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Study on Augmented Reality and its Applications in the Field of Medicine

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Abstract

Augmented reality (AR) is one of the latest innovations taking route into various markets which include gaming, medicine, automotive, retail amongst others. AR technology has been in development since the 1960's. AR technology lets users see the real world and projects digital information onto the existing environment. In many ways, AR is a mixture of Virtual reality, imposed into real life. These virtual contents are typically in the form of digital imagery or sound, usually applied in 3D models or videos. AR works via the use of a range of sensors such as a camera, computer components or a display device.

Particularly, augmented reality can be a more promising technique of a surgery which requires great precision. This paper introduces an overview of augmented reality and reviews the recent applications in medicine.

Key words – Augmented reality, Innovation, Medicine, Technology, Virtual reality, Virtual, 3D

Introduction

The first experiments with medical images date back to the year 1895, when W. C. Röntgen discovered the existence of X-ray. This marks the starting point of using medical images in the clinical practice. The development of ultrasound (USG), computed tomography (CT), magnetic resonance imaging (MRI), and other imaging techniques allows physicians to use two-dimensional (2D) medical images and three-dimensional (3D) reconstructions in diagnosis and treatment of various health problems. Further development of medical technology has given an opportunity to combine anatomical and functional (or physiological) imaging in advanced diagnostic procedures, that is, functional MRI (fMRI) or single photon emission computed tomography (SPECT/CT). These methods allowed physicians to better understand both the anatomical and the functional aspects of a target area.

The latest development in medical imaging technology focuses on the acquisition of real-time information and data visualization. Improved accessibility of real-time data is becoming

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increasingly important as their usage often makes the diagnosis and treatment faster and more reliable. This is especially true in surgery, where the real-time access to 2D or 3D reconstructed images during an ongoing surgery can prove to be crucial. This access is further enhanced by the introduction of augmented reality (AR)—a fusion of projected computer-generated (CG) images and real environment.

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.[1][2] An augogram is a computer generated image that is used to create AR. Augography is the science and practice of making augograms for AR. AR can be defined as a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects

Augmented Reality and Virtual Reality – What's the Difference?

Before we proceed further, we would like to give you an insight since these two technologies are often mixed up, and we'll explain the differences between the two. In short, augmented reality is the use of computer technology to create and integrate artificial objects in a real environment. For example, AR is based on the existing environment and projects digital information onto it while letting users still see the real world. Virtual reality is the use of computer technology to create a completely simulated environment with nothing left from the real world.

The typical picture we imagine when thinking about virtual reality is someone in a headset and headphones moving their head and arms to interact with the virtual world. The best known examples of VR are Google Cardboard, Samsung Gear VR, and HTC Vive.

Augmented reality usually uses glasses or a pass-through camera to let the user see the real world around in real time. Artificial elements are then projected onto the glass or shown on the screen on top of the camera feed. Widely known examples of AR technology are Google Glass and Pokémon Go.

According to CapTech, the main differences between two technologies lie in the fields of hardware, social interaction and access. When compared, VR hardware that is bigger and less convenient than a smartphone or iPad is needed for AR apps. AR is also more attractive in terms of social interaction, as it allows communication with other people while VR applications are usually closed off to the rest of the real world. In terms of access, AR is less expensive and much easier.

The popularity of the technology means that it can be a very promising digital technology for the healthcare industry. Let's review some examples of using AR in healthcare and find the benefits it can provide for healthcare professionals and their patients.

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Aims and Objectives

Aim- The study aims at understanding augmented reality, it's application in the field of medicine and creating awareness about it among healthcare providers.

Objectives-

1. To understand in detail about augmented reality
2. To understand the basic principles of augmented reality
3. To understand the technology involved in augmented reality
4. To study it's applications in the field of medicine
5. To understand the benefits and shortcomings of augmented reality
6. To create awareness among healthcare providers for a better tomorrow

Methodology

The study is based on exploratory research. Secondary data is collected from various sources such as books, web, broadcasting and articles.

Observation and Result

A. Basic Principles of Augmented Reality

An augmented reality system provides the surgeon with computer-processed imaging data in real-time via dedicated hardware and software. The projection of AR is made possible by using displays, projectors, cameras, trackers, or other specialized equipment. The main principle of a basic AR system is presented in Figure 1. The most basic method is to superimpose a CG image on a real-world imagery captured by a camera and displaying the combination of these on a computer, tablet PC, or a video projector [1–7]. In case it is impossible to mount a video projector in the operating room, a portable video projection device has been designed [3, 4]. The main advantage of AR is that the surgeon is not forced to look away from the surgical site as opposed to common visualization techniques.

Another possibility is to use a special head-mounted display (HMD, sometimes referred to as "smart glasses") which resembles eyeglasses. They use special projectors, head tracking, and depth cameras to display CG images on the glass, effectively creating the illusion of augmented reality. Several AR systems with a HMD have already been developed with success [1, 8]. Using a HMD is beneficial as there is almost no obstruction in the surgeon's view compared to a traditional display; it is not necessary to move the display, and the need of a proper line-of-sight alignment between the display and the surgeon is not as accented [9].

Another useful feature of AR is the ability to control the opacity of displayed objects [13, 14]. Most HMDs allow the wearer to turn off all displayed images, becoming fully opaque, thus

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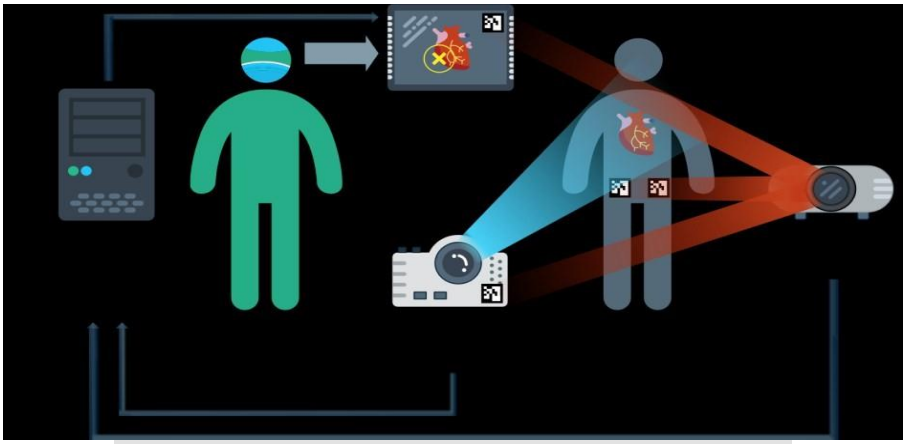
removing any possible distractions in an emergency. Furthermore, it is possible to utilize voice recognition to create voice commands, enabling hands-free control of the device. This is especially important in surgery as it allows surgeons to control the device without the need of assistance or break aseptic protocols. Another interesting option is to use gesture recognition, allowing the team to interact with the hardware even on sterile surfaces or in the air through body movements [6].



A scheme showing the basic principles of augmented reality

B. Technology required for AR

AR in medicine mainly comprises three technical parts such as camera calibration, patient registration, and object tracking [5-7].

1. **Camera Calibration**

   Generally, real world objects are captured by a camera and reproduced on a display. AR merges virtual objects with the real world, which requires transformation between the camera and real world coordinates. Before estimating the transformation, the characteristics of the camera must be defined. Pinhole model is a simple camera model that maps the 3D real world onto two-dimensional (2D) coordinates called the image plane. 3D points are mapped onto the 2D image plane by translating the point on a straight line towards the camera center until it intersects the image plane [8,9]. is mapping is called perspective projection, and the transformation between the image and real world coordinates can be represented as a projection matrix. Thus, camera calibration is the estimation of the projection matrix parameters for a pinhole model [10-12].

2. **Patient Registration**

   Patient data for preoperative planning is 3D volume data taken from computed tomography (CT) or magnetic resonance imaging (MRI). Since it provides a view of the internal anatomy and target points for the surgeon, patient data should be registered with respect to a patient of the real world coordinates, which is called patient registration [5]. Point based registration is a reliable solution, where registration is performed with ducials a xed on the patient. One set, consisting of more than four ducial points, is registered to another set of corresponding points using a rigid transformation. However, the accuracy of ducial based registration varies depending on

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the number of ducials and measurement quality of each ducial position, as well as their spatial arrangement [2]. To improve registration accuracy, iterative closest point (ICP) based surface matching is often used in combination with point based registration [13-15]. However, careful selection and collection of 3D surface data is critical for nal accuracy, usually expressed in terms of target registration error (TRE).

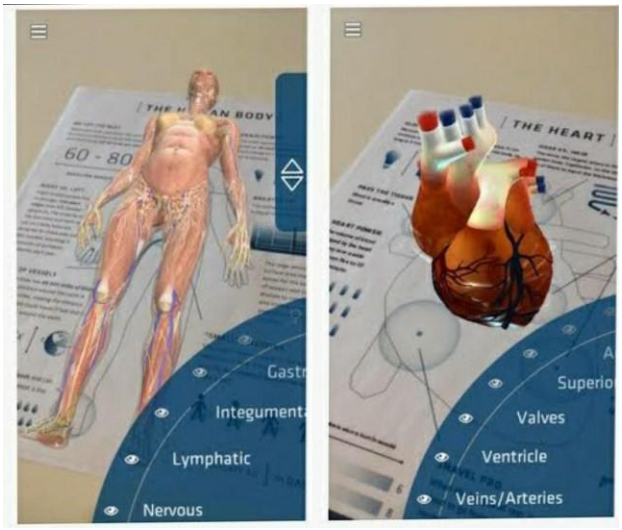
3. **Object Tracking**

Object tracking is to estimate the spatial position of the camera or marker on surgical instruments, and is an essential component of a medical AR system. In AR tracking, the relative position of an object on the basis of the camera position is generally calculated. When given a calibrated camera with known intrinsic parameters, the relative position can be determined as a set of three or more paired points between the 3D and projected 2D coordinates [11,12,16-18].Combining these technologies, we can implement an AR system that overlays virtual objects on the endoscope or surgical microscope view.

C. Applications of Augmented Reality in Medicine

1. Anatomy 4D

This is again an app developed for the educational purposes for the medical colleges. This app gives an interactive 4D experience of human anatomy to teachers, medical professionals, and students of all levels. [6]



2. Diagnostic and Treatment Applications of AR

It has given surgeons an ability to retrieve information about the patient obtaining the treatment much rapidly. This facility has actually helped the surgery procedures to the maximum as the important details can be made visible all the time without diverting their attention from patient to screens. [6]

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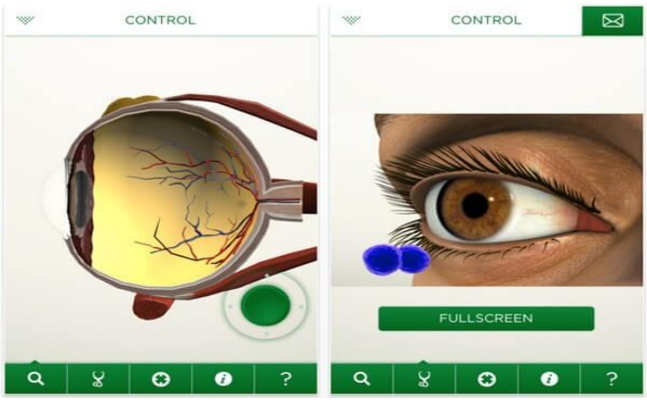
3. Eye Decide Application

Patients often struggle when they have to describe their symptoms to their doctors accurately. In other cases, people often find themselves overreacting a medical situation or on the contrary, belittle the problem. In ophthalmology, augmented reality might be the answer for patient education. EyeDecide is one of its kind medical app which uses the camera display for simulating the impact of specific conditions on a person's vision. Using apps like EyeDecide, doctors can show simulation of the vision of a patient suffering from a specific condition. For instance, the app can demonstrate the impact of Cataract or AMD and thus helping patients understand their symptoms and their actual medical state. If patients can experience the long-term effects of their lifestyle on their health, it could motivate people to make positive changes.



4. VIPAAR

VIPAAR is short for Virtual Interactive Presence and Augmented Reality for remote surgical assistance. It is a video support solution, which helps a remote surgeon to operate a patient via the surgeon on the site wearing Glass and point and guide. [6]

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5. Accuvein

The start-up company AccuVein is using AR technology to make both nurses' and patients' lives easier. AccuVein's marketing specialist, Vinny Luciano said 40% of IVs (intravenous injections) miss the vein on the first stick, with the numbers getting worse for children and the elderly. AccuVein uses augmented reality by using a handheld scanner that projects over skin and shows nurses and doctors where veins are in the patients' bodies. Luciano estimates that it's been used on more than 10 million patients, making finding a vein on the first stick 3.5x more likely. Such technologies could assist healthcare professionals and extend their skills.

6. Augmented Reality can save lives by showing defibrillators nearby

AED4EU was created by Lucien Engelen from the Radboud University Nijmegen Medical Centre, The Netherlands. Its users can add places where automated external defibrillators or AEDs are located and this database can be accessed
through this new application. Moreover, with the Layar browser, you can project the exact location of the nearest AEDs on the screen of your phone and it would take a minute to find them and help those in need. So augmented reality brings crucial pieces of information to those in need or danger.

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7. Google Glass might help new mothers struggling with breastfeeding

While Google Glass couldn't conquer the world, it was used to help new mothers with breastfeeding.The Melbourne office of an innovation company called Small World conducted a Google Glass trial with the Australian Breastfeeding Association that effectively allowed their telephone counsellors to see through the eyes of mothers while they breastfed at home. Through such a way struggling mothers could get expert help at any time of the day and they did not even have to put down the baby from their arms. By sharing the patient's perspective, consultations get to a new level.

8. Motivating runners through zombies

Imagine that you are walking through a dark and abandoned alley, and you suddenly hear the groaning and the slow movement of a strange creature. I am pretty sure that even the laziest person would speed up after realizing that a "real zombie" is after him. This is the basic idea behind the Zombies, Run! application. The game monopolizes on the fact that fear can motivate people and the fact that everything seems to be more fun when turned into a game. This app is perfect for those who consider running a boring activity. If you not only hear but also see virtual zombies projected onto your phone or device's screen, you will not only increase your speed and endurance, but also feel that time is just flying by.

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9. **Pharma** companies can provide more innovative drug information
Have you ever been curious about how a drug works in your body? Even if you got interested in discovering how the distant world of pills and medicaments work, I bet you lost all your enthusiasm after you read the boring and indecipherable drug description. Now, augmented reality is here to change it. With the help of AR, patients can see how the drug works in 3D in front of their eyes instead of just reading long descriptions on the bottle. Lab workers could monitor their experiments with augmented reality equipment. In pharmaceutical factories, workers could start working without hands on trainings as the device would tell them what to do, and how to do it.

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10. Augmented reality can assist surgeons in the OR

Doctors and even patients are aware of the fact that when it comes to surgery, precision is of prime importance. Now, AR can help surgeons become more efficient at surgeries. Whether they are conducting a minimally invasive procedure or locating a tumor in liver, AR healthcare apps can help save lives and treat patients seamlessly. Medsights Tech developed a software to test the feasibility of using augmented reality to create accurate 3-dimensional reconstructions of tumors. The complex image reconstructing technology basically empowers surgeons with x-ray views – without any radiation exposure, in real time. TheThe earlier mentioned Grossmann, who was part of the team performing the first live operation using medical VR, told me that HoloAnatomy, which is using HoloLens to display real data-anatomical models, is a wonderful and rather intuitive use of AR having obvious advantages over traditional methods.

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11. Hololens changing medical education and the study of anatomy

Case Western Reserve University and the Cleveland Clinic have partnered with Microsoft to release a HoloLens app called HoloAnatomy to visualize the human body in an easy and spectacular way. With Microsoft's HoloLens Headset, app users are able to see everything from muscles to the tiniest veins before their eyes on a dynamic holographic model. I believe it will revolutionize medical education, as students will be able to see the human body in 3D instead of the usual working method: black-and-white pictures and written descriptions in books. Although Microsoft Hololens is far from the "perfect" experience, there is no reason to believe that we will not get there soon. Thus, the most effective way to get used to this future trend is starting to educate ourselves and our children.

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12. Teaching kids about the human body

The UK-based company, Curiscope creates immersive learning experiences in virtual and augmented reality. They developed the Virtuali-tee T-shirt, through which you can see the inner parts of the human body through realistic holograms. Virtuali-tee brings anatomy to life to such a point of illusion which already represents Arthur C. Clarke's famous third law. "Any sufficiently advanced technology is indistinguishable from magic." Do you remember which your favorite toy as a kid was? For example, LEGO. Assembling little LEGO-parts into something new, creating castles, cars, complex cities – that is one of the best activities in the world. It stimulates your fantasy, your creativity, develops your skills for holistic vision as well as your attention to detail. Lately, there have been various videogames which attempt to recreate LEGO in the virtual space – such as Minecraft. ParentsParents often complain that their kids are just sitting in front of some screens, not learning anything about their environment and themselves, but I do not agree. Minecraft also enhances creativity, develops the way children see the world around them – but in a different way as LEGO. I think that from here, it is only one leap before we reach LEGO with AR, where the advantages of building something in the real world might be combined with virtual imagination.

This way, our kids would be able to know that real is real, but would also be ready to exploit the opportunities AR can provide us with.

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Discussion

- **Strengths of Augmented Reality [7]**

1. **Critical Data in plain view and hands -free gesture technology**
   Nowadays, computer devices helps the doctors to easily record the information of patient. The process of maintaining the patient information has been changing with technologies like gesture technology paired with AR glasses that allows medical professionals to see patient information projected in front of them and then record information with hand and motions.

2. **Taking or transfusing blood**
   Elderly patients and infants have very small veins due to which blood collection from their bodies is not so easy. Companies like Evena developed an AR solution that makes doctors and nurses visible the veins of their patients see easily on their arm, which makes it easy for blood tests. The smart glasses map out the veins on the outside of the patients arm so that the process of blood collection is easier for the patient.

3. **Ultrasounds**
   The AR software companies have developed transportable ultra sound technology. This technology helps the technicians and patients to view the ultrasound image through smart glasses. A transportable ultra sound can be very useful while travelling where portability is important.

4. **Spinal Surgery**
   The spinal surgery sometimes is a long process. The AR technology is trying to reduce the time for surgery and the result of it. Israeli-based company Augmedics created a technology that displays spinal information on the spine of the patient so that doctors can monitor the patient throughout and have the spinal information as needed.
   Surgeons wear a head-mounted display that allows the surgeons to see through the patients' skin as if they have X-ray vision.

- Weaknesses of Augmented Reality

1. **Social Rejection**
   Though AR is modern but it may become difficult for the people to adapt it. It may not. They may not trust the results of the applications.

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2. **Poor Experience**
   The concept is useful but when it is used it might seem to be lacking somewhere. Its poor resolution, User interface, & the actual experience might not reach upto the user's expectations.

3. **Digital Fatigue**
   The combination of digital and physical worlds is just too much beyond the expectation. The people have been surrounded by their mobile phones, television but sometimes its better to visible the virtual information directly being existed.

4. **Legal**
   AR companies are unable to track the legal issues while using it at scale. The issue of privacy and safety lead to huge regulation, making it difficult for AR development.

5. **Security**
   AR hackers directly implant harmful content into applications via advertising. Many attackers control the AR channels directly. The users may click on such ads that leads to the website server and may result into malicious attack. There are also network attackers who can monitor interactions between AR browsers and users. [10]

- Threats

1. **Invades Privacy**
   AR can be prone to many people one to data hacks which is dangerous as we are unaware of how much data is presented in virtual environment. Many people might fear that the way in which the information is accessed by the authorities which may result in the attack.[9]

2. **Hampers Interaction with Real-World**
   AR may provide new innovative ways for people to communicate, but there could also be possibility that people might lose their social life through reduced human interaction. [9]

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Conclusion

Studies suggest that AR systems are becoming comparable to traditional navigation techniques, with precision and safety sufficient for routine clinical practice. Most problems faced presently will be solved by further medical and technological research. Augmented reality appears to be a powerful tool possibly capable of revolutionizing the field of surgery through a rational use. In the future, AR will likely serve as an advanced human-computer interface, working in symbiosis with surgeons, allowing them to achieve even better results.

Nevertheless, further advancement is much needed to achieve maximum potential and cost-effectiveness of augmented reality. Augmented reality applications that have supported combination learning has resulted in public interest. The use of AR technology can be proved to be great help for medical professionals which result in less risk of the patients treatment. People might find of great help which would make their life easy. It can help a lot in development of innovative ideas.

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