

Designing Extended Reality Worlds that Expand Human Abilities

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Abstract—Extended Reality (XR) systems enable a variety of experiences that range from subtle and discreet sensations to profound perceptual and motor mediation. Consequently, they open new opportunities for interactions with mixed, physical-virtual objects and environments, which ultimately enable users to develop new perceptual and cognitive abilities. In this context, this keynote invites a reconsideration of how interaction design influences the way we perceive, understand, and act in increasingly computer-mediated worlds. To this end, I will present several examples of wearable and ambient XR systems designed to support sensory, motor, and cognitive augmentation, with insights from interactive technology design, accessibility, and philosophy, and provide implications for the future design and development of XR environments.

Keywords—extended reality, human augmentation, mixed reality, augmented reality, cognitive augmentation

I. EXTENDED ABSTRACT

A diversity of user experiences can be designed through extended reality (XR) technologies, resulting in new ways to perceive one's surroundings, engage through motor response, and reason about the felt experiences. From wearable devices, such as head-mounted displays and haptic gloves, to spatial augmentations, such as those enabled by video projections and ambient sound, interactions in XR environments directly influence our perception, action, and thinking.

In this context, cognitive augmentation can be seen as a direct consequence of expanding perception and action due to superimposition of experiences in XR environments. This creates the need for a new thinking paradigm, which I call extended thinking [1], representing a complement to both critical and computational thinking. According to this view, three dimensions become central when reasoning about perception, action, and presence in XR environments: worlds, objects, and transitions between worlds. These reflect the ontological status, affordances, and dynamics of thinking enabled by XR experiences, as follows. According to the world dimension, extending thinking addresses the nature of the extended world and one's presence in it, for example by distinguishing among different possible worlds across the Reality-Virtuality Continuum [2]; following the object dimension, extended thinking involves the nature of objects and the experiences they enable, such as physical objects that acquire new interaction capacities as if they were digital [3]; finally, the traversing dimension involves extended thinking for navigating through different realities representations, such as in cross-reality systems [4]. The interplay between physical and virtual elements, in various presentation forms and modalities, leads to different mental models that users employ to organize and interpret information [5].

In this talk, I will present examples of interactive systems involving wearable and ambient devices designed to offer sensory, motor, or cognitive augmentation, for which extended thinking constitutes an essential set of cognitive

skills. In these systems, users experience mixed-reality bodies, where virtual hands align with the physical body; robots feature both physical and virtual arms; and extended reality displays combine physical and virtual characteristics for providing effective feedback. Drawing on these examples, I propose implications for the future design of XR [6], where extended thinking can be effectively applied. Ultimately, this talk invites a reconsideration of how interaction design influences the way we perceive, understand, and act in increasingly computer-mediated worlds.

II. SPEAKER BIOGRAPHY

Radu-Daniel Vatavu is a Professor of Computer Science at the Ștefan cel Mare University of Suceava and an elected Corresponding Member of the Romanian Academy. He conducts research in Human-Computer Interaction (HCI), Augmented/Mixed/Extended Reality (AR/MR/XR), Ambient Intelligence (AmI), and Accessible Computing, and his work primarily focuses on natural interaction with computing systems, ranging from mobile and wearable devices to large displays and extended reality environments. Prof. Vatavu leads the Machine Intelligence and Information Visualization Lab, an interdisciplinary research laboratory dedicated to advancing knowledge in natural, meaningful, and accessible interactions among humans, computers, and environments. His research has received multiple awards, including at CHI, EICS, ICMI, IMX, and W4A.

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