

## **Summary of the Paper “Pervasive Augmented Reality—Technology and Ethics”, IEEE Pervasive Computing, (3) 2022**

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### **Introduction**

Pervasive augmented reality (AR) is a mobile technology which may have significant impact on various aspects of our future life. The paper "Pervasive Augmented Reality - Technology and Ethics" introduces the most important technical aspects of pervasive AR and highlights four ethical concerns regarding this emerging technology: data and privacy, health and safety, illusion and belief, and rights and access. It predicts a potential shift from smartphones to head-worn displays, which implement AR functionalities, giving examples which already exist, like Microsoft's HoloLens or the Snap Spectacles. Future head-worn displays are expected to integrate sensing, processing, and interaction functions, providing continuous and ubiquitous augmentation of the user's environment with digital information. While pervasive AR has transformative potential in communication, collaboration, education, and decision-making, the authors of the paper also acknowledge potential unintended consequences such as challenges in recognizing truth, commercial exploitation, privacy erosion, social interference, attention distraction, and increased digital inequality. They emphasize a shared responsibility among various stakeholders, especially technologists, in addressing the ethical challenges associated with the development and integration of pervasive AR, calling for a timely discussion of these ethical issues to influence the design and implementation decisions before it is too late.

### **Technical Aspects of Pervasive Augmented Reality**

One main issue of pervasive AR right now is the realisation of displays integrated into traditional glasses because of several limitations of this technology, like low fidelity of the image or a limited field of view (FOV). To display relevant, context dependent information on the screen also a variety of sensors is needed. These are used to track the position of the user, sense the user state, and capture user input. All this information has then to be combined and interpreted. One way to do that is using artificial intelligence (AI), which chooses the most relevant information for each context. Another key aspect needed for pervasive AR is the communication to the internet. With approaching technologies like 6G reaching speeds up to 95 Gb/s the needed exchange of big amounts of data will not be a limiting factor. As some technologies are already available and we are experiencing a rapid development in all important technical fields for pervasive AR, commercial implementations will soon be available, integrating all functionalities in one device which can be worn like normal glasses in everyday life. This means that we will be soon at a point where pervasive

AR displays will be the ubiquitous interface to digital information, leading to numerous ethical problems which must be considered beforehand:

## **Data and Privacy**

Privacy is a major concern with AR technology. The paper highlights two main privacy issues: the extensive data collection required by companies producing these technologies and the security measures to prevent unauthorized access. The example of Google Glass in 2013 is cited, emphasizing the controversy surrounding the device's camera and the potential misuse of collected data. With pervasive AR this problem will get even more relevant, as one of its main features is the always on functionality, which leads to a continuous collection of potential private data. The paper underscores the need for addressing privacy and security concerns to prevent the abuse of personal information by companies developing AR technologies and raises awareness about these issues to prevent potential problems in the future. It also states that the solutions used for traditional AR or other technologies will not be useable for pervasive AR, so completely new approaches have to be developed.

## **Health and Safety**

There are several health concerns associated with AR. The most important ones are perceptual distraction, blind spots, ergonomic issues, and unknown long-term effects of AR exposure. With pervasive AR these concerns will become even more relevant, as there is no limited use time. The insufficient understanding of how these effects, especially with prolonged exposure, may impact individuals in the future need to be considered when designing pervasive AR devices. Also, potential issues with attention, distraction, and cognitive workload need consideration before augmented reality becomes widespread. One solution for these problems could be that the content seen by the user is carefully chosen considering the various health aspects.

## **Illusion and Belief**

In this paragraph, concerns related to illusion and belief in augmented reality are considered, highlighting the potential for prolonged usage to blur the lines between virtual and real experiences, raising questions about when the illusions created by the technology could be perceived as real. This issue is connected to challenges in determining ownership of virtual objects in augmented reality, as these objects exist only in the digital realm. The article emphasizes the difficulty of regulating a person's belief in owning virtual objects that lack physical existence. As a solution for that problem, a way to separate the virtual and real world needs to be found. Also, the user should be able to choose the level of deception when using pervasive AR.

## **Rights and Access**

Mentioning existing AR applications like Pokemon Go this part of the paper is raising concerns about rights and access, with ongoing discussions on controlling the placement of virtual objects on physical property. Pervasive AR is anticipated to further impact the notion of private and public property ownership, potentially widening or narrowing the digital divide in many social contexts. Issues regarding virtual space ownership, personal data, and universal access are addressed. The authors suggest the need for potential legal adaptations to grant property owners rights over virtual space, regulations to control virtual overlays in public spaces, and considerations of data ownership laws to address potential exploitation and manipulation. They emphasize that, like other digital technologies, pervasive AR should be accessible by everyone to prevent inequalities and intentional disruptions by governments. To do so, social norms and legal frameworks need to be developed in tandem with technological development.

## **Conclusion**

The authors have outlined future pervasive AR technologies and identified four main ethical dimensions: data and privacy, health and safety, illusion and belief, and rights and access. The authors argue that existing ethical discussions on technology are often retrospective and insufficient for the continuous augmentation of the environment with computer-generated information that pervasive AR entails. They call for a more comprehensive and holistic "ethics-by-design" approach in the design and development of pervasive AR systems. The authors emphasize the need for technologists to play a key role in ethical considerations and advocate for a techno-empirical approach involving the construction and testing of tangible, ethical artifacts in both lab and field settings. The ethical discussions presented are intended as a proposal for broader consideration, particularly among technologists, social scientists, and other stakeholders involved in the development and integration of future pervasive AR technology.

## **Reference:**

H. Regenbrecht, S. Zwanenburg and T. Langlotz, "Pervasive Augmented Reality—Technology and Ethics," in *IEEE Pervasive Computing*, vol. 21, no. 3, pp. 84-91, 1 July-Sept. 2022, doi: 10.1109/MPRV.2022.3152993.