Content

Technological developments have made creating AR-enhanced content for journalism a relatively straightforward, simple process. The following is a seven-step outline of the process of creating AR-enhanced content for journalism using a mobile application available since 2012:

1. Use a mobile digital device, such as an iPad, iPhone, or Android device
2. Install and open a mobile AR app on that device (e.g., Aurasma Lite)
3. Select a news story in a newspaper, a photo or video from one medium, or an object in the physical world to act as an AR trigger
4. Select an image, video, graphic, or audio clip to use to add to the news story or other object selected in step 3
5. Embed the AR from step 4 into a news story from step 3
6. Label the AR to enable readers or citizens to recognize it

Figure 10. Chinese hand scroll from the Nanjing Museum
Source: © Permission provided by Nanjing Museum.

7. Share the AR trigger link via email or social media or create an AR channel to publish with the general public the AR content enhancement

What follows is an example created by the senior author's wife, Jackie O. Pavlik, a multimedia artist from Teachers College at Columbia University. She selected an image of a Chinese hand scroll exhibited in 2012 at the Metropolitan Museum of Art in New York City and on loan from the Nanjing Museum in China. As shown in Figure 10, the hand scroll, from 1964, is called *Heaven and Earth Glow Red*. Ms. Pavlik located in the Met's multimedia archive a video of a museum curator explaining the nature and meaning of the hand scroll. She used Aurasma Lite to embed a link to the video into the image. She first saw a photo of the hand scroll when it was published in the *New York Times* as an image accompanying a story about the hand scroll collection at the Met.[114] Readers of this monograph can access the link in the corresponding endnote using a mobile device, or scan the QR code, which contains the link, as shown in Figure 11. Scan the image of the hand scroll using Aurasma on a smartphone and experience the AR-enhanced storytelling content that might one day be found in a future newspaper story.[115] It is worth noting here that the AR-tagged image can be scanned by a mobile device anywhere an individual encounters that image: in a newspaper, magazine, or book, on a billboard, website, plasma screen, large-screen TV, or T-shirt, or at the Met.

As a further illustration of the relative simplicity of the technology, the senior author collaborated with his wife to create a second AR example with a photograph and video they recorded with an iPhone 4S. Folk singer, environmentalist, and

Figure 11. Aurasma quick response (QR) code for curator video explaining the Chinese hand scroll

American storyteller Pete Seeger is well known for many things, including his unique signature, which features not only his immediately recognizable name, but also his banjo.[116] On his banjo are the words, "This machine surrounds hate & forces it to surrender."[117] The senior author, who resides only a short distance from Mr. Seeger, visited him on his mountain home overlooking the Hudson River and asked him how he came to create his unique signature, as shown in Figure 12. Embedded in Figure 12 is an AR enhancement, an Aurasma-linked video of Mr. Seeger explaining the story behind his banjo signature.[118] Readers of this monograph can scan the endnote here or the corresponding QR code, as shown in Figure 13, to activate the Aurasma AR trigger for the video.[119]

AR as a Digital Foundation for the Fourth Estate

Digital technology, the Internet, and mobile media are transforming journalism and media on a variety of levels. We have examined one aspect of that transformation in particular—the emergence of AR as a storytelling form for journalism. AR has the potential to actively engage citizens in news content by enabling interactive on-demand

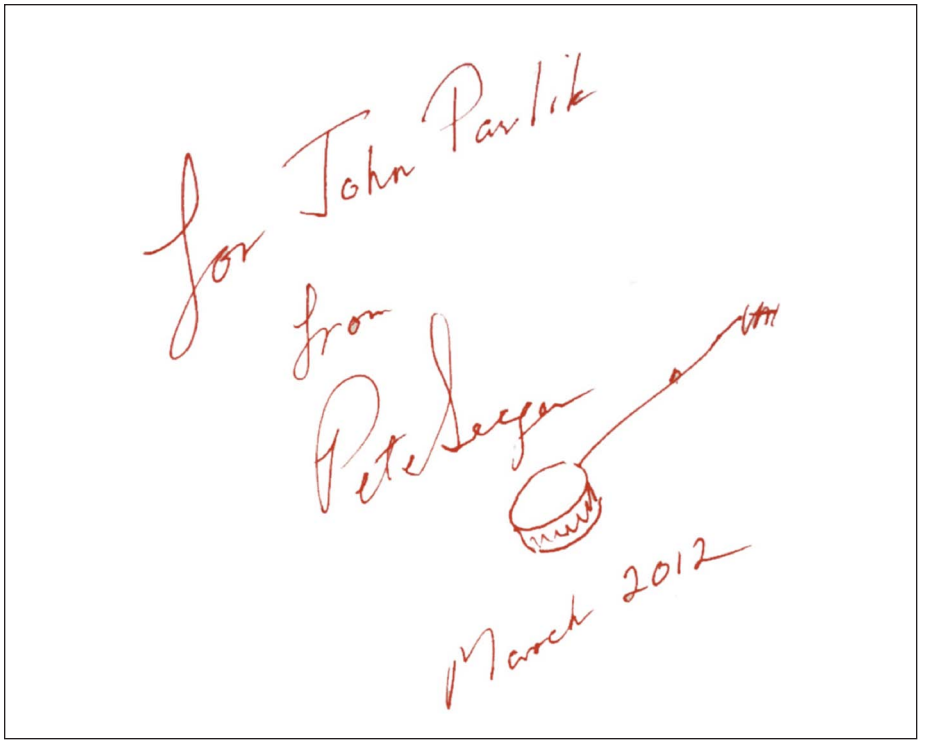


Figure 12. Pete Seeger banjo signature, scan with Aurasma for augmented reality (AR) video enhancement for Mr. Seeger's story about origin of signature (first share AR trigger in endnote)
Source: Permission provided by Pete Seeger.

access to layers of additional content in various formats, including video, audio, animation, 3-D graphics, and social media. Historical background and other contextual information can be provided via mobile devices layered in AR. For citizens, such AR-delivered contextualization could help serve a democratizing effect by providing immersive storytelling in which individuals actively participate in first-person narratives rather than passively watching, reading, or listening to the third-person narratives of traditional journalism.

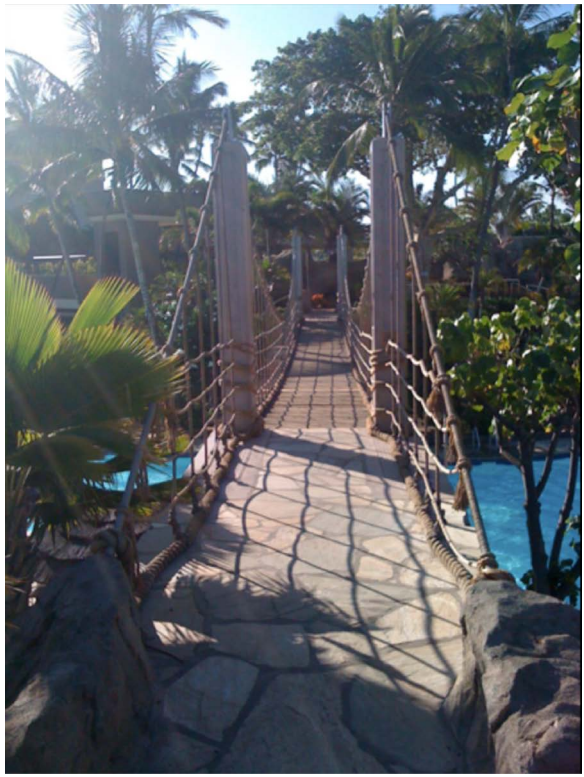
Future directions for the use of mobile AR involve the possible use of geo-tagging content for a variety of other content purposes, including digital watermarking. Adding a GPS stamp or watermark can be vital to authenticating news photos, video, and audio, as well as to protect copyright. Shown in Figures 14 and 15 are images taken by the senior author using an iPhone and automatically geo-tagged for authentication. Such technology can be essential in establishing that a reporter was on the site of a news event or interview. This feature can minimize the possibility of a reporter potentially

Figure 13. Quick response (QR) code for Seeger banjo signature augmented reality (AR) video

fabricating the news. In conflict zones, such authentication can be vital for establishing the veracity of news photos or videos of highly controversial images.

Authentication is an essential element in journalism and the news, particularly in an age of global media when media are increasingly dependent on freelance and independent journalists. Credibility is the only real asset that news organization and journalists have. Without the trust of the public, reporters have little to offer beyond what any citizen journalist or other provider of information can deliver. Historically, it is the independence and believability of journalism that has helped secure its position as the so-called fourth estate, or fourth branch of government. By securing the public's trust, journalism can effectively serve its role as a check on the other three formal branches of government: judicial, legislative, and executive. Journalism can thus help to hold government (or other large institutions) accountable for its actions and policies. Moreover, by securing the public's trust, journalism can serve as a reliable source of information for citizens to make informed decisions through the democratic process.

Unfortunately, some in the world's journalism industry have used mobile and digital technologies to violate and erode the public's trust. Nowhere is this more visible than in the phone-hacking scandal that rocked Rupert Murdoch's News Corporation



Figures 14. Geo-tagged and date-stamped photo taken by the author with iPhone in Hawaii, of a rope bridge
Figure 15 illustrates its location on Google Earth.

media empire in the United Kingdom, causing him in 2011 to close the *News of the World*—a newspaper that had been in business for 167 years.[120]

Instead of using mobile and digital technologies as a way to breach legal and ethical boundaries, news organizations can use the powerful technology of mobile AR to engage readers in a democratic discourse on matters of public importance.

AR technology can also help citizen journalists who work independently or those who work with a large organization such as the CNN iReport.[121] CNN allows citizens to report via written stories or video-composed stories that are gathered in its iReport section.[122] In some cases, citizen journalists report on the unique experience of their local community or are first responders to local news events. AR can be used to expand such citizen journalist coverage. Many of these citizen reporters are technology savvy and will be in a leading position to adopt AR technology into their reporting work flow. As such, AR could further the local democratic process by increasing the

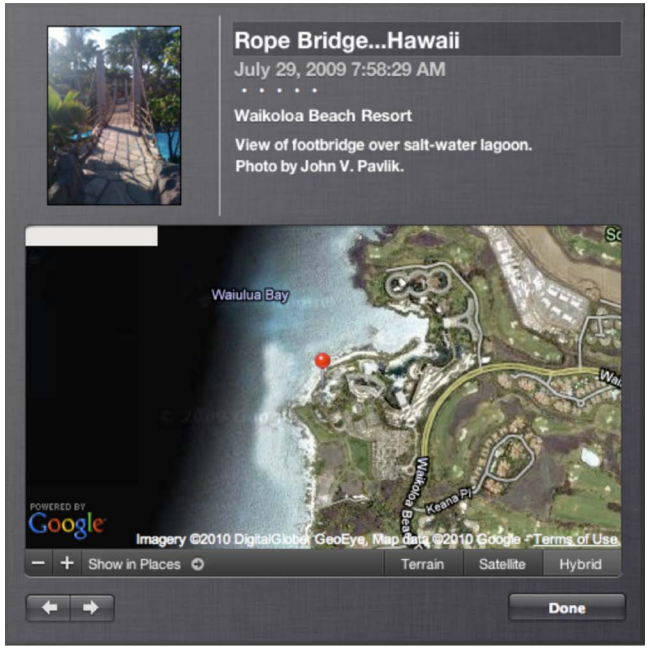


Figure 15. The geo-tagged and date-stamped photo automatically located on Google Earth, a feature used in augmented reality

engagement of local citizen journalists in covering their communities with geographically connected reporting.

As mobile AR applications improve, along with further miniaturization of related technologies, there will emerge expanded commercial use of AR content trials. These experiments will increase the public's interest for media-based AR experiences. In March 2012 Marvel announced it would introduce via Aurasma AR-enhanced comic book storytelling for smartphones and tablets.[123] AR is also converging with Internet technologies such as Google Earth, a 3-D virtual globe application for desktop and mobile devices.[124] This combination enables geo-coded storytelling and narrative forms via the Internet.[125] Smartphones via 3G and 4G networks and advanced web apps such as Google Earth enable the growth of AR applications in a variety of forms.

AR apps available on smartphones bring a realistic quality to AR that may help propel it into the media mainstream. Imagine a visit to a city for the first time. A smartphone with a news app running Aurasma could provide access to a vast array of geo-located news stories or relevant public information (such as crime data or car-pedestrian accidents) geo-tagged to a one-block radius of that corner. Data-driven stories could be mined from that location. Facts could be mapped from that location and visually

displayed in a variety of formats chosen by the visitor. This extensive collection of material is possible on any number of mobile AR platforms, including Aurasma and the Wikitude World Browser. Such AR-based journalism could serve a vital function in the democratic process as citizens could come to know their communities in a more systematic fashion based on data, not the often haphazard pattern of news reporting that has often characterized community-based journalism in the analog age of media.

Media and cultural organizations may see the potential of using AR collaboratively to give audiences remote access via Google Earth to virtual cultural sites around the nation and the world. Imagine the sensation of walking through a small village in Botswana on the outskirts of the capital city, Gaborone, while you are still in your own living room. There will be opportunities for universities to partner with media and other cultural organizations to develop these AR applications in forms that bridge education, research, and entertainment. These AR applications could serve a vital function for democracy as well, by helping advance the public's understanding of remote situations and circumstances, problems and people, but via compelling, first-person narratives and told in more systematic, data-driven stories.

Furthermore, AR applications via mobile and social media could function in real time and give individuals in remote locations simultaneous virtual access to the experiences of others.

For example, imagine it is February 10, 2011, and you are at home. A citizen journalist is in Tahrir Square in Cairo, Egypt, with a smartphone. She captures real-time video, photographs, and audio of the growing protest. Since she is connected via social media to a worldwide audience, she makes geo-tagged content available in real time for anyone in the world with access to experience an AR view of the square via Google Earth—seeing, hearing, and virtually experiencing, and commenting on, the protest. The same technology could be used for students or anyone else to collaboratively experience in real time any other location around the world, wherever news, cultural events, or other matters of interest or public importance occur. Such applications are likely to grow in demand, as mobile media proliferate in the United States and around the world. It is estimated that in 2012 there are more than 260 million mobile television subscribers worldwide who can access video via smartphones. The number is expected to reach nearly 500 million by the end of 2013. There were virtually zero mobile TV viewers in 2006.[126]

AR is just an early step toward a future in which new content forms emerge in the convergence of digital technology, the Internet, and mobile and social media. Innovation and collaborative opportunities between academic researchers and media enterprises may yield storytelling forms that bring new generations of citizens back to journalism and the media and into the interactive online public spaces rich with social media and other digital communication forms where democracy can flourish in the twenty-first century.

Concluding Reflections

AR has emerged as a technology that may disrupt and transform traditional methods of storytelling in journalism.[127] Research reported here suggests the transformation has the potential to create a form of storytelling that is more about citizen engagement in a participatory, first-person narrative form rather than the long-standing third-person approach common to most newspaper, magazine, television, and radio reporting. Moreover, the geo-locative nature of AR is ideally suited to the place-based traditions of news reporting, yet it has the capability to bring this model to an entirely new level of precision—down to the level of tagging not only each story, photograph, or video, but also each fact or source with the exact time and location it was reported. This geo-tagging can enable journalism to embrace the notion of data mining and presentation in entirely new ways.

Innovative opportunities driven by the convergence of mobile media and AR are in rapid development. News organizations are experimenting with AR and consumers are beginning to learn about the features, qualities, and possibilities of this technology. Early efforts to harness the news media potential of AR have been in the relatively simple application of QR codes, as well as applications for marketing, sports events, and cultural reporting. Expect wider AR journalistic storytelling possibilities in the near future.

As wearable devices enter the marketplace, journalistic uses of AR that create AR-enhanced content, such as the situated documentary, may enter mainstream media. If these developments occur, applications of AR for reporting on matters of public importance may bring this potentially engaging technology into the arena of the democratic process. Citizens, particularly youth who have been at times disengaged from traditional news media in favor of social media and other newer devices, may find a reentry point into digital journalism. AR-enhanced news content may provide an on-demand vehicle via mobile media, particularly popular among today's youth. Younger citizens may be drawn to the interactive, social, and multimedia contextualized information AR-enhanced news content embeds into the real world.

Problems and concerns are also apparent in AR and journalism. The potential danger of censorship, especially for visually based search engines that operate in a global media space in which geo-graphically tagged content is linked to social media, is a concern. Such censorship may be especially likely when the corporate parents are potentially trillion-dollar global behemoths that may not share the traditional news values and free speech core principals that formerly family-owned newspapers once held dear as twentieth-century guardians of the First Amendment.

A second area of serious concern is the potential erosion of privacy in the age of not only digital media, but also hyper reality, today's AR. Where content is tagged to precise locations and exact dates and times and individuals, the temptation to sell that information to advertisers is so powerful it may be irresistible. However, geo-marketing is not necessarily a negative occurrence if the consumer has a choice in the matter. If a user can freely and easily opt in or out, he or she may be able to have free or reduced-cost access

to digital media, or AR-enhanced content. This agreement might be an equitable trade-off, at least for some. At the same time, AR spyware may not be the sole domain of corporations. Governments may find such AR-tagged content and those who generate or use it to be of great value during criminal or terrorist investigations.

Developments in AR for journalism and media offer significant implications for future research. Of importance, there is a series of research questions that emerge from the findings and analysis presented in this monograph. The following are some of the most significant research questions that the authors propose for future research, based on the case study, the interviews, and the roundtable analyzed here.

First, to what extent will AR engage citizens more actively in media content than that same content without AR enhancement? This research question follows from the notion that individuals may be less engaged when passively processing information.[128]

Second, will citizens who interact with AR-enhanced content spend more time than on that same media content without AR enhancement? This research question is based on the notion that active processing more deeply engages individuals, and they may be more likely to linger with that information.

Third, as an immersive media form, will AR-enhanced news content generate greater cognitive processing among audience members than that same media content without AR enhancement? This research question follows from the notion that the combination of media involved in AR, including visual, aural, and haptic, will more fully engage the user's cognitive processes.[129]

Fourth, will AR content generate greater recall and other cognitive effects than that same media content without AR enhancement? This prediction follows from the notion that learning is aided from the reinforcement of not only multimedia involved in AR but also its greater cognitive processing.[130]

Fifth, what storytelling forms will evolve as news organizations, journalists, and citizens use AR in journalism? This research question follows from the expectation that innovative individuals and organizations will continue to adapt the unsettled technology of AR in its application to journalism and the media.

Finally, there is a set of research hypotheses, or corollary predictions, derived from Rogers's diffusion model:

1. The greater the perceived relative advantage of AR as a storytelling form, the greater its adoption by news organizations and its use by consumers
2. The greater the compatibility of AR to existing news media practices and culture, the greater its rate of news media adoption
3. The simpler AR technology becomes, the faster its rate of adoption by news and media organizations and citizens in their use
4. The more AR is seen in use among other news organizations, the more rapid the adoption of AR by news organizations

Ultimately, the adoption of AR-enhanced news content in journalism, such as in the form of the situated documentary, may lead to a more engaged citizenry. This could lead to a more informed citizenry.

These research questions and hypotheses suggest directions for future research on AR and journalistic innovation. However, we should also note certain important limitations to this research. Much of what has been reported here has been exploratory and based on limited data, including a small number of expert interviews, a single case study, and roundtable discussion, as well as early media trials of AR applications. This research provides only a preliminary perspective on how an emerging technology could be used in transforming the storytelling structure of journalism.

The potential to provide more contextualized news content and serve a more engaged citizenry in democratic discourse is a laudable goal. Whether the use of a new technology such as AR can lead to that goal may depend on human factors as well as economic variables. Nevertheless, innovative journalists currently use AR to create a bold new form of journalism that is both ubiquitous and relevant to deliver participatory, immersive, and community-based stories.

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Bios

John V. Pavlik is Associate Dean for Research at Northwestern University Qatar. He has written widely on emerging technology and its implications for journalism, media and society.

Frank Bridges is a media studies Ph.D. student at Rutgers University's School of Communication and Information. His research interests are the political economy of music and visual communication.