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Journalism in Virtual Reality –
Opportunities and Future Research Challenges

ABSTRACT
This paper presents a state-of-the-art overview on journalism and its opportunities and challenges in virtual reality. First we take a look at what kind of real-life journalistic experiments there have been made in this field so far, then we analyze the research literature on journalistic VR. The paper proceeds to discuss the emergence of virtual reality and immersive journalism explored in the latest reports in the fields of HCI and VR design. In order to analyse VR-journalism further, early draft of analysis model is being developed based on sample of three VR-productions and four VR-applications. The paper concludes to discuss the results of the analysis and outlines more advanced and interdisciplinary research approach for studying and designing journalistic VR productions.

1. INTRODUCTION
Virtual reality (VR) was assumed to change everything in communication already in the turn of the new millennium [3]. Especially Second Life as a virtual environment was marketed to be the new place where humans could interact. News agency Reuters even inserted one of its technology reporters to work only in the Second Life for two years, in 2006-2008 [27]. When the Reuters' "virtual reporter" was called back 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 manufacture of Virtual glasses [18] Oculus VR with astonishing 2 billion dollars. Oculus was just 18 months old start-up funded by a Kickstarter campaign. It can be argued that the number of VR companies were limited until 2014.Therefore, Facebook's investment in VR could be seen as a seminal moment in 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 lowering cost increases the number of application fields, predicting a breakthrough of using the technology also by masses. In 2014 also Google entered to the VR business with its inexpensive Cardboard.
In addition, Valve, Sony, Samsung, Microsoft and Nokia have developed VR headsets or cameras. So, once again, traditional media companies were not the innovators, but tech companies who provide the platform and technological enablers [8]. The New York Times Magazine editor Jake Silverstein, who's been leading the Times into VR, envisions VR to take its own place among the other formats [25]. The NYT VR app has been the most successful app launch ever according to Silverstein [25].

As a concept, Virtual Reality (VR) is in 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 overlayed 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 lies primarily in the Virtuality end of the continuum, specifically in VR. However, we will cover some prior research in relation to journalism in AR, as it is a step towards journalism in VR.

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

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

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

2. JOURNALISM AND VR TODAY

One of the first steps into VR journalism has been the use of 360 videos. You just insert a VR camera inside an event and it records everything in 360 degrees. Youtube search for "360 video" gives over 22,900,000 hits (22.6.2016). It can be claimed that for example the run-up for the US elections have produced a number of 360 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 also distributed over million Google made VR cardboards to its home delivery subscribers [30].
The first journalistic VR piece in the New York Times was 11-minute long feature or mini-documentary "The Displaced". It was focusing on the stories of three children forced to leave their homes, because of crisis in Lebanon, South Sudan and Ukraine. The VR story was part of 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 working process. Actually, the user of the VR headset and the NYT VR app was able to enter in the middle of everything and even fly in a helicopter in the City. Interestingly, also the first sponsor, the General Electric, produced an animated video for the NYT VR app in terms of showing VR's potential for advertisers and marketers. Later also VR content sponsored by Ford, Infinity, Google and Pulitzer Center. [11]

NYT's second round of sending out Google Cardboards happened 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 have produced over 20 different mini-documentaries or art pieces for the NYT VR app by mid-September 2016 [29]. The variation has been from the refugee crisis to Paris attacks aftermaths, US presidential elections and seeking planet Pluto's frigid heart. The latest mini documentary (11.8.2016, 11 minutes) was about the fight for Falluja. New York Times was embedded with Iraqi forces as they retake a city from ISIS. [29].

New York Times showing the way, other American news outlets like ABC, Vice, and the Verge, have followed the fashion and started their VR production: "virtual reality shorts" [30]. Interestingly, there is still no consensus on how to name these new VR genres of journalism. Also "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 chapter we'll discuss about the research findings in more detail.

3. OVERVIEW OF THE RESEARCH ON VR -JOURNALISM

3.1 User experience of AR&VR in journalism

Relatively little research exists on user experience (UX) of AR and VR in journalism, although some ideas and prototypes have been created and evaluated. Feiner et al. [9] suggested already in late 1990's 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 the locative crowdsourced user generated news content by means of AR [31]. The concept of situated documentary to describes immersive storytelling in which a user experiences past news events while wearing a head-worn display when moving (on foot, in car etc.) in real-life through the location where events took place [16]. Idea is to place geo-tagged interactive and immersive media items in the real world aiming to enrich the experience of the real world.

Immersive journalism refers to the production of news to support participants (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 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 being there at the scene of the news story, and participant's body is part of the news story, either as him/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] report creating an immersive journalism experience as a first-person experience of a stress position in Virtual Reality. The context of the experience was 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 standing in a crouched position and the participant would first see the character from a third-person perspective, before switching to the first-person view. No formal experiment was run, but participants were asked to experience the news story informally. Based on the feedback from three participants' interviews, they experienced being there as well as plausibility, which lead 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 to feel like a prisoner, supporting the journalistic goals of creating empathy and understanding, in this case, for the prisoners.

First experiments on using telepresence in journalistic work processes have been reported. Kishore et al [12] have investigated "beaming" the physical representation of a

journalist or an interviewee by full body motion capture and streaming to a distant location. The capture data is mapped in real time onto a humanoid robot at the remote location to create a perceptual illusion of the robot being their own body. Robot's eyes stream back stereoscopic video to the Head-Mounted Display (HMD) of the journalist or interviewee. A two-way audio connection enables communication between the journalist and interviewee. Field study with real-life reporting aimed to understand how comfortable those interacting with the robot in remote location felt and if their experience was positive.The initial results from a study with six participants located in a remote location with the humanoid robot indicate the following [12]. Participants expressed mixed feelings to interact with a real person, instead of a robot. Half of the persons in the presence of the humanoid robot which represented the visitor (either journalist or interviewee), were positive or neutral in their feeling to interact with a real person, instead of a robot. However, half of them disagreed. Slightly less difference in perceptions of the respondents and slightly more positive responses were given for assessing if the person controlling the robot was felt to be in the same physical space with him/her. The agreement with assessing whether it is a good idea to use a robot for journalism purposes was again divided. Four participants agreed that they felt comfortable in the presence of the robot, and felt they could solve tasks with the robot. On the contrary, 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 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 for interacting with the humanoid robot, whether representing a journalist, or an interviewee, may have less strangeness already 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 the humanoid robot which 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 travelling 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 experiences of users whether participating in the production processes or consuming the created stories. These studies can aid in developing novel effective journalistic production processes, making news in the 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 will start with how the technical and narrative content production of making journalistic VR is dealt in the research literature. One of the first reports on the production of journalistic VR [1] compares the traditional documentary TV-production process with VR production. The outcome is that in VR productions creating framing, composition and perspective both the use of technical tools and narrative thinking and are highly different from the ones in traditional TV-production.

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

The editing of the journalistic narratives in VR is also changing the rules of journalistic work. For example, in making a VR production 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 one single shot that the users can then explore as they want. This changes the narrative possibilities of editing the content dramatically. Important problem to be solved is how one can create narrative structures without using the editing conventions based on film and TV-productions. In Doyle et al [6] one of the possible solutions is to use the strategies used in gaming 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 the users means a radical shift in the journalistic mindset. Also camera movements are different than in film or TV. VR cameras move less than the traditional ones because camera movement can cause nausea for users.

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

The Tow Center report highlights the tradeoffs that journalists have to be aware of when making VR at the present stage. The producers have to decide to which end of 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 handling the various details with suitable software. Also a large budget and timeline flexibility is needed. The use of high quality also means that the possible audience can be reduced to those few with the right high-end headsets. When pursuing lower quality is less costly but also means limited technical and narrative possibilities and poorer quality but larger amount 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 costly. Because the technology is developing fast it is difficult to decide what equipment should be used. However, the problems at present - immature technology and high production costs - can be solved when 360-degree cameras make their way to the 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 easier than before.

To summarize the outcomes of the research literature on production, first of all, 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 or 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 the data based stories by using natural hand gestures and actions like grabbing, turning, pushing, pulling, or with multiple fingers or hands (see also [15]).
With these kind of features VR can bring audiences closer to a story than any previous platform [1]. Secondly, the technical development of VR journalism is still in its infancy. There are lots of challenges like that the high-end, live motion virtual reality with interactive features is very expensive to produce and the production cycle is slow. Also the production processes and tools are not effective enough, not integrated to the journalistic work, requiring wide range of new professional skills not common to journalists.

It is clear that more research, experiments, development and theoretical work is needed both in the field of narration and developing technological tools and production processes to fulfill the great expectations that VR offers for journalism and news industry. However it should be noted that there is already a rich tradition of VR research and design conducted in other fields than journalism. This paper continues to 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 both 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] conclude that head and body tracking, and appropriate multisensory changes in correspondence with body moves tend to lead to place illusion. In media experience plausibility is important as it is related to the dynamics of the events and the situation [4]. Slater et al. [23] summarize that users who feel highly present should find the VR more engaging than 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] characterize each of these 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 videos. High quality graphics can in limited spaces 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 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 centred interaction in which a minimal lag and maximized match is aimed to be generated between user's motor actions and the corresponding system response. For example, the user really walks in real environment, and body movements when walking create a corresponding optical flow [23].

4.2 Design considerations for VR
Human factors issues, in case of AR and VR especially natural interaction, ease of use, comfort of use as well as safety of the users, need to be considered when designing new applications and services also 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 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. User's action can be manipulation of an object or data, or user's movement that causes a change in the virtual environment, for example. The technical limitations need to be considered as constraints to be minimized when developing user interfaces for VR applications. The design decision on the preciseness of 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 experiential point of view. Recent research suggests that seminatural 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 safety of users. Reports on feeling of illness or symptoms related to motion sickness are being reported as the number of 3D movies and stereoscopic displays and systems tracking user's viewpoint are rapidly increasing. Rebenitsch et al [17] summarize based on a review of previous research that likelihood of symptoms range 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. Highest rating of symptoms in

cybersickness is related to disorientation (vertigo, dizziness), with nausea ratings as second, and oculomotor (headache, eyestrain) as third highest symptom rating. Research shows that the side-effects can be decreased by habituation with sessions every 2-5/7 days [17]. However, Rebenitsch et al. [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 for 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, in transport, or on the spare moments throughout the day, like coffee breaks or similar. Next we will move on from research findings to analysing 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 are developing a model for bringing together and analysing more closely the technological, productional, narrative and design features of journalistic VR productions. A more developed tool for analysis is needed in order to clarify what are 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 have analysed few VR-productions in more detail to understand what are the current trends in the field and also 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 could be defined as 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 NYT VR application, and also a collection of three videos from the Sundance film festival. In this way, the NYT VR stream is not only for journalistic products, but for sponsored content, and art pieces, respectively.

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

All aforementioned three VR mini-documentaries were published as a part of a larger story packet, including also 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 texts of the productions ranged from nine to 55. This clearly shows, how much workforce is needed for high-quality VR productions, but also that the number seems to be diminishing. The highest number, 55, relates to the Departed, which was among the first VR productions by the NYT 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 texts. Furthermore, one main difference between the first and two latter ones was the number of countries the story was filmed in. The Departed was made in three countries, and of course, more local staff was needed.

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

In Pilgrimage the VR camera was placed on several spots in Mecca showing religious sights, and some background scenes like ice cream vans, and a tv-studio. The Fight of Falluja was consisted of several battle scenes and also aftermath clips including destroyed buildings, cars, prisons and even a corpse of a soldier. The fight of Falluja was narrated as a reporters and photographers field work.

The Displaced and the fight for Falluja were 11:08 minutes long, and Pilgrimage 4:33. Comparing to other items in the NYT VR stream (average was about 7 minutes), the shortest was 1:44 about the food drop in Africa, and the longest, TV-serie MR Robot VR experience 13:07.

Additionally, in the beginning of September 2016 we analysed closer 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 NYT VR (The New York Times), VR Stories (USA TODAY), Guardian News and Media (Guardian News and Media) and RYOT - VR (Huffington Post). In addition, we included also application Jaunt VR by company called JauntVR as they create 360° video experiences for VR for ABC News. Jaunt VR is 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.

When looking at the installs of news applications by far the most downloads of the app are for NYT VR, not surprisingly due to their early activity in promoting VR to their readers. All applications are available for both iOS and Android. Content can be watched usually either with a smartphone or smartphone + headgear, primarily a

cardboard set. The VR content and stories are usually based on 360° videos. The VR content of three apps concentrate primarily on news and documentaries (NYT VR, USA TODAY, Guardian), whereas Huffington Post's RYOT - VR provides also entertainment. Based on these tentative findings the real-life based nature of news favors 360° videos as content format opposed to computer graphics based virtual environments, which can be more complex and expensive to create. Currently combining VR computer graphics and 360° 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.

As stated earlier, remarks above are just tentative by nature made to illustrate some main trends in the field in order to help us to develop our analysis model further. For the next phase of analysis of journalistic VR we suggest that it should include at least following elements: theme of the production, narration options, dimensions of presence and immersion, features of emotionality, production technology options (camera, edit), tech options for consuming the content (glasses, smart phone etc.). In addition, we propose that identification of the components of experience for journalistic content and genres, and understanding the characteristics of the context of use are vital for user-centered design, and development of storytelling, applications, and interaction within VR- journalism.

6. DISCUSSION AND CONCLUSIONS

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

Another signal for this coming new era is the astonishing popularity of Pokemon Go mobile game around the world. It shows that AR has really amazing potentials for activating users and giving almost unimagined first person experiences for them.
The news industry in the US has already awakened and experimenting with VR environments. However, there are still many obstacles for a major breakthrough of VR journalism. First of all, the technical development of VR journalism is still in its infancy. There exist a number of challenges, for example, that the high end, live motion virtual reality with interactive features is expensive to produce and the production cycle is slow. Secondly the production processes and tools are not effective enough, not integrated to the journalistic work, requiring wide range of new professional skills. Thirdly 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.In order to create new narrative conventions and production methods, journalism should utilize the strategies that have been used in other fields using VR, for example in the gaming industry.

The costly production is of course a problem which 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. In order to offer fresh experiences for the senses that really make users want for more and hopefully also 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 safety of the users, need to be considered when designing new applications and productions also for journalism.

This paper has shown that relatively little research exists on 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 for understanding the factors that contribute to user experience in VR journalism, and the possibilities for 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 knowlegde that has been so far lacking in the journalistic media houses and newsrooms. With this approach we are able to find answers to various questions at the same time, like the following ones:

- How to 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 the business models should be incorporated into the 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 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 which 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. Also the possibility of giving users freedom to explore the VR environment means important addition to the possibilities of journalism in the highly competitive media environment of 2010s. We believe that this challenge should be met with the interdisciplinary research principles depicted tentatively above.

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