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Augmented Reality in the field of Medicine: A Review Paper

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Abstract: Augmented reality employs the use of 3D/2D modeled digital objects superimposed on top of a live video stream for purposes including but not limited to entertainment, education, professional fields such as animation etc. This study explores the use of Augmented Reality to help medical professionals by employing the sue of Augmented Reality to display detailed models of organs, skeletal system, etc. The research aims to improve the ease of use and understanding of conventional medical texts. A research aiming to verify the feasibility of AR in medical field was conducted. The findings are promising and indicate improvements in the learning experience for medical students. The technology can be deployed in hospitals and medical schools where such professionals are trained.

Keywords: Augmented Reality; Unity; AR Toolkit; AR Foundation;

1. Introduction

Augmented Reality otherwise shortened to AR in common use, is the use of digital visual elements and audio among other things that are superimposed on the real word via a live stream of video using modern technologies.

Tens of billions of connected IoT devices already exist in the world and this number is anticipated to keep increasing as the Internet connectivity has become a standard feature for a great number of electronics devices. The size of the global IoT market has grown to 212 billion US dollars by 2019.

To share the data and information we can make use of IoT enabled devices for added convenience and control for the users. The IoT market revenue is forecasted to reach 1.6 trillion by 2025 [1].

The aim of the reconstruction stage is to recover structure from images using either multi-view stereo techniques or manual work. As relevant images may be captured by various cameras at different lighting conditions with cluttering cars and pedestrians, it has to calibrate camera parameters, remove clutters, and detect 3D point correspondences.

While one may assume AR is a new technology, its roots go as far back as the 1950s, envisioned by Morton Heilig and dubbed as the "cinema of the future." Morton went on to realize his vision in 1962 when he built the first prototype. However, the AR we are familiar with today didn't get invented until 1968 when Ivan Sutherland created an optical see-through head mounted display.[2]

Figure 1: Ivan Sutherlands HMD

Since then, AR has been implemented hugely in the mobile entertainment industry. The First AR game ARQuake was released back in 2000. Now AR is very commonplace in countless apps ranging from games to educational apps and services.[3]

The methods used for AR can be decomposed into Marker-based AR and Marker-less AR.

Marker based AR used distinct shapes or patterns pre-registered with the software to detect and super impose the virtual data. Common examples include mobile games that detect a particular code printed on a paper to place its 3D models.[4]

Marker-less AR, as the name suggests, does not require any Marker, and freely allows the user to put the 3D models wherever they want. This is achieved by using the devices sensors such as the time-of-flight sensor, accelerometer, and gyroscope to detect the correct depth, orientation, and perspective to place the objects. Marker-less AR has multiple commonly used applications:[5]

1. Location based AR.
   AR apps that use the context of location to display specific data that can only been seen at that location. A very popular example of this application is the famous game Pokémon Go! Developed by Niantic.
2. Outlining AR.
   Outlining AR specializes in highlighting boundaries and edges for easier detection. It is widely used in HUDs in cars for better driving.
3. Superimposition AR.
   Superimposition enhances real life objects for example scanning a real physical object and creating a digital replica of it.
4. Projection based AR.
   Projection based AR does not require a camera or a display to implement AR, rather it relies on actual light projections, also known as hologram. It is expected to have a wider use in business.

Our research in particular aims at using AR to help medical professionals. It is a very common occurrence that medical trainees face difficulties learning human anatomy and the rapidly developing procedures related to it. Trainees get confused and rely on text-based resources to understand something which requires a three-dimensional view of the organ or structure in question. Trying to understand it the conventional way can be frustrating.
We can use real time visual information to help the doctors by giving them a fully interactive virtual models of organs to study. Having a 3D model to refer to, in addition to curriculum to complement learning with Augmented Reality, one can streamline an otherwise arduous process of referring multiple books and images to understand simple mechanics of the human body. To create an interactive solution to this problem, we decided to research into the feasibility and advantages of using Augmented Reality that uses the camera and 3D models of organs and other structures inside the human body to guide the user and help them understand the

organ easily. One of the easiest and most effective tools to achieve this is Unity's ARFoundation.

2. Augmented Reality technologies

2.1 Definition and Taxonomy

In one of the most commonly accepted definitions, researcher Ron Azuma says that Augmented Reality is technology that has three key requirements [6]:

1) It blends real and virtual content
2) It can be interacted with in real time
3) It is capable of working in a 3D environment

These three features also define the technical necessities of an Augmented Reality system, namely that it needs to have a display that can combine real and virtual images, a computer system that can produce interactive graphics the responds to user input in real time, and a tracking mechanism that can find the position of the user's viewpoint and enable the virtual image to appear fixed in the real world.

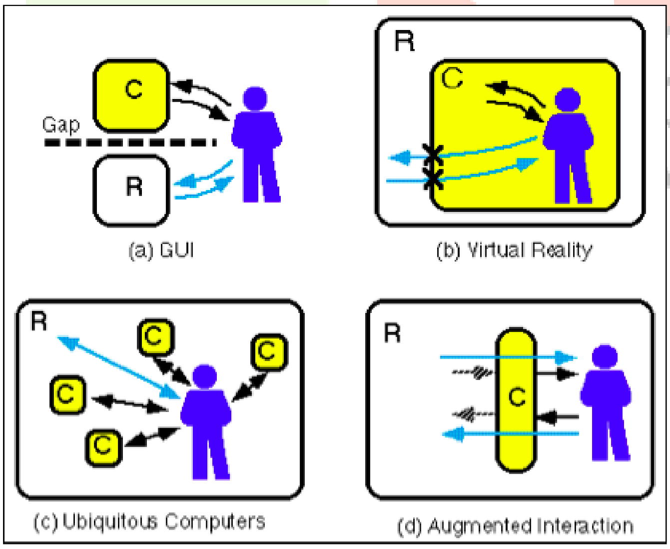

Figure 2.1: Comparison of Human-Computer Interaction types (R = real world, C = computer).

In the larger context, Augmented Reality pertains to latest effort by scientists and engineers to create computer interfaces that are seamless and enhance user interaction with the physical world. As Figure 2.1(a) shows, with a conventional personal computer and desktop WIMP [7] (Windows, Icons, Menus, Pointer) based Graphical User Interface (GUI) there is a definite separation between what the on-screen digital domain and the physical world. One approach to alleviate this can be through the approach of Ubiquitous Computing (Figure 2.1(c)) where computing and sensing technology is seamlessly embedded within the physical world. another approach is to use virtual reality (VR) (Figure 2.1(b)) [7] where the user wears a head mounted display and their view of the physical world is totally replaced by what is rendered by the computer relaying the information of the surroundings from the outside. in a VR system, the user is totally separated from the physical world, isolated in their head mounted display, hence the computer is again invisible to the user. In contrast, AR interfaces are designed to augment interactions in the physical world itself (Figure 2.1(d)). As it is evident from figure 2.1, the technologies used in Virtual Reality (VR) and Augmented Reality (AR) are largely similar, however, the main goal of Virtual Reality is to completely replace the physical world with am immersive virtual environment. In contrast, the goal of VR is not to replace the real world, but to augment it through inclusion of virtual objects within the real world itself. If seen from an artistic standpoint, this difference allows a VR environment to be much more stylized in its art-style when compared to AR, where the virtual objects must be as life-like as possible, so that they can blend well with the real world.

	Virtual Reality	Augmented Reality
Scene Generation	Allows creative freedom	Minimal but realistic
Display Device	Fully immersive, Wide Field of View	Non-immersive, small to medium Field of View
Tracking and Sensing	Accommodates less accurate solutions	Needs to be accurate

Table 2.1: Virtual Reality and Augmented Reality Technological Requirements

2.2 Computer vision Methods in AR

Computer vision is responsible for rendering the 3D virtual objects from the same viewpoint as that of the user. I.e., that of the tracking device being used by the user to experience Augmented Reality. AR image registration uses a method of computer vision mostly related to video tracking. These methods mainly consist of two stages: tracking an object and reconstructing the virtual object. Tracking system can be configured to use feature detection, edge detection, face detection or some other image processing methodology to translate the images into camera into positional information of objects appearing in the scene. Most of the currently available tracking methodologies can be broadly classified into two categories: feature-based and model-based.[8]

Feature-based tracking methods work by discovering the connection between 2D image features and their 3D world frame coordinates. Model-based methods make use of model of the tracked object's features such as CAD models or 2D templates having distinguishable features.[9]

The reconstructing stage employs the data obtained from the first stage to reconstruct a coordinate-system in the real world to facilitate placement of virtual objects.[10]

Some methods assume the presence of fiducial markers in the environment or objects with known 3D geometry in order to facilitate object recognition [11]. Others can also have the scene's 3d structure per-calculated beforehand, however in this case, the device will have to remain stationary. If the entire scene is not pre-calculated beforehand, then we need to adopt a technique called Simultaneous Localization And Mapping (SLAM)[12], which is used to map fiducial markers or 3D models according to their relative positions in the real world. In the case where no assumptions or pre-calculations about the 3D environment be made, Structure from Motion (SfM) methodology is used. This technique can be further divided into two subcategories: feature point tracking and camera parameter estimation.

Tracking methods in AR depend mostly on the type of environment the AR device will be used in as well as the type of AR system developed. The environment being tracked can be indoors, outdoors or a combination of both. In a similar fashion, the AR system employed can be configured to be mobile or static. Some AR systems assume that the AR device will remain static, some assume that only a specific set of movements can occur, i.e., the movement or path that the AR device will follow is known in advance. For an AR system operating in an environment which is unknown (not pre-calculated), the main problem for the computer vision system is to reconstruct both the camera movement as well as the incoming sensor data pertaining to position, since no assumption about the position can be made in this scenario, SfM method is used for reconstructing the scene [10]. Fiducial markers or 3D objects with known shape and dimensions are placed in the environment and the computer vision uses these objects to track its relative position in the real world.

Nowadays, developers who want to build an AR based application can make use of existing AR libraries, such as ARToolKit [13], ARFoundation, ARCore, ARKit, Vuforia, etc. ARToolKit, which was developed in 1999 by Hirkazu Kato from Nara Institute of Science and Technology was released by the University of Washington HIT Lab. It was one of the first computer vision library that allowed users to create Augmented Reality applications. It used video tracking capabilities to calculate the real-time position of the camera and its orientation relative to physical markers in a method similar to SfM technique. Once the camera position was ascertained, the virtual camera can be placed in the same exact position and 3D computer graphics models can be drawn to overlay the markers.

Figure 2.2: An early prototype of the Human Vision System (HVS)

A recent approach for advancement in visual tracking has been to figure out how the human brain recognized such objects in the first place [14]. As it is possible for humans to recognize an infinite number of objects and people in fractions of seconds. If a model can be developed which mimics the way a human brain distinguishes objects, then the computer vision will be able to overcome the challenges it is facing today and keep moving forward.

3. Augmented Reality in Medical Sciences

Medical Sciences are advancing at a rapid pace. New procedures, technologies and practices are replacing the outdated techniques of the past. Due to these increasing demands in the content required to be learned by a doctor nowadays, there are benefits in exploring new and more efficient techniques to teach and deliver the knowledge [15]. The use of Augmented Reality can enhance the learning process in physiology and anatomy, where doctors are required to have a three-dimensional knowledge of the human organ systems and structures. Augmented reality, paired with a curriculum which complements it, can vastly improve the learning process for such medical professionals.

A research was conducted to assess the usefulness of learning when a matching lesson were delivered over augmented reality by means of either the Microsoft HoloLens or a mobile handheld tablet device. 38 pre-clinical scholar's participants completed a lesson describing the physiology and anatomy of the mind. before and after tests, they were examined to estimate acquired knowledge. As the activity was done, there were no substantial differences amongst test scores from lesson delivery in either the HoloLens or mobile-based augmented reality.

But the hands-on help received through the AR (Augmented Reality) was much more comprehensible than a computer screen with pictures on it.

Technology progressively aids students with increased access to learning materials and expands the availability of data by providing learning tools for college kids on the far side the schoolroom [16] and may offer dynamic and other ways to deliver content which includes multiple senses. additionally, there's associate increasing use of those technologies on the far side the tertiary atmosphere, like in medical coaching for laparoscopic surgical coaching, diagnostic procedure, and neurosurgical procedures [17]. this suggests that utilizing unique technologies among a medical or health science curricula might not solely facilitate learning, but also enhances hands-on practice too.

Augmented reality (AR) projects augmented visuals to the user via optical see-through displays or see-through video displays. Most commonly, this is performed through the use of a handheld mobile device (i.e., smartphone or tablet). The technology works by overlaying computer-generated graphics or virtual objects on the user's natural setting to develop the experience and provide an amalgamated view [18] [19]. It is a real-world environment which is overlaid with collaborative, digital elements. This enables improved immersive experiences that were originally used for gaming,

It also offers a way for educators or developers to afford scaffolded education experiences for students in a way that can allow self-paced and even problem-based learning in physiology.

and anatomy. This can be implemented in places like formal scientific laboratories, providing assistance to students in the first few years of a medical programme as they transition to university study. Researchers are exploring the teaching environments that can / are improved through the use of AR student- interaction, engagement, motivation, attitudes, satisfaction and academic performance along with pedagogical affordances. Augmented reality and mixed reality are rarely used as exclusive terms in the fiction, when in practice they can often be well-thought-out synonymous. The Microsoft HoloLens is one such device that interests many educators, in recent years, introduced head-mounted display which uses holographic technology to produce augmented visuals. These holograms can be controlled with hand gestures or voice commands. The HoloLens falls within the augmented reality portion of the Milgram Virtuality Continuum [20], having substantial real-world objects with a smaller number of augmented visuals. The HoloLens allows a binocular depth cue, bestowing the ability to replicate unaffected 3D models, whereas mobile-based augmented reality is restricted by a flat surface and can only display pseudo-3D illustrations of the models.

4. Conclusions

This study provides evidence-based support to the idea and feasibility of the use of Augmented Reality in the field of Medicine. Research and Development in the field of Augmented Reality started in 1950's, and it has seen many breakthroughs. The idea of using AR in the field of medicine is much more practical than it was a decade ago. Augmented Reality, paired with modifications in the curriculum that complements its use, can truly bring about a paradigm shift in how the medical professionals are trained. The fact that cadavers are becoming difficult to obtain due to financial, ethical, and supervisory constraints gives the idea of using Augmented Reality models all the more support. The ideas and techniques explored in this research paper can also be modified to be used in the field of education in general.

Technologies like SLAM also enhance the feasibility of using Augmented Reality in unmapped environments, for use in operations like displaying models, navigation, architecture, etc. Relatively recent advancements like Structure from Motion (SfM) technique allows the use of Augmented Reality with handheld devices and is perhaps the biggest breakthrough in the field so far, as it opens the use of this technology in virtually any field imaginable.

Future research should further develop and confirm these initial findings by developing new methods, or modifying the methods outlined in this publication, to employ Augmented Reality in the field of education in general. We believe that apart from looking for the use of Augmented Reality in the field of Medicine and education, future research should also look for its use in other fields like architecture, entertainment, navigation, customer interaction, marketing, video games, tourism, etc. This is very much the key component in future attempts to overcome the shortcomings of Augmented Reality and make it more accessible and practical to use.

References

1. Peoples, C. (2021). Priority activities for smart cities and the infrastructure. In Solving Urban Infrastructure Problems Using Smart City Technologies (pp. 159-182). Elsevier.

2. Huang, Y., Liu, Y., & Wang, Y. (2009, October). AR-View: An augmented reality device for digital reconstruction of Yuangmingyuan. In 2009 IEEE International Symposium on Mixed and Augmented Reality-Arts, Media and Humanities (pp. 3-7). IEEE.

3. Grosch, M., & Gidion, G. (2012, October). Media Use for Learning by Students in Higher Education An International Empirical Survey. In E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 1805-1812). Association for the Advancement of Computing in Education (AACE).

4. Khan, A., Khusro, S., Rauf, A., & Mahfooz, S. (2015). Rebirth of augmented reality-enhancing reality via smartphones. Bahria University Journal of Information & Communication Technology, 8(1), 110.

5. Chatzopoulos, D., Bermejo, C., Huang, Z., & Hui, P. (2017). Mobile augmented reality survey: From where we are to where we go. Ieee Access, 5, 6917-6950.

6. Azuma, R. T. (1997). A survey of augmented reality. Presence: Teleoperators & Virtual Environments, 6(4), 355-385.

7. Burdea, G. C., & Coiffet, P. (2003). Virtual reality technology. John Wiley & Sons.

8. Zhou, F., Duh, H. B. L., & Billinghurst, M. (2008, September). Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. In 2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality (pp. 193-202). IEEE.

9. Lee, B., & Chun, J. (2010, April). Interactive manipulation of augmented objects in marker-less ar using vision-based hand interaction. In 2010 Seventh International Conference on Information Technology: New Generations (pp. 398-403). IEEE.

10. Carmigniani, J., & Furht, B. (2011). Augmented reality: an overview. Handbook of augmented reality, 3-46.

11. Huang, Y., Liu, Y., & Wang, Y. (2009, October). AR-View: An augmented reality device for digital reconstruction of Yuangmingyuan. In 2009 IEEE International Symposium on Mixed and Augmented Reality-Arts, Media and Humanities (pp. 3-7). IEEE.

12. Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. Multimedia tools and applications, 51(1), 341-377.

13. Kato, H., Billinghurst, M., Poupyrev, I., Imamoto, K., & Tachibana, K. (2000, October). Virtual object manipulation on a table-top AR environment. In Proceedings IEEE and ACM International Symposium on Augmented Reality (ISAR 2000) (pp. 111-119). Ieee.

14. Akgul, O., Penekli, H. I., & Genc, Y. (2016, November). Applying deep learning in augmented reality tracking. In 2016 12th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS) (pp. 47-54). IEEE.

15. Moro, C., Phelps, C., Redmond, P., & Stromberga, Z. (2021). HoloLens and mobile augmented reality in medical and health science education: A randomised controlled trial. British Journal of Educational Technology, 52(2), 680-694.

16. Boutboul, D., Kuehn, H. S., Van de Wyngaert, Z., Niemela, J. E., Callebaut, I., Stoddard, J., ... & Rosenzweig, S. D. (2018). Dominant-negative IKZF1 mutations cause a T, B, and myeloid cell combined immunodeficiency. The Journal of clinical investigation, 128(7), 3071-3087.

17. Barsom, E. Z., Graafland, M., & Schijven, M. P. (2016). Systematic review on the effectiveness of augmented reality applications in medical training. Surgical endoscopy, 30(10), 4174-4183.

18. Maas, M. J., & Hughes, J. M. (2020). Virtual, augmented and mixed reality in K–12 education: A review of the literature. Technology, Pedagogy and Education, 29(2), 231-249.

19. Rolland, J. P., & Fuchs, H. (2000). Optical versus video see-through head-mounted displays in medical visualization. Presence: Teleoperators & Virtual Environments, 9(3), 287-309.

20. Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems, 77(12), 1321-1329.