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Public Domain

Mixed Reality at Work: Health, Social and Ethical Implication

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Abstract

In this position paper, we address the ethical and social issues regarding the use of mixed reality devices in professional contexts, in particular for industrial settings: health, exclusion and discrimination, accidental risk, over-control, meaning. Finally, we present some potential solutions from a human-computer interaction design perspective such as tangible trusted user control and sensors automatic shutdown.

Author Keywords

Mixed reality; head-mounted display; accident; over-monitoring; privacy; working environment; industry.

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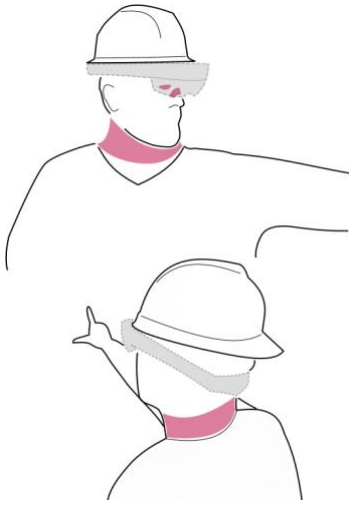


Figure 1: Health issues regarding devices weight and displays, in particular neck, noise and eyes strains.

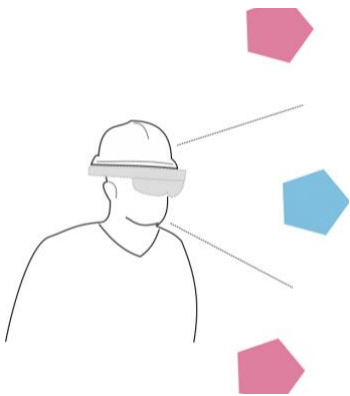


Figure 2: Exacerbated health issues due to the content height.

Introduction

As with many concepts before, the professional domains are the first to adopt new advanced technologies. Mixed reality is not an exception and it is already applied to many areas (industrial, health, architecture...) and envisioned to much more. The use cases of mixed reality are virtually endless, from the learning and assistance *in situ* to the remote help and control, the gain and benefits from the executives are easily palpable in terms of productivity but the positive impact must also be reflected to the direct users. Indeed, this new paradigm of adding a virtual layer on top of the reality thanks to multiple sensors directed towards the user and its environment may radically change the nature of work. In this context, we focused our position paper on identifying the potential risks regarding ethics associated with mixed reality in industrial context [8] and discuss about preventing solutions from a human-computer interaction design.

1. Health risk inherent from devices

Reasonably we assume that current and even near to medium-term future form factor of mixed reality devices applied to industrial context is between smart glasses and headset. In such case, the ergonomics characteristics such as weight of the device is an important factor of health that may cause (already reported subjectively [21]) nose, neck strain or other musculoskeletal disorders (**Figure 1**). Moreover, excessive exposition to physically close displays may quickly induce eyes fatigues or headaches [23].

HCI Research & Design Discussion

From the hardware perspective, we should combine two already implemented solutions. (1) Externalizing most of the components of the mixed reality devices and

thus minimizing the head-worn components (adopted by Magic Leap One¹, NReal² or Epson Moverio³). (2) Integrating the mixed reality device to more comfortable headsets such as hard hats or resting on the forehead, and thus relieving any potential pain to the nose (adopted by Microsoft HoloLens 2⁴).

From the software perspective, we should minimize and limit the number of virtual contents out of users' horizon line such as very high or low (**Figure 2**) that may exacerbate neck strain due to head movement and posture (observed during authors' industrial experiments). Having virtual content *in situ* means that we will consume it in a much wider range of postures. We should run field and laboratory-controlled studies and design interactions accordingly to postures that goes beyond the usual sitting, standing or walking by including those regularly encountered in industry such as crouching, lying on the back, cramped working conditions... (**Figure 3**)

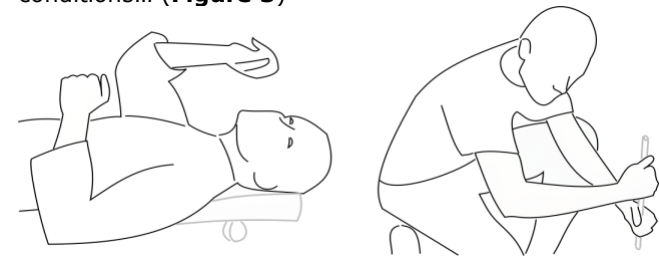


Figure 3: Effects of regular industrial postures such as lying on the back and crouching that need to be studied.

¹ <https://www.magicleap.com>

² <https://www.nreal.ai>

³ <https://moverio.epson.com>

⁴ <https://www.microsoft.com/en-us/hololens>

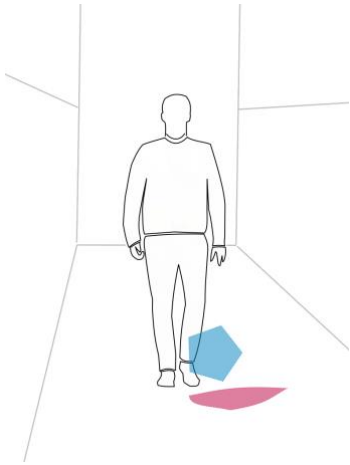


Figure 4: Accidental risk by occlusion (e.g. virtual content over a hole).

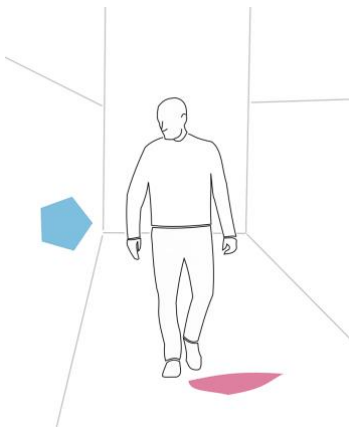


Figure 5: Accidental risk by distraction.

2. Accidental risk

Immersive environment offered by mixed reality may increase accidental injuries risk due to collisions or falling caused by occlusion that for instance may prevent seeing a hazardous entity (e.g. a hole or pipe, **Figure 4**). Preventing occlusion is not sufficient, because virtual content may also distract and prevent the user from focusing on the hazardous entities, which would have the same unfortunate accidental results (**Figure 5**), an issue already reported with mobile augmented reality game such as Pokémon Go [2, 9].

HCI Research & Design Discussion

The occlusion issue has been regarded in previous studies to avoid hiding different kind of real content [11], such as bystanders' head [16]. Less effort has been engaged into the effect of distraction issues [13].

3. Work exclusion and discrimination risk

In regard to health risk, some people may be more or less physiologically able to adopt these devices, and thus create a new exclusion from a particular population.

HCI Research & Design Discussion

We should emphasize the exploration of other devices form factor and way of consuming mixed reality, in particular these with external displays, prone to multi-user and collaborative experience, such as SixthSense [14, 15] that placed a pocket projector on the user.

4. Over-monitoring/control risk

At some point, mixed reality needs to collect contextual data in order to exist, the virtual layer is coherent only if the virtual content is well placed, at the right moment. The space and time content cohesion will

increase accordingly with the quantity of collected data. The collected data will be extremely sensitive about the worker and may cause an over-monitoring and control from executives. Even if law will regulate the use of collected data, it will affect the hierarchical trust at work by knowing that what a mixed reality user will see, hear, do and much more may be monitored. Over-monitoring, in particular via cameras, have significant negative effects regarding work stress [1], satisfaction and affective commitment [7]. Other potential effects of the feeling of excessive monitoring:

- Strict respect of the processes to avoid being considered against the prescribed rules, which may harm an essential process at work: regulations-in-action by the operator and thus leading to decrease in performance and system reliability [12].
- More hacks (**Figure 6**) from the worker that cause riskier bypass strategies, such as purposely not looking at some sensitive points of interest, leading to accidental scenarios.

HCI Research & Design Discussion

From the hardware perspective, the mixed reality devices may directly integrate modular strategy with physical trusted switch to activate and deactivate any sensors (such as cameras, micro, inertial central...

Figure 7). However, this approach may be a double-edged design, on one hand, reassuring users with extremely trusted solution, one the other hand, it concedes that the technology cannot be trusted [22].

From the software perspective, every mixed reality system should include fine-grained permissions, adding a layer between raw data from continuous sensing



Figure 6: Famous tangible hack to protect webcam privacy issues.

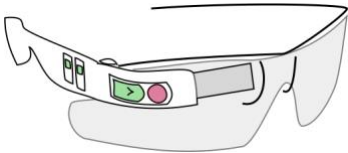


Figure 7: Integrating tangible sensor switches to the augmented/mixed reality devices.

components and applications to access only specific high-level data [3, 5, 6, 17, 18, 20]. Another design strategy would be to automatically deactivate sensors after some delays, requiring a push from the user to restart, instead of the opposite.

5. Work meaning-loss risk

Assistance with mixed reality may be overused and externalizing most of the cognitive task to artificially intelligent helper may increase the robotization of workers and decrease their autonomy, which would lead to a loss of meaning at work and finally deepen mental health problems. Such effect is already palpable in industrial warehouse where workers are told exactly where to find and put objects with auditive or visual cues.

HCI Research & Design Discussion

Perhaps a potential solution would be to actively integrate mixed reality gamification to disguise work, increase motivation while giving feedback to workers about the benefit of the performed tasks to the company [4, 10].

Conclusion

In this paper, we started to identify different issues regarding health, social and ethical implication of mixed reality. We are aware that it is far from an exhaustive list and from our examples we focused on industrial working conditions only because it is not only an anticipation for tomorrow, but for the present. However, most of the points may be applied as much to non-working environment, encountered in everyday life.

Authors

Damien Brun is a Ph.D. student in Cognitive Computing from TELUQ University (Canada) and tends to specialize in mixed reality head-mounted display interactions that include text-entry interfaces and multimodal interaction combining different devices for sensitive industrial context such as nuclear power plants. He is supervised by *Charles Gouin-Vallerand* from Université de Sherbrooke (Canada) and *Sébastien George* from Le Mans Université (France). *Stéphane Safin* is assistant professor in cognitive ergonomics at Télécom Paris, Institut Polytechnique de Paris (France).

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