Position Paper for CHI 2019 Workshop on Challenges Using Head-Mounted Displays in Shared and Social Spaces

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ABSTRACT

This is a position paper for the Challenges Using Head-Mounted Displays in Shared and Social Spaces for CHI '19, reflecting the author's position regarding some of the significant challenges for usage and acceptability of Head-Mounted Displays (HMDs) in shared, social and public spaces. It also describes the some of the author's interests, relevant background work and potential discussion topics.

KEYWORDS

Virtual Reality; Augmented Reality; Mixed Reality

BACKGROUND INFORMATION & RELEVANT WORK

First, to introduce myself, I am a PhD student at the University of Glasgow. My work is primarily focused on mixed reality interaction for virtual reality (VR). My main topic of study focuses on increasing a VR HMD user's awareness of their surrounding area of which I am most interested in their interaction with co-located people in their vicinity. Current HMDs restrict a user's ability to communicate with nearby people. Communication, a bidirectional process, is made largely uni-directional when attempting to communicate with a HMD user as the co-located person is left to

somehow initiate the communication. Although current consumer HMDs include methods such as the HTC Vive's Knock Knock feature and Microsoft's Mixed Reality Flashlight help bridge the gap between the virtual environment and reality such methods can be thought of as rudimentary at best. These methods are reliant on the co-located person(s) initiating the communication with the HMD user and do not allow full bidirectional communication to occur between the HMD user and co-located person(s). Much of my work has focused on this problem space and examining how a more bidirectional communication can be established between a HMD user and co-located person(s).

Due to the bidirectional nature of the communication process, challenges are faced on both sides of the interaction. From the perspective of the co-located person it is largely a question of how to attract the attention of the HMD user. In this area, on-going work of mine includes a survey, focus groups and in-lab studies to investigate how a co-located person would expect to attract the attention of a HMD user. The aim is with knowledge of how they expect to interact and are most comfortable interacting that we will be able to design better methods of initiating a communication with a HMD user from the perspective of a co-located person. While the problems faced by the co-located person are largely those of initiating the communication, those faced by the HMD user differ and include how the communication or co-presence is represented within the virtual environment. To this end, work of mine has looked at potential representations of co-presence and desired attention the HMD user inside of a virtual environment. Building on the work of McGill et al. [7] we compared two visual methods (an avatar and text notification) against two audio methods (a notification beep and sonar) and their potential to communicate the existence of a co-located person and that they desired the attention of the HMD user. Interestingly we found that a subset of participants felt an increased feeling of anxiety and discomfort at being informed of the existence of a co-located person without any positional data about the co-presence being communicated. This sensation was termed as being "in the dark" due the comparison by one participant to the feeling of being in a pitch black room and told someone else was in the same room as them. At this workshop I would like to see both perspectives of the interaction included in the discussion.

On a more theoretical note, I think that a wider discussion surrounding the language being used when we discuss problems related to social HMD usage. In this regard while reviewing literature surrounding co-located HMD user interaction, augmented virtuality installations, shared experiences and co-located VR usage I began development on a taxonomy to model the roles and states within this interaction. This was motivated by the lack of consistency amongst on-going work regarding the language used to describe the common problems and scenarios being researched. Gugenheimer et al.'s *"Non-HMD user"* [2] becomes Mai et al.'s *"integrated bystander"* [6]. Lankes et al.'s *"VR player"* [3] is Gugenheimer el al.'s *"HMD user"* [2], etc. A visualisation / comparison of all the terms used to mean the same thing might be amusing joke as part of the discussion. Although I originally envisioned the taxonomy to model a general interaction between a HMD user and other person though as I

continue to work on it, it may change somewhat. However to briefly summarise the taxonomy in its current form, as I feel it very applicable to this workshop, we proposed the potential roles within the interaction as being:

- **HMD user:** The HMD user with whom the interaction is taking place
- **Co-located HMD user:** Co-located person who is also using a HMD
- **Co-located Non-HMD person:** Co-located person who is not using a HMD
  - **Non-HMD user:** Co-located person, without a HMD, who can influence the virtual experience
  - **Bystander:** Co-located person, without a HMD, with no influence on the virtual experience

Each role would then either *wittingly* or *unwittingly* inhabit one of three potential states. Each of the states is generally defined for the above roles in the taxonomy but for brevity a general summary is as follows:

Table 1: General Description of States:

State	Description
Unaware	Does not want any part of the interaction and ignores the opposing side of the interaction
Aware	Is aware of the other side of the interaction but is not engaged with them
Collaboration	Is aware of the other side of the interaction and is engaged in an interaction with them

COMMENTS ON RELATED WORK

In the previous section I have outlined some of my work section I believe that improving HMD user awareness of co-presence, and I believe that creating a more bidirectional communication process between a HMD user and co-located person is relevant topic for this workshop. The work of McGill et al. [7], Simeone [9] and Ghosh et al. [1] towards creating notification methods to better inform the HMD user of existing co-presence I feel is extremely relevant to the discussion of challenges faced by HMD usage in shared and social spaces. Venkatesh describes the living room in the home as even being a highly social environment [10] and the work by McGill et al, etc. is highly relevant to the future usage of HMDs in the home.

Outside of increased HMD user awareness I have interests in co-located HMD interaction (both in terms of multiple HMD users and a single HMD user and co-located Non-HMD persons) and augmented virtuality installations and experiences. Each of these consider the problem of "social HMD usage" in their own manner. Of particular interest I enjoy the work to create collaborative asynchronous gameplay between a HMD user and co-located person(s) of Gugenheimer et al. who

developed the ShareVR system [2] to provide the co-located person with a visualisation of the virtual environment and interaction with the HMD user through a variety of peripherals. I also enjoy Li et al. who presented a context-aware projection mapping system to connect HMD users and co-located people through a tangible physical space [5]. Using this system they created the CatEscape application [4] which required a HMD user and co-located person work together to complete the experience. In particular I find such work reminiscent of early work in the field which sought to investigate the potential for the medium while the technology was still fairly rudimentary, especially by today's standards. I find it reminds me of the approach taken by Pausch et al. [8] in their investigation into VR storytelling and the medium's ability to be tell stories rather than to just tackle yet another technical or hardware related problem.

CLOSING REMARKS

To close more generally, I feel that HMD usage in a shared, social context is a HCI problem in its purest. Rather than help solve the technical challenges of using HMD usage I do think we should increase our efforts towards the inherent challenges of using HMDs. Technically headsets today are vastly more capable and impressive than those of the past and the technology itself, I believe, has finally reached Gartner's plateau of productivity. As such I think that the inherent usability challenges faced by HMD usage - co-located HMD interaction, HMD usage in social spaces, increasing HMD user awareness to their surrounding area, etc. should be a key focus of HMD research. Workshops such as this one and on-going work presented above (and others) provide me with encouragement that others too feel this way about the technology.

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