Intelligent Avatars, Holographic Tools, Digitized Objects: An Extended Reality Simulation Demonstration

Things An Extended Reality Simulation Demonstration

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Abstract—This article addresses the following key-question: How can we design engaging and effective medical education both online and on site? Such a question leads to explore the extended reality (XR), that is a term referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables. XR includes representative forms such as AR, VR, and MR, and the areas interpolated among them. A focal dimension addressed with this article is that of MR, that is a domain of particular interest today: It takes place not only in the physical world or in the virtual world, but is a mix of the real and the virtual words that is opening to another key-dimension, currently known as metaverse. A fully developed metaverse doesn't really exist today, even if there are a number of developments towards it. The metaverse is expected to be a collective virtual space, created by the convergence of virtually enhanced physical and digital reality. We can think of the metaverse as the next version of the Internet: we're years away from the actualization of the internet's 3D layer of interoperable and interlinked immersive environments, any way we're approaching it. And quite probably we are approaching more than one metaverse. Different technologies may enable the metaverses; for example, they can be enabled by MR wearable augments. Glasses-free MR is another very interesting dimension today: e-REAL®, as a MR environment for hybrid simulation and medical education in general, can be a stand-alone solution or even networked between multiple places through a link to a special videoconferencing system. Digital humans and human-sized holograms are part of the e-REAL scenarios, making this solution unique, rich, and diversified.

Keywords—extended reality, demonstrations, e-REAL

1 Extended reality, online and on site, for medical education

Extended Reality (XR) technologies, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), have been increasingly used in medical simulation to enhance medical education and training. One of the most significant benefits of using XR technologies in medical simulation is the ability to create highly realistic and immersive training scenarios that simulate real-life medical procedures and emergencies. Medical students and healthcare professionals can use VR, AR, or MR to practice procedures and surgical techniques in a safe, controlled environment without the risk of harming patients.

Moreover, XR technologies can also provide real-time feedback on the trainee's performance, allowing them to improve their skills and techniques. For example, VR simulations can provide haptic feedback, enabling trainees to feel the sensation of cutting into tissue, making incisions, and manipulating organs.

Another benefit of using XR technologies in medical simulation is the ability to simulate rare or complex medical cases that may not be readily available in real-life training scenarios. In this way, medical professionals can gain valuable experience and knowledge in a safe and controlled environment. So we can say that XR technologies have enormous potential in medical simulation, and their use is likely to continue to grow in the future as more advanced and sophisticated systems are developed.

This article addresses the following key-question: How can we design engaging and effective medical education both online and on site? Such a question leads to explore the XR, that is a term referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables.

Opportunities to train and practice in simulated environments have existed since the early 1990s. The emergence of VR-based training in the medical education field, first using procedural and surgical simulations, was described in 1997 by Hoffman and Vu [1]. Since then, the use of VR, AR, or MR environments has grown exponentially. XR is a term referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables: It includes representative forms such as AR, VR, and MR, and the areas interpolated among them. XR is a superset which includes the entire spectrum from the complete real to the complete virtual in the concept of reality–virtuality continuum introduced by Milgram, Takemura, Utsumi, and Kishin [2].

The levels of virtuality range from partial sensory inputs to immersive virtuality, which is usually enabled by head-mounted displays. MR is a particularly interesting domain today. A MR is a merging of real and virtual worlds where objects in the actual physical surroundings play a direct functional role within the virtual environment simulation [3].

Imagine a setting like the one displayed in Figure 1 where a physical space is converted into a "phygital" place, with sensors embedded inside some components, like medical tools and patient simulators.

Fig. 1. e-REAL phygital classroom at the International Red Cross "Luigi Gusmeroli" learning center in Bologna, Italy: learning medical procedures using a skilled trainer during a hybrid simulation within an environment enhanced by interactive medical imagery and a realistic avatar able to interact with the learners

Sensors and embedded systems work together to provide one of the most important aspects of the Internet of Things (IoT): detecting changes in an object (device or asset) and/or the environment, allowing for capture of relevant data for real-time and/or post-processing. Sensors are used for detection of changes in the physical and/or logical relationship of one object to another(s) and/or the environment. Physical changes may include temperature, light, pressure, sound, and motion. Logical changes include the presence/absence of an electronically traceable entity, location, and/or activity. Within an IoT context, physical and logical changes are equally important. Sensor types are a number: a short list include acoustic, ambient light/optical, electric/magnetic, force/pressure, chemicals/gas/radiation, humidity, leakage/level/flow, locked/unlocked, motion/acceleration, temperature. By one or more sensors, MR is enabled and provides an interactive and immersive experience.

Now imagine another MR implementation from a dramatically different angle, as shown in Figure 2. As opposed to having the users interact with physical surroundings while viewing precisely correlated imagery within a fully immersive display, AR displays can be used to place computer-generated objects within the user's real-world surroundings [4].

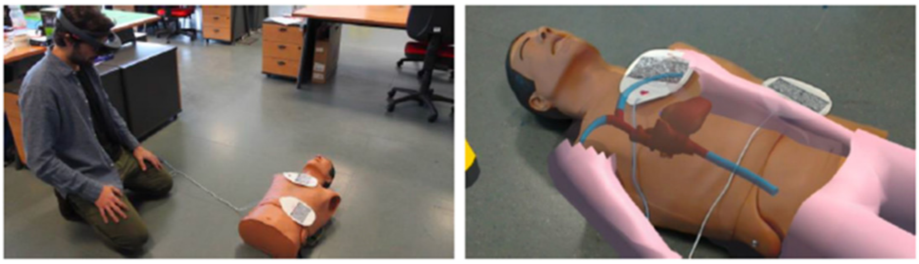

Fig. 2. A PhD student from the polytechnic school of Turin, Italy, is wearing AR head-mounted displays and experiencing a MR training on site, where the half-manikin used for a training module about basic life support and defibrillation is digitally reconstructed within the glasses—that are also providing a multilayer vision with a schematic representation of the heart

MR takes place not only in the physical world or in the virtual world, but is a mix of the real and the virtual. We define MR as a hybrid reality or the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. It's the "phygital" that is an emerging keyword, concept, and trend. In a time where the digital world is so omni-present, it's important to not lose sight of the relevance and presence that physicality can provide.

For example, in team-based training, using TV monitors in portrait mode with interactive videos as a stand-in for a real team member [5]. Another example from the same team-based training field include experimenting with health care tools for telemedicine within a MR cooperative setting enabled by a "metaverse"; that is another pretty new word that stands for a network of 3D virtual worlds enabling social connection and collaboration from different places. The term "metaverse" has its origins in the 1992 science fiction novel *Snow Crash* as a portmanteau of "meta" and "universe" [6].

Fig. 3. Representative metaverse based on MR technology enabling visualization and some collaboration from different places

In recent years, various metaverses have been developed for popular use such as virtual world platforms like *Second Life* or videogames, and a number of new ones are announced or even advertised presently. What really matters, from our perspective, is that some metaverse iterations involve integration between virtual and physical spaces. These are the most interesting ones for an effective XR medical education to be delivered in real time both online and into phygital places.

2 e-REAL: glasses-free mixed reality

What makes MR so interesting today for medical education, and simulation in particular, is the glasses-free solution like that we developed under the name of e-REAL® [7]. In e-REAL, digital and physical objects co-exist in the real world, not within a headset, making e-REAL unique. e-REAL, as a MR environment for hybrid simulation, can be a stand-alone solution or even networked between multiple locations, linked by a special videoconferencing system optimized to process operations without perceivable latency. This connectivity allows not only virtual objects sharing (like medical imagery, infographics, etc.) in real time, but also remote cooperation [8].

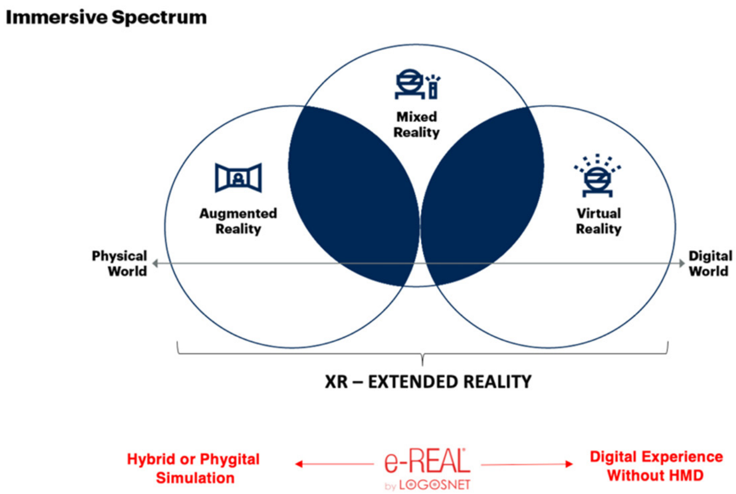

Fig. 4. The immersive spectrum of XR and e-REAL as a solution enabling glasses-free learning experiences, both on site MR and online VR

e-REAL is both an online solution for glasses-free VR and an on-site (or phygital) MR solution. The phygital configuration is a glasses-free solution that uses ultra-short throw projectors, gesture shaping lidars, and cameras to turn blank walls and empty spaces into immersive and interactive environments. It is designed as an easy, user-centric, and cost-effective solution compared to the old CAVE environments, which are too rigid, difficult to be managed, and expensive. The online solution is a glasses-free platform, available as both desktop or cloud-based, enabling remote cooperation in real-time. Both the e-REAL solutions are at the forefront of the XR options.

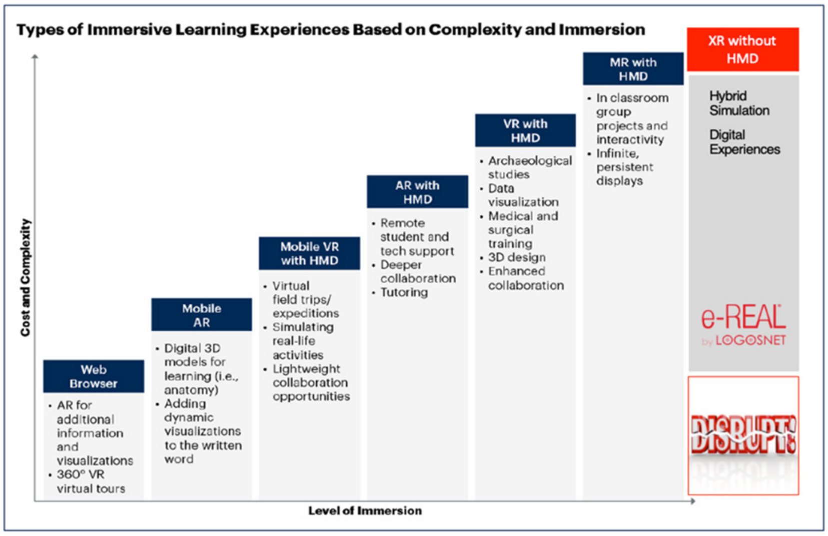

Fig. 5. Types of immersive learning experiences available today

Similar to being immersed within a videogame, learners are challenged by facing cases within multifaceted medical scenarios. Digital humans, or avatars, are part of the solution both online and in the phygital settings.

Fig. 6. An e-REAL digital human, enhanced by dialogic artificial intelligence

Fig. 7. Representative time management, writing and overlaying features available in both the e-REAL online VR platform and in the phygital MR classroom

Holograms may be part of the e-REAL phygital and online settings as well, with the learner utilizing wearable augments such as AR head-mounted displays. Also, human-sized holograms can be reproduced within the e-REAL phygital setting. Those specific types of holograms may be pre-recorded or may even be live.

Fig. 8. Representative human-sized hologram. e-REAL holograms are autostereoscopic and fully parallax, so cognitively they are directly translated to a mental image

e-REAL digital holograms allow people to fully view parallax 3D images from every angle. These holograms show details that can't be viewed in traditional holograms that are horizontal parallax only.

e-REAL holograms are cutting edge, captivate audiences, are glasses-free, and offer an unparalleled degree of interactivity. Learners can see around a hologram from all angles, gaining rich insights and profound educational results.

e-REAL holograms are autostereoscopic and fully parallax, so cognitively they are directly translated to a mental image—while traditional holograms, as well as 2D textbook handouts, require 3D reconstruction within the working memory [9].

Human-sized holograms and digital humans are part of the e-REAL scenarios, making this solution unique, rich and diversified.

Summarizing, based on the examples from the demonstration highlighted above (Figures 6 and 7), we can say that e-REAL is a set of innovative solutions aimed at enhancing learning with a systemic, multilayer and multi-perspective approach. Reality in the digital age is becoming more and more virtual. In healthcare simulation, the dematerialization of the learning environment is allowed by new technologies that offer options to improve the usability of traditional e-learning methods. Sharing and mixing up the latest trends from digitalization and virtualization, neurosciences, artificial intelligence, and advanced simulation allows us to establish a new paradigm for education and training.

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