IJIRIS: International Journal of Innovative Research in Information Security
Volume 10, Issue 04, May 2024
E-ISSN: 2349-7017
P-ISSN: 2349-7009
https://www.ijiris.com/archives

Intelligent Environment using Extended Reality and Machine Learning to Improve Healthcare

Revathi K
Assistant Professor, Dept of CSE
Eastpoint College of Engineering,
Bangalore, INDA
revathik.cse@eastpoint.ac.in

Publication History
Manuscript Reference No: IJIRIS/RS/Vol.10/Issue04/MYIS10102
Research Article | Open Access | Double-Blind Peer-Reviewed | Article ID: IJIRIS/RS/Vol.10/Issue04/MYIS10102
Received: 07, April 2024 | Revised:16, April 2024 | Accepted: 27, April 2024 Published Online: 07, May 2024 Volume 2024
Article ID MYIS10102 http://www.ijiris.com/volumes/Vol10/iss-04/23.MYIS10102.pdf
Article Citation: Revathi(2024). Intelligent Environment using Extended Reality and Machine Learning to Improve Healthcare. International Journal of Innovative Research in Information Security, Volume 10, Issue 04, Pages 224-229
doi:> https://doi.org/10.26562/ijiris.2024.v1004.23
BibTex key: Revathi@2024Intelligent

Copyright: ©2024 This is an open access article distributed under the terms of the Creative Commons Attribution License; which Permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract: Intelligent Environments (IEs) represent a paradigm shift in the way we interact with our surroundings, leveraging Ambient Intelligence (Aml) to create responsive and adaptive spaces that seamlessly integrate technology into the built environment. By harnessing sensors, actuators, and artificial intelligence, IEs have the potential to enhance human experience, improve efficiency, and promote sustainability across various domains, including smart homes, workplaces, cities, and healthcare facilities. This paper provides an overview of IE concepts, discusses key technologies and applications, explores design considerations, and outlines future directions for research and development in this dynamic field. This paper focuses on the study of the potential use of Extended Reality technologies in order to promote Green Health as well as their use in Smart Hospitals, one of the variants of Smart Environments, incorporating Machine Learning and Computer Vision, as a tool to support and improve healthcare, both from the point of view of the health professional and the patient, through a literature review and analysis of the current situation. Resulting in the elaboration of a conceptual model with the suggestion of technologies that can be used to achieve this scenario selected for their potential, and then the development of prototypes of parts of the conceptual model for Extended Reality Headsets as concept validation.

Keywords: Extended Reality, Healthcare, Smart Hospital, Machine Learning, Computer Vision, Internet of Things, Green Health

I. INTRODUCTION

As time goes by, healthcare institutions become increasingly overloaded and understaffed, and current professionals grow more tired and find it challenging to maintain good performance and motivation, not only in their work but also in their interaction with patients, which has become more notable during the recent pandemic of Covid-19 [1], at the same time the patients also become more tired of the time consumed and needed to take care of their physical health at cost of travels, time and their mental state. Although the new technologies have being used to support and improve healthcare, since the invention of the computer which set free the medical staff from carrying loads of papers and processing information by hand, the advanced medical machines like medical robots that support in hard and complex tasks such as operations till the more recent Internet of Things (IoT) devices that are starting to be more present in those institutions, the Extended Reality (XR) technologies are still hardly being seen in use aside from research projects or for specific and limited use cases such as exercises and medical training. XR has the potential to improve well-being and Green Health of both patients and professionals by enabling scenarios and actions those others technologies were not able to while requiring a low cost, both to the users as well to the environment. After understanding the current results, is analysed what can be improved and how, through the development of a conceptual model with base on the combination of XR technologies and Machine Learning (ML) to improve Healthcare, being identified and described potential technologies to be used and implemented prototypes as proof of concept.

II. OVERALL GOAL

This paper is to study the use of XR applications with ML to improve Healthcare, from a technological point-of-view, and well-being while promoting Green Health, among other concepts and technologies that are considered part of the future of Healthcare Institutions. The scenario envisaged is one that depends on interoperability between healthcare institutions, as is to be expected in an Electronic Health Record (EHR) structure. To achieve this, an analysis of the most recent technologies is required, as well as the implementation and experimentation to validate the concepts.

Additionally, specific categories of end-users have been assigned to each type of XR application, considering factors such as portability, affordability, potential use, and constraints.

III. EXTENDED REALITY

Figure 1: Augmented Reality, Mixed Reality and Virtual Reality

XR is a term used to group the technologies Virtual Reality (VR), Augmented Reality (AR), MR and all future immersive technologies which merge the physical and virtual worlds, is used to promote the new realities. This XR technologies can become a more complex and intrigued field that it is seen on the surface, starting from the term "Extended Reality" itself till categories and sub-categories

Virtual Reality:

VR is the oldest and most well established term among the XR technologies, the concept of VR can be mapped till the years 1980s being first described by Sir Charles Wheatstone, yet only started to become what is seen nowadays in 2012 with the kickstart of Oculus for the "first truly immersive virtual reality headset". VR can be found being used on many fields like the entertainment industry, education, medicine or job's training.

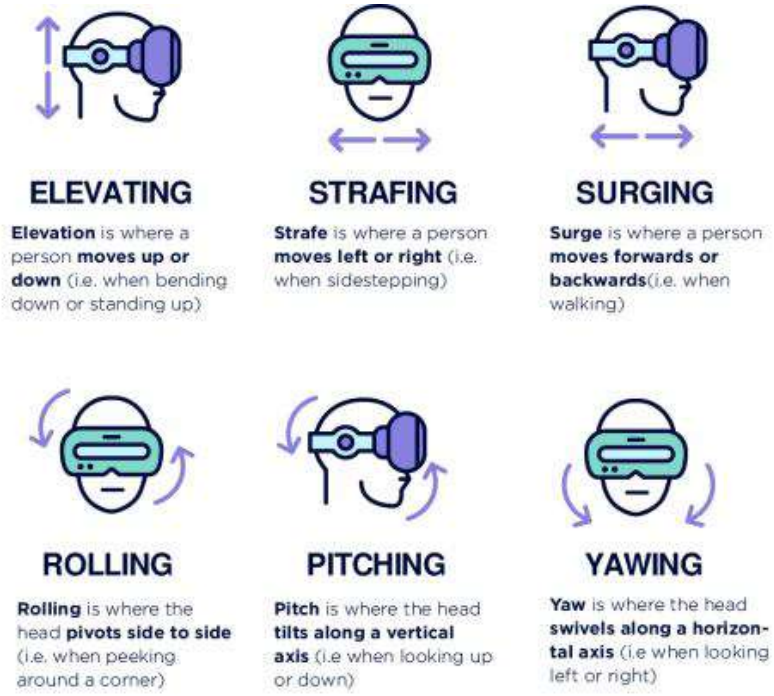

Figure 2: Degrees of Freedom in Virtual Reality

When it comes to immersion in VR, certain aspects must be taken in account such as sense of presence, movement and how the user control/interacts with the digital while avoiding cybersickness like Vection Illusion. Spatial audio, immersive diegetic/non-diegetic sounds and, when possible, olfactory sensations or even the use of haptic feedback are also important factors to create a good VR experience and to immerse the user into the digital environment.

Augmented Reality:

Like VR, AR is also already established on the market and due to rather easier accessibility for not requiring a specific kind of device like VR or MR it can be seen being used in domains where VR has yet to establish like manufacturing, being also a preferential choice of industries when looking for entering in the XR world. Most of the recent smartphones and tablets are able to run AR applications and the capacity of supporting this technology is starting to be considered a "must have" by the manufacturers. AR can be considered the counterpart of VR, in AR the digital world is the guest in the human's reality and the virtual content overlays onto the real world.

Mixed Reality:

MR is among the most recent terms in XR technologies and while already existing for some years, like Metaverse and Meta (2.2).This looks a lot like AR, and because of AR being already established and well-known, tends to be replaced by it or considered as an extension like Assisted Reality, MR consists ofan equal interaction between the digital and real world, an AR experience where the human can interact with the digital, preferentially without the need of controllers or secondary devices,

IV. IOMT

As many others industries, the Healthcare Industry also benefits from the Fourth Industrial Revolution, the use of IoT systems in Healthcare, like observed in Figure 3 is named as Internet of Medical Things (IoMT), and among all sectors it can be considered one of the more in need and desperate, with the population growth, the extension of the life expectation rate, the increase of healthcare needs and the inability of the current system to answer all changes. This can improve and enable the care of the patients starting in their own homes, since the use of intelligent toilets to analyse urine or intelligent homes able to adjust noise and lights for autistic patients, the use of wearable also consists as an example of IoMT through the broadcasting of real-time biological data which can be better analysed than the default "self-analysis" made by patients while also minimising the need of medical appointments. The use of this devices also enable immediate response on emergencies which could end in fatalities like home accidents with elders, but while able to support the patient in the comfort of their homes, some scenarios still require physical presence in a Hospital such as for operations.

Figure 3: Medical Internet of Things in Healthcare

V. ARTIFICIAL INTELLIGENCE AND COMPUTER VISION TECHNOLOGIES

One of the main technologies that can be used to improve healthcare is ML, which involves and can be found being applied on different fields and for different goals, being some current and famous use cases the use of language models, commonly known as "chatbots", like ChatGPT, natural language processing (e.g. Email filters), synthetic media models (e.g. Deepfake) and Artificial Inteligence (AI) Art. Considering the use of XR as core of the project and taking in account the kind of data available to be retrieved from the XR devices, the use of ML with CV is the pathway with more potential for MR, while VR has more potential for data analysis. ML is a subset of AI focused in developing models that enable computers to learn based only in data provided by the developer, in a way to be able to make predictions, provide answers without the implementation of the logic and rules, which is created by the computer. This subset of AI has diverse uses across various fields, including image and speech recognition, along text processing or in creating autonomous vehicles, is being an essential part of areas like manufacturing and healthcare. CV is the field that enables computers to understand visual information from digital images and videos, being videos a sequence of images, it aims to provide the computer the natural abilities of humans to analyse and process meaningful data, by making use of processes like feature extraction and pattern recognition.

While ML and CV are different concepts, they are commonly used together to achieve some technologies that are nowadays famous worldwide like Face Recognition, but while using ML concepts and methods, Face Recognition or Object Detection are part of the domain of CV.

VI. CONCEPTUAL MODEL

The developed conceptual model comes as proposal of developing solutions which aim to that future with focus in the use of XR technologies, which shows potential in being eco-friendly, having as major constraint the user adaptability

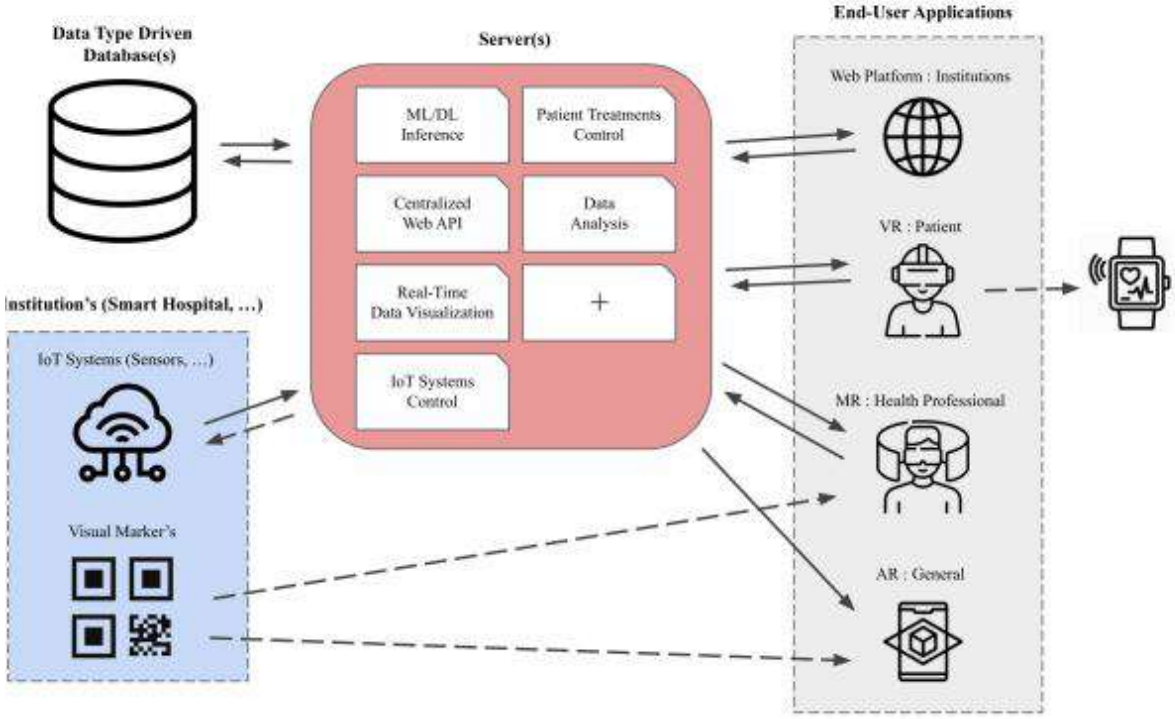

Figure4: Conceptual Model

- Data Type Driven Databases: Between basic hospital data such as patient identification and historic, IoT data and Big Data, a unique DB cannot be able to answer all components or even if able, not be optimized for each type of data or services, as such the chosen DB's must be based on the type of data being saved.
- Institutions Components: When it comes to Institutions, being (Smart) Hospitals, Nursing Homes or Medical Centers, between others, these can be equipped with different IoT devices such as heating/cooling systems or Smart TV's, being one of the principals and acknowledge, the sensors, which also presents themselves in the more different forms such as temperature sensor or proximity, even utensils can include sensors such as diapers
- Institution Web Application: While XR HMD are optimal to data visualization and consult, the same does not apply to inserting data, the use of controllers make the process slow and hand tracking is still evolving, even the more advanced HMD may not able to follow the same hand writing speed used when in physical keyboards.
- Patients and Virtual Reality: VR HMD are among the more financially accessible XR devices, having a big variety on quality and hardware depending on the person goals, among them, the more famous one is the Meta Quest 2, formerly known as Oculus Quest 2, this comes for is low price hardly beaten in the market, around 283 euros in 2023, and for being standalone per default which makes this device the one normally bought for first-timers, and while expected to be replaced by the released Meta Quest 3, this one also has a competitive price around 473 euros on release.

VII. IMPLEMENTATION

Holographic Remoting Player application: By installing this application in the HL2 and connecting both the device and the computer running Unity to the same network, the HL2 can run the application without the need for building. While this option has benefits, there are limitations, such as the inability to use the HL2 holographic keyboard

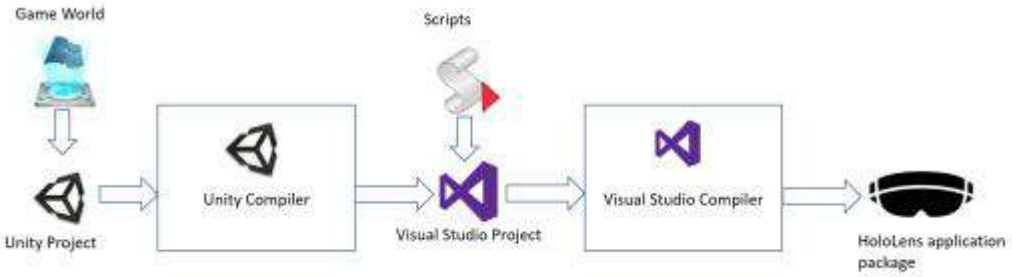

Figure 5: HoloLens2 Build Pipeline

To simply the process of prototyping four uses cases was idealized, use cases these being applied in a scenario of a nursing home, improving elder's well-being and empowering the caregivers.

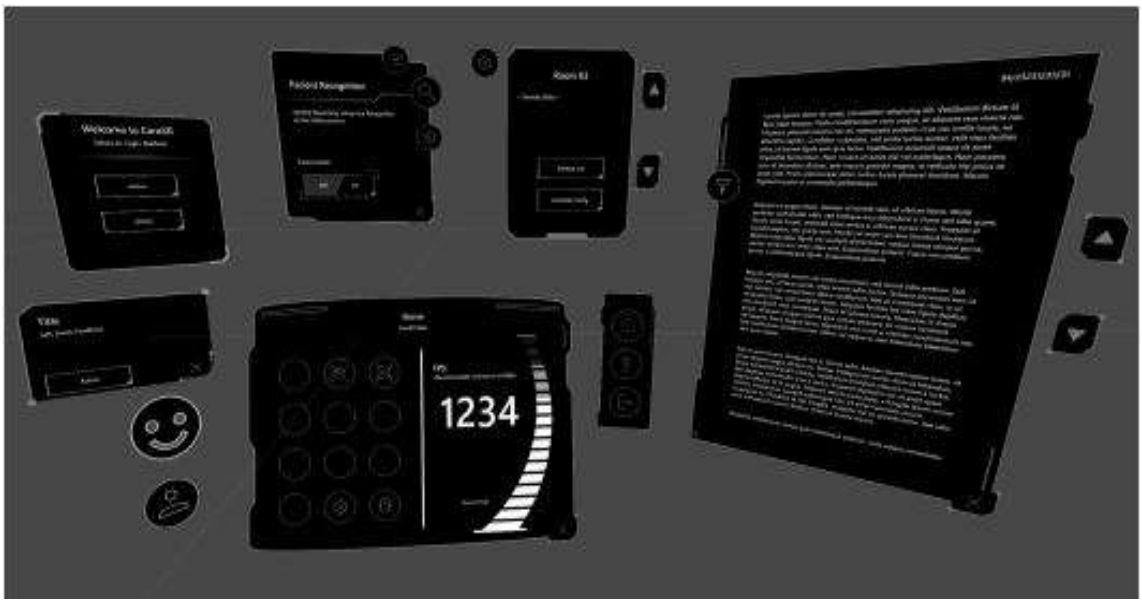

Figure 6: Mixed Reality Interfaces Samples

Figure 7: Medication Alert with Mixed AI reality

VIII. FUTURE WORK

The integration of Extended Reality (XR) and Machine Learning (ML) within intelligent environments offers exciting opportunities to improve healthcare delivery. By combining immersive XR experiences with ML-driven analytics, healthcare providers can enhance medical training, patient care, and clinical collaboration. However, realizing the full potential of XR and ML in healthcare requires addressing technical, regulatory, and ethical challenges.

Future research should focus on developing robust XR applications, advancing ML algorithms, and fostering interdisciplinary collaborations to drive innovation in healthcare. At the current moment of the thesis submission, the project Green Health its still ongoing, being the submission needed for academic progression, and the development itself continues, the VR application is considered completed since it already surpasses the necessaries requirements, however the MR application is still lacking in some features due to the current state of development of the MS Face Detection with YuNet. Some aspects of the project can't be answered by a Web Based application or Unity, the main one detected being the upload of Panoramic Images, due to the limit size of uploads which would affect the image quality and Unity being unable to do such thing, being necessary the development of a computer application like with UWP or Windows Forms.

REFERENCES

[1]. M.Ulfa, M. Azuma, and A. Steiner, "Burnout status of healthcare workers in the world during the peak period of the COVID-19 pandemic", en, Front Psychol, vol. 13, p. 952 783, Sep. 2022. https://doi:/10.3389/fpsyg.2022.952783

[2]. J.A.Delmerico, R. Poranne, F. Bogo, H. Oleynikova, E. Vollenweider, S. Coros, J. I. Nieto, and M. Pollefeys, "Spatial computing and intuitive interaction: Bringing mixed reality and robotics together", CoRR, vol. abs/2202.01493, 2022. arXiv:2202.01493. arXiv: 2202.01493.

[3]. J.Dalton, Reality check: How immersive technologies can transform your business. Kogan Page Publishers, Jan. 2021.

[4]. A.Çöltekin, I. Lochhead, M. Madden, S. Christophe, A. Devaux, C. Pettit, O. Lock, S. Shukla, L. Herman, Z. Stachon, P. Kubí ˇ cek, D. Snopková, S. Bernardes, and N. Hedley, "Extended reality in spatial sciences: A ˇ review of research challenges and future directions", ISPRS International Journal of Geo-Information, vol. 9, no. 7, 2020, ISSN: 2220-9964. https://doi:/10.3390/ijgi9070439

[5]. P.A.Rauschnabel, R. Felix, C. Hinsch, H. Shahab, and F. Alt, "What is xr? towards a framework for augmented and virtual reality", Computers in Human Behavior, vol. 133, p. 107 289, 2022, ISSN: 0747-5632. https://doi:/10.1016/j.chb.2022.107289

[6]. M.H. Shahab, E. Ghazali, and M. Mohtar, "The role of elaboration likelihood model in consumer behaviour research and its extension to new technologies: A review and future research agenda", International Journal of Consumer Studies, vol. 45, no. 4, pp. 664–689, 2021. https://doi:/10.1111/ijcs.12658

[7]. K.E.Schein and P. A. Rauschnabel, "Augmented reality in manufacturing: Exploring workers' perceptions of barriers", IEEE Transactions on Engineering Management, pp. 1–14, 2021. https://doi:/10.1109/TEM.2021.3093833

[8]. Y.-C.Tan, S. R. Chandukala, and S. K. Reddy, "Augmented reality in retail and its impact on sales", Journal of Marketing, vol. 86, no. 1, pp. 48–66, 2022.

[9]. M.Billinghurst, A. Clark, and G. Lee, "A survey of augmented reality", Foundations and Trends® in Human–Computer Interaction, vol. 8, no. 2-3, pp. 73–272, 2015, ISSN: 1551-3955. https://doi:/10.1561/1100000049

[10]. J.Liu,Y. Xie, S. Gu, and X. Chen, "A slam-based mobile augmented reality tracking registration algorithm", International Journal of Pattern Recognition and Artificial Intelligence, vol. 34, no. 01, p. 2 054 005, 2020. https://doi:/10.1142/S0218001420540051