

# Journalism in Virtual Reality: Opportunities and Future Research Challenges

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## ABSTRACT

This paper presents a state-of-the-art overview of journalism and its opportunities and challenges in virtual reality (VR). First, we examine what kind of real-life journalistic experiments have been made in this field thus far, and then we analyze the research literature on journalistic VR. We discuss the emergence of virtual reality and immersive journalism explored in the latest reports in the fields of Human-Computer Interaction (HCI) and VR design. To analyze VR journalism further, we develop an early draft of an analysis model based on sample of three VR productions and four VR applications. We conclude by discussing the results of the analysis and outline a more advanced and interdisciplinary research approach for studying and designing journalistic VR productions.

## CCS Concepts

• **Human-Computer Interaction (HCI), New forms of journalism and media, Virtual, augmented and mixed reality.**

## Keywords

Virtual reality; VR; journalism; Immersive journalism; VR journalism; innovation journalism; HCI; augmented reality; AR, mixed reality; MR

## 1. INTRODUCTION

Virtual reality (VR) was assumed to have changed everything in communication at the beginning of the new millennium [3]. Especially, Second Life as a virtual environment was marketed the new place where humans could interact. News agency Reuters even inserted one of its technology reporters in Second Life to work for two years, in 2006–2008 [27]. When the Reuters “virtual reporter” was called back from the virtual environment to report on real-life events, it was widely interpreted that the VR hype was over [26]. Then the buzz around VR started again. Facebook announced in March 2014 that it had bought a manufacturer of virtual reality glasses [18], Oculus VR, for an astonishing US\$2 billion. Oculus was an 18-month-old start-up funded by a Kickstarter campaign.

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Until 2014, the number of VR companies was limited. Therefore, Facebook’s investment in VR could be seen as a seminal moment in the tech industry.

Mark Zuckerberg wrote in his Facebook posting [32] that one day “immersive, augmented reality will become a part of daily life for billions of people.” He also believed that VR is “really a new communication platform.” According to Wired magazine, “advances in processing power and sensor technology have meant that the cost has reduced to a point where it can finally impact multiple industries, and startups are using it in sectors as diverse as entertainment, design, scientific research, defense, communication and education” [3]. The decreasing cost increases the number of application fields, predicting a breakthrough in the use of the technology by the masses. In 2014, Google entered the VR business with the inexpensive Cardboard headset. In addition, Valve, Sony, Samsung, Microsoft and Nokia have developed VR headsets or cameras. Therefore, once again, traditional media companies were not the innovators, but tech companies that provide the platform and technological enablers [8]. New York Times Magazine Editor Jake Silverstein, who had been leading the Times into VR, envisions VR taking its own place among the other formats [25]. The New York Times VR app was the most successful app launch ever according to Silverstein [25].

As a concept, VR is at the very end of the reality–virtuality continuum. VR is defined as a computer-generated three-dimensional environment that is interactive and in which a person is immersed [19]. In between the two ends of the continuum is mixed reality (MR) [20]. MR refers to mixing of real and virtual, and the amount of mixing can vary. Augmented reality (AR) is part of MR, closer to reality than virtuality. In AR, the view of the real world is overlaid with digital, computer-generated information or objects (audio, graphics, photos, video, animation) such as in the recently launched Pokemon Go mobile game, for example. Our focus and interest lie primarily in the virtuality end of the continuum, specifically in VR. However, we cover some prior research in relation to journalism in AR, as it is a step toward journalism in VR.

This paper provides an overview of the state-of-the art of the current situation of journalism in VR, analyzing the journalistic production processes for VR in light of recent research reports and outlining the key challenges when designing for VR. Based on the prior research findings, we construct an analysis model for VR reality stories or products and use it to describe the key features of early VR journalism. Based on the overview and key findings of the analysis, we present an interdisciplinary research and development approach and discuss it in the concluding remarks of the paper.

The research questions are as follows:

- What is the state-of-the-art in the field of journalism in VR?
- What are the key findings in the research on journalistic VR and VR in general?
- How should the key features of the existing journalistic VR be studied?
- How can the various fields of VR-related research (communication and journalism studies, computer science, and human-technology interaction) be organized around a series of pilots or prototypes in the field of journalistic VR?

This paper starts with a review of the intensive interplay between journalism and virtual reality in recent years.

## 2. JOURNALISM AND VR TODAY

One of the first steps into VR journalism was the use of 360-degree videos. You just insert a VR camera inside an event, and the camera records everything in 360 degrees. A YouTube search for “360 video” gives more than 22,900,000 hits (22.6.2016). For example, the run-up to the U.S. elections produced a number of 360-degree videos by many news organizations in 2015 and 2016.

The New York Times [30] was one of the most serious early adopters of VR headsets. The company published its first VR app in November 2015 [28] and distributed more than million Google-made VR Cardboard headsets to home delivery subscribers [30]. The first journalistic VR piece in the New York Times was an 11-minute long feature, or mini-documentary, “The Displaced.” It focused on the stories of three children forced to leave their homes because of crises in Lebanon, South Sudan and Ukraine. The VR story was part of the New York Times Magazine’s cover story about the global refugee crisis. Another early journalistic VR story was about the work of a street artist in New York. The street artist was hired to create the cover for the New York Times Magazine, and the VR story showed the artist’s working process. A user of the VR headset and the New York Times VR app was able to enter in the middle of everything and even fly in a helicopter in the city. Interestingly, the first sponsor, General Electric, produced an animated video for the New York Times VR app that showed VR’s potential for advertisers and marketers. Later, VR content was sponsored by Ford, Infinity, Google and the Pulitzer Center [11].

The New York Times’ second round of sending out Google Cardboard headsets occurred in April 2016, when the paper delivered 300,000 headsets to its “most loyal” digital customers, based on subscription length [30]. Since the start, the New York Times has produced more than 20 different mini-documentaries or art pieces for the New York Times VR app by mid-September 2016 [29]. They vary from the refugee crisis to the aftermath of the Paris terrorist attacks, the U.S. presidential election and the search for the frigid heart of the planet Pluto. The latest mini-documentary (11.8.2016, 11 minutes) was about the fight for Falluja, Iraq. The New York Times was embedded with Iraqi forces as they retook the city from ISIS [29].

With the New York Times showing the way, other American news outlets, such as ABC, Vice, and the Verge, have followed and started their VR productions: “virtual reality shorts” [30]. Interestingly, there is still no consensus on what to name these new VR genres of journalism. The terms “immersive journalism” [10] and “augmented reality” (AR) have been used in the literature, depending on the focus and amount of reality vs. virtuality [16]. In the next section, we discuss the research findings in more detail.

## 3. OVERVIEW OF THE RESEARCH ON VR JOURNALISM

### 3.1 User Experience of AR and VR in Journalism

Little research exists on the user experience (UX) of AR and VR in journalism, although some ideas and prototypes have been created and evaluated. Feiner et al. [9] suggested in the late 1990s that journalists could provide news content to be consumed at the location of the event. More recently, suggestions for supporting crowdsourcing of news content by presenting the crowdsourcing tasks with AR have been made, as well as presenting and gamifying locative crowdsourced user-generated news content with AR [31]. The term situated documentary describes immersive storytelling in which a user experiences past news events while wearing a head-worn display when moving (on foot, in a car etc.) in real life through the location where events took place [16]. The idea is to place geo-tagged interactive and immersive media items in the real world to enrich the experience of the real world.

Immersive journalism refers to the production of news to support participants (the audience) gaining first-person experiences of the events or situations in the news stories [4]. Typically, the person is represented as an avatar (an animated three-dimensional [3D] representation of the participant) with a first-person view in the virtual environment and enters a virtually recreated scenario of the news story [4]. In immersive journalism, the participant feels he or she is there at the scene of the news story, and the participant’s body is part of the news story, either as himself or herself, as a visitor at the location, or as a character of the news story [4]. In addition, illusion related to the body ownership [22] can be created that supports immersive journalism.

De la Pena et al. [4] reported creating an immersive journalism experience as a first-person experience of a stress position in virtual reality. The context was a detainee’s experience of being held in a cell, in this case a virtual cell. The second component was an audio track created based on authentic interrogation material, creating an illusion of an interrogation in the adjacent cell. A male virtual human was in a cell in a crouched position, and the participant first saw the character from the third-person perspective, before switching to the first-person view. No formal experiment was run, but the participants were asked to experience the news story informally. Based on the feedback from interviews with three participants, they experienced being there as well as plausibility, which led to realistic responses in the experienced situation. They also mentioned their virtual body and its awkward position creating a feeling of discomfort. In addition, one participant mentioned feeling like a prisoner, supporting the journalistic goals of creating empathy and understanding, in this case, for the prisoners.

Experiments that use telepresence in journalistic work processes have been reported. Kishore et al. [12] investigated “beaming” the physical representation of a journalist or an interviewee with full-body motion capture and streaming to a distant location. The capture data is mapped in real time onto a humanoid robot at a remote location to create a perceptual illusion of the robot being their own body. The robot’s eyes stream back stereoscopic video to the head-mounted display (HMD) of the journalist or interviewee. A two-way audio connection enabled communication between the journalist and the interviewee. A field study with real-life reporting aimed at understanding how comfortable those interacting with the robot in the remote location felt and if their experience was positive. The initial results from the study with six participants

located in a remote location with the humanoid robot indicated the following [12]. Participants expressed mixed feelings about interacting with a real person, instead of a robot. Half of the persons in the presence of the humanoid robot that represented the visitor (either the journalist or the interviewee) had positive or neutral feelings about interacting with a real person, instead of a robot. However, half disagreed. Slightly less difference in the perceptions of the respondents and slightly more positive responses were given for assessing whether the person controlling the robot was felt to be in the same physical space as him or her. Assessments of whether it is a good idea to use a robot for journalism purposes were again divided. Four participants agreed that they felt comfortable in the presence of the robot and felt they could solve tasks with the robot. In contrast, two participants felt threatened by the robot. In addition, two participants were afraid to make mistakes or break something while interacting with the robot. As for creating the illusion of one's own body by the humanoid robot used in the beaming, the journalist described these sensations to have taken place even after longer periods of time. These initial experiences of interacting with the humanoid robot, whether representing a journalist or an interviewee, may be less strange in the near future as robots become more common in everyday life.

The proposed initial solution also paves the way for reporting from the location of events without physically being there, with the help of a humanoid robot that can deliver a first-person view and connect and interact with the interviewees in person [12]. Opportunities exist for reporting events with physical danger or fast unfolding stories in distant places. The interviewee can be teleported to a studio or some other place without traveling costs to have a "face-to-face" interview. In addition, the appearance of the reporter (as well as the interviewee) can be modified to minimize prejudice as Kishore et al. [12] suggest.

As can be seen from these examples, more research is needed on immersive storytelling in journalism, and users' experiences whether the users are participating in the production processes or consuming the created stories. These studies can aid in developing novel effective journalistic production processes, making news in virtual reality, and creating content that the users, the paying customers, are willing to pay for. Furthermore, interacting with media items, exploring and experiencing the content and interacting with it, needs further research.

### 3.2 Research on the Production of Journalistic VR

We start with how the technical and narrative content production of making journalistic VR is dealt with in the research literature. One of the first reports on the production of journalistic VR [1] compared the traditional documentary TV production process with VR production. In creating framing, composition and perspective in VR productions, the use of technical tools and narrative thinking are very different from those in traditional TV production.

The technical production of journalistic VR is divided into three stages that have their own technologies and required skills [1]. The first stage is capturing the content with cameras and sound, the second stage is post production with image processing, motion graphics CGI and 3D modeling software, and the third stage is distribution with headset technologies and their associated content stores. At present, all three stages are in flux.

The editing of journalistic narratives in VR is also changing the rules of journalistic work. For example, in making a VR production, the director has to work with framing that is not fixed and edit the

content without using cuts in the traditional way. In VR, the continuous piece of immersive 360-degree video that creates one scene is often done with a single shot that the users can then explore as they want. This changes the narrative possibilities of editing the content dramatically. An important problem to be solved is how one can create narrative structures without using the editing conventions based on film and TV productions. According to Doyle et al. [6], a possible solution is to use gaming strategies so that the piece allows users to explore scenes and discover characters and information at their own pace, similar to how a user navigates through a video game [6]. Giving so much freedom to users means a radical shift in the journalistic mindset. In addition, camera movements are different from those in film or TV. VR cameras move less than traditional cameras because camera movement can cause nausea for users.

The Tow Center report [1] concluded that, thus far, there appear to be two strategies for crafting journalistic narrative for documentary VR. The first is to have directed action take place in the front of the "surround" camera, and the second is to adulterate the immersive video with extra elements, such as computer-generated graphics or additional video layers. This means that the preexisting grammar of the film is altered [1].

The Tow Center report highlighted the tradeoffs that journalists have to be aware of when they make VR at the present stage. The producers have to decide which users they are trying to reach. When using high-quality technology with interactive content, the project should include (in addition to journalists) a team of VR experts who handle the various details with suitable software. In addition, a large budget and timeline flexibility are needed. The use of high quality also means that the possible audience could be reduced to those few with the right high-end headsets. Pursuing lower quality is less costly but also means limited technical and narrative possibilities and poorer quality but a larger number of users.

Many VR producers (for example, in [6]) state that the production time and cost, including cumbersome postproduction and the stitching process, can be laborious, time-consuming and expensive. Because the technology is developing fast, it is difficult to decide what equipment should be used. However, the current problems (immature technology and high production costs) can be solved when 360-degree cameras make their way to VR newsrooms and productions. When the content-gathering technology, data capture, postproduction software, and the quality of the headsets are evolving, more immersive experiences can soon be created cheaper, better and more easily than before.

To summarize the outcomes of the research literature on production, the narrative development in journalistic VR is at a very early stage. This is why the journalism industry should actively explore a wide variety of genres and formats, not just VR documentaries. The genres of fast turnaround VR, live VR and game-like VR could be fruitful for more rapid, news-like purposes. Another promising avenue for experiments is data visualization. VR can mean that users can really literally handle and explore data-based stories by using natural hand gestures and actions, such as grabbing, turning, pushing, pulling or with multiple fingers or hands (see also [15]). With these kinds of features, VR can bring audiences closer to a story than any previous platform [1]. Second, the technical development of VR journalism is still in its infancy. There are many challenges: For example, high-end, live motion virtual reality with interactive features is very expensive to produce, and the production cycle is slow. In addition, the production processes and tools are not effective enough, not

integrated in journalistic work and require a wide range of new professional skills not common to journalists.

It is clear that more research, experiments, development and theoretical work are needed in the field of narration and developing technological tools and production processes to fulfill the great expectations that VR offers for journalism and the news industry. However, a rich tradition of VR research and design has been conducted in fields other than journalism. We now explore the key aspects and findings of designing VR related to human consciousness, senses, human computer interaction and user experiences.

## 4. EXPERIENTIAL ASPECTS OF VR

### 4.1. Presence and Immersion

From the point of experiencing events far away or “at the scene” spatially, and to build empathy and understanding that journalism can aim for in VR, presence and immersion are key concepts to be supported.

Presence refers to the sense of being there, a state of consciousness, which has even been claimed to be the central goal of virtual reality. Presence is a subjective and objective description of the degree of being there. Subjective refers to the realistic feeling of the place, whereas objective is an observable behavioral phenomenon of behaving similarly as in a real environment and situation. Recently, presence has been deconstructed into place illusion, the sensation of being and operating at a remote or virtual place, and plausibility (feeling that what is happening is really happening) [21]. De la Pena et al. [4] concluded that head and body tracking and appropriate multisensory changes in correspondence with body moves tend to lead to place illusion. In the media experience, plausibility is important as it is related to the dynamics of the events and the situation [4]. Slater et al. [23] summarized that users who feel highly present should find VR more engaging than the surrounding world. They should also experience the VR environment as places they have visited, rather than as seen images.

Immersion is an objective and quantifiable description of the technology [23]. It describes “the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality” [23]. Slater et al. [23] characterized each as follows. Inclusive is the extent of shutting out the physical reality. Extensive is the accommodated range of sensory modalities. Surrounding is the extent (wideness) of panoramic view. Vivid refers to the modality’s simulated resolution, fidelity and variety of energy and represents the richness, information content, resolution and quality of displays. This is also referred to as display fidelity, which is defined as “the objective degree of exactness with which real-world sensory stimuli are reproduced” [13]. When considering the journalistic content presented and consumed with VR technologies, the highest level of exactness is created visually by 360-degree videos. In limited spaces, high-quality graphics can currently create almost similar sensations visually.

Immersion also requires matching. Matching refers to the match between the user’s body movements and the information presented on the displays [23]. For example, turning the head results in a corresponding change to the visual and auditory displays, requiring body mapping, at least the head. In addition, a self-presentation as a virtual body perceiving and possibly interacting with objects is needed in VR [23]. Slater et al. [24] suggest body-centered interaction in which a minimal lag and maximized match is aimed to be generated between a user’s motor actions and the

corresponding system response. For example, the user really walks in a real environment, and the body movements when walking create a corresponding optical flow [23].

### 4.2 Design Considerations for VR

Human factors issues, in the case of AR and VR, especially natural interaction, ease of use, comfort of use, as well as the safety of the users, need to be considered when designing new applications and services for journalism.

Interacting with the virtual environment, and its media content and information, including data, is one key issue to be solved. Interaction fidelity refers to “the objective degree of exactness with which real-world interactions can be reproduced” [14]). Interactivity is related to any action by the user that causes a change in the virtual environment [7] and can include from one to several modalities in the input by the user, and in the feedback to the user by the system. A user’s action can be manipulation of an object or data, or a user’s movement that causes a change in the virtual environment, for example. The technical limitations need to be considered constraints to be minimized when developing user interfaces for VR applications. The design decision about the preciseness of the interaction compared to real life can vary between accurate modeling, which may currently lead to too slow and delayed response times, and crude modeling of key characteristics of interactivity that can lead to too simple VR solutions from the experiential point of view. Recent research suggests that semi-natural interactions are worse for user performance than low-fidelity interactions or high-fidelity interactions and are therefore not recommended to be implemented [14]. Lower user performance can also be expected to impact user experience negatively. Creating and using design patterns for interaction, and mimicking natural interactions can provide a solution for interactivity in VR journalism. Design patterns are needed to be created for VR applications.

Cybersickness affects user comfort and even user safety. Reports of feeling of ill and symptoms related to motion sickness are being reported as the number of 3D movies and stereoscopic displays and systems tracking the user’s viewpoint are rapidly increasing. Rebenitsch and Owen [17] summarized based on a review of previous research that the likelihood of symptoms ranges from 30% to 80%. They define cybersickness as “the onset of nausea, oculomotor, and/or disorientation while experiencing virtual environments in head-mounted displays, large screens, and curved screen systems.” Visually induced motion sickness (VIMS) is nausea, oculomotor and/or disorientation induced specifically by any visual stimuli. Cybersickness can cause several simultaneous symptoms (e.g., nausea, pale skin, dizziness, cold sweats, vomiting, headaches). Symptoms vary depending on the individual. The most common symptoms in cybersickness are related to disorientation (vertigo, dizziness), with nausea rated second, and oculomotor (headache, eyestrain) the third most common symptom. Research shows that the side effects can be decreased by habituation with sessions every 2-5/7 days [17]. However, Rebenitsch and Owen [17] raise as most problematic the results related to the duration of symptoms (even over an hour) after long exposure to virtual environments, specifically regarding disorientation. As disorientation affects balance, they suggest that traveling immediately following long immersion is not recommended at least for an hour. Users need to be at least cautioned about these effects in case the exposure is not brief. Duration of symptoms is especially relevant for consuming journalistic content, when considering some of the typical ubiquitous consumption patterns while waiting, on transportation or in spare moments throughout the day, like

coffee breaks or similar. Next, we move on from research findings to analyzing some of the first products of journalistic virtual reality and developing a more coherent analysis model for VR journalism.

## 5. TENTATIVE ANALYSIS OF JOURNALISTIC VR

Taking into account the scattered findings of previous research presented earlier, we develop a model for bringing together and analyzing more closely the technological, productional, narrative and design features of journalistic VR productions. A more developed tool for analysis is needed to clarify the dominant narrative and design patterns in the prevalent first phase of VR productions and to develop novel ideas for journalistic VR to come. We analyzed several VR productions in more detail to understand the current trends in the field and to develop our research approach and model of analysis further.

We went through all the New York Times' VR stories published before mid-September 2016 (N=18). Most of the stories were high-quality mini-documentaries. They represented several different categories of content: art and culture, entertainment, foreign reporting, nature and science, and sports. In addition, five sponsored VR pieces were published in the stream of New York Times VR application and a collection of three videos from the Sundance film festival. In this way, the New York Times VR stream is not only for journalistic products but also for sponsored content and art pieces.

For this paper, only a small sample of New York Times' VR stories was chosen: mini-documentaries "The Departed," "Pilgrimage" and "The Fight for Falluja." These three VR stories represent the foreign reporting category, which was clearly the most popular theme in the New York Times VR stream (N=9). Traditionally, crisis reporting has offered emotionally powerful videos and images for news outlets, and this seems to be the case in VR reporting.

The three VR mini-documentaries were published as part of a larger story package, including long front-page features in the New York Times Magazine and various other elements on the web. In this way, the mini-documentaries were like VR extensions, but they could also be viewed autonomously, as independent stories.

The number of people mentioned in the end text of the productions ranged from nine to 55. This clearly shows how large a workforce is needed for high-quality VR productions, but also that the number seems to be diminishing. The highest number, 55, is related to "The Departed," which was among the first VR productions by the New York Times in collaboration with VRSE, published in November 2015. Two other foreign reporting mini-documentaries were produced in the summer 2016, and only 9 and 13 names were listed in the end text. Furthermore, one main difference between the first and the latter two works was the number of countries in which the story was filmed. "The Departed" was made in three countries, and of course, more local staff was needed.

"The Departed" also used a different narration style. It was based on local children's voices, and the English translations were projected artificially on the video. In addition, facts about migration were shown as text between the clips. "Pilgrimage" and "The Fight for Falluja" used both the voice-over of a reporter.

In "Pilgrimage," the VR camera was placed in several spots in Mecca showing religious sights, and some background scenes, such as ice cream vans, and a TV studio. "The Fight for Falluja" consisted of several battle scenes and aftermath clips, including

destroyed buildings, cars, prisons, and even the corpse of a soldier. "The Fight for Falluja" was narrated as a reporter's and photographer's field work.

"The Displaced" and "The Fight for Falluja" are 11:08 minutes long, and "Pilgrimage" is 4:33. Compared to other items in the New York Times VR stream (the average was about 7 minutes), the shortest was 1:44 about the food drop in Africa, and the longest, the TV series Mr. Robot VR experience, 13:07.

Additionally, in the beginning of September 2016, we analyzed more closely four journalistic VR applications available in Apple's Appstore and Android Play Store made by well-known journalistic content providers for some of the most prominent media houses. The four applications analyzed were the New York Times VR (The New York Times), VR Stories (USA TODAY), Guardian News and Media (Guardian), and RYOT - VR (Huffington Post). We included the application Jaunt VR by the company JauntVR as they create 360-degree video experiences for VR for ABC News. Jaunt VR is also used as the app for ABC News VR content. The VR content of ABC News can also be accessed with mobile or desktop at [ABCNews.com/VR](http://ABCNews.com/VR).

When looking at the installs of news applications, by far the highest number of downloads of the app are for New York Times VR, not surprisingly due to their early activity in promoting VR to their readers. All applications are available for iOS and Android. Content can be watched usually either with a smartphone or a smartphone and headgear, such as the Google Cardboard set. The VR content and stories are primarily based on 360-degree videos. The VR content of three apps concentrates primarily on news and documentaries (New York Times VR, USA TODAY, Guardian), whereas Huffington Post's RYOT - VR also provides entertainment. Based on these tentative findings, the real-life based nature of news favors 360-degree videos as a content format opposed to computer graphics-based virtual environments, which can be more complex and expensive to create. Currently, a combination of VR computer graphics and 360-degree video content, for example, is not seen in the journalistic VR content. However, real audio recordings have been combined with computer graphics based environments to create realistic experiences.

We have illustrated some of the main trends in the field to help develop our analysis model further. For the next phase of analysis of journalistic VR, we suggest that it should include at least the following elements: theme of the production, narration options, dimensions of presence and immersion, features of emotionality, production technology options (camera, edit) and tech options for consuming the content (glasses, smartphone etc.). In addition, we propose that identification of the components of the experience and the characteristics of the context of use are vital for user-centered design and the development of storytelling, applications, and interaction within VR journalism.

## 6. DISCUSSION AND CONCLUSIONS

This paper has shown that VR or AR is not going to become a natural environment for journalism overnight. However, many industry experts think that the time is ripe for a real breakthrough and that the "Cardboard phase" will end soon, and consumers will demand more upgraded headsets. Facebook's serious investment in Oculus Rift is a signal in this direction.

Another signal of this coming new era is the astonishing popularity of the Pokemon Go mobile game around the world. It shows that AR has amazing potential for activating users and giving them almost unimagined first-person experiences.

The news industry in the United States has already awakened and is experimenting with VR environments. However, there are still many obstacles to a major breakthrough of VR journalism. First, the technical development of VR journalism is still in its infancy. A number of challenges exist: For example, high-end, live motion virtual reality with interactive features is expensive to produce, and the production cycle is slow. Second, the production processes and tools are not effective enough, not integrated in the journalistic work and require a wide range of new professional skills. Third, the narrative development in journalistic VR is at a very early stage. This is why the journalism industry and researchers should actively explore and try a wide variety of genres in VR, not just documentaries. To create new narrative conventions and production methods, journalism should utilize strategies used in other fields that use VR, for example in the gaming industry.

The costly production, of course, is a problem that can limit the possibilities of VR only for the most affluent media houses. To prevent this, more effective, inexpensive and rapid work processes should be ideated, developed and trialed. In addition, there are important lessons learned for the journalism industry from the previous research and development of VR. To offer fresh experiences for the senses that really make users want more and hopefully pay for VR journalism in a form or another, the two central elements of VR—presence and immersion—should be built to offer a realistic sense of the place and inclusive surrounding for users to explore. It is also crucial to remember that human factors issues, especially natural interaction, ease of use, comfort of use, as well as user safety, need to be considered when designing new applications and productions for journalism.

This paper has shown that little research exists on the production and user experience of AR and VR in journalism. Although some research exists, more systematic approaches exploring the opportunities, experiential factors and possible genres are needed. Further ideas and concepts need to be explored and experiments conducted with prototypes to understand the factors that contribute to user experience in VR journalism, and the possibilities for a completely new type of immersive experiences.

To conclude this exploration, we have outlined a multidisciplinary research approach that combines rapid prototype development cycles with more profound research questions coming from different fields of research. In creating the prototypes, testing the production methods and designing and studying the user experience, the different goals of research come together and benefit each other. In building, testing, and iterating prototypes, we will create new knowledge that thus far has been lacking in the journalistic media houses and newsrooms. With this approach, we are able to find answers to various questions at the same time, such as the following:

- How to develop pleasurable human-technology interaction (HTI) and user experience in VR? (task for programming, HTI, and service design)
- How to develop novel solutions, production methods and tools that meet the principles and ethics of journalism, creating new genres of journalistic content? (tasks for communication and journalism studies)
- How should the business models be incorporated into journalistic VR? (task for online business studies)

We believe that this kind of multidisciplinary approach combining programming, HTI, service design, journalism studies and business studies incorporated into fast cycles of developing prototypes will boost the field more efficiently than traditional, more descriptive research on the best practices of journalistic VR.

To conclude, there are great potential gains in the marriage of virtual reality and journalism. The research findings presented in this paper show that one of the core values of virtual reality for journalism lies in the possibility of building a sense of presence that can build an emotional connection to a story, a place and a person. It may give users a greater understanding of the stories and build empathy for the people and their lives that the stories tell about. In addition, the possibility of giving users the freedom to explore the VR environment means an important addition to the possibilities of journalism in the highly competitive media environment of the 2010s. We believe that this challenge should be met with the interdisciplinary research principles depicted tentatively here.

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