Augmented Reality in Surgical Procedures

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Abstract - *Augmented Reality may not be as immersive and exciting as a virtual reality, but this technology is proving itself to be very unique and useful in our day-to-day lives. This paper introduces an overview of the uses of augmented reality in the health and research sector. We will present a varied implementation and usage of the existing tools to create a better method for surgical procedures. The purpose of this system is to create a learning and understanding of these concepts such as structures and mechanisms. The manipulation of 3D structures through tactile feedback can create an innovative study. Instead of studying about various surgical procedures through scans and related studies the surgeons can visualize a 3D model of the human subject and manipulate it to learn more. The main aim of this paper is to use this model as a scale over the target body during surgery hence aiding accurate incisions and procedures.*

Key Words*: *Augmented Reality, Object Recognition, Target Placement, Surgical Procedures, 3D Models

1.INTRODUCTION

Augmented Reality is a comprehensive interaction of real-based display which is proposed to change the procedures in various fields such as medicine, education, entertainment and manufacturing industries. The technological and scientific problems involved in surgical procedures is complex and multidisciplinary. In this paper we have chosen to focus on the features of Augmented Reality to overcome these problems. There are various existing tools like Minimally invasive therapy (MIT) which uses 3D structures and models to perform interactive study of surgical procedures. But they involve a lot of limiting factors which are as follows:

1.1 Immature and unreliable tools for presenting 3D models.

1.2 It is a fragmented research.

1.3 Lack of researchers capable to create appropriate and accurate 3D models and visualizations, while having sufficient insight into the surgical flow and clinical tasks and human factors involved during invasive surgery.

Augmented Reality helps you visualize and register accurate 3D models and structures positioned in the real world. With the use of Augmented Reality in medical procedures, a surgeon can visualize internal organs inside a body and improve the understanding of the treatment process by interacting with the real world. A brief description of the components used in this system is given below.

2. TECHNOLOGIES USED

2.1 Patient Registration and 3D Model X-Ray generation

X-Rays are generally used to create a study of the problem and decide on a possible treatment. X-Rays can be used to create 3D models using multiple X-Rays of various planes. The entry is one or two X-related pictures made on perpendicular planes and a 3D model of the body of the patient with the particular portion of the body to be operated on. The model must be developed from a good patient's CT pictures only once. The model is projected on the two planes of the corresponding images. The projections are matched in an accurate shape with the X-ray images by an algorithm and the rendered projections are converted back into a 3D model. It takes less than a minute to generate the 3D shape of the patient's body especially the required part of the body, with an error of less than 1.5 mm.

This procedure can be used by orthopedic surgeons to plan surgeries in 3D without using radiation-intensive and expensive CT scans, which is a great advantage in areas where CT Scans are extremely costly and patients are sensitive to radiation.

2.2 Camera Calibration

Generally, a camera is used to capture an image and then it is rendered on a display. Augmented Reality merges virtual items with the true globe, requiring conversion between the camera and coordinates of the true globe. The features of the camera must be described before estimating the conversion. Pinhole model is a straightforward camera model which maps the real 3D world to two-dimensional (2D) coordinates called the plane of the picture. 3D points are mapped to the 2D image plane by translating the point to the middle of the camera in a straight row until the image plane is intersected. This mapping is referred to as perspective projection and the conversion between picture 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. This can be used to place the 3D model over a plane to study the model. The 3D X-Ray models can be placed over a patient and can be used as a scale to make accurate incisions. This is called object tracking and placement. Tracking of a registered object can help you place the accurate 3D model of the patient over the target to use it as a scale.

2.3 Object Tracking

Object tracking is intended to predict the camera or marker's spatial position on surgical instruments and is an essential component of a medical AR scheme. In AR monitoring, the relative location of an object is usually calculated based on the camera position. A calibrated camera with recognized intrinsic parameters can be used to determine the comparative position as a collection of three or more combined points between the 3D and the predicted 2D coordinates [1,2,3-5].

A mixture of these technologies can be used to introduce an AR scheme that overlays endoscopic or surgical microscope virtual items.

Fig -1: Calculated incisions during surgery

Fig -2: Camera calibration to place model of patient

3. MEDICAL APPLICATIONS

In this section we will work with and optimize the various surgical procedures in which augmented reality can play a stellar role. Some of which include spinal surgery, cardiac, sinus. We briefly explain the attributes of each surgery and how augmented reality can help in the same.

3.1. Spinal Surgery

For spinal surgery, correctly localizing the surgical instrument inside the patient's body is the most important consideration. Therefore, surgical navigation systems based on Augmented Reality are commonly recognized and have become a very significant study subject in this sector, helping the surgeon to acknowledge patient anatomical structures [6]. Although AR offers a visual representation that is very intuitive, incorrect perception of depth is a severe problem. To enhance depth perception, an integration of a VR and AR scheme was suggested to show the distance between surgical instruments and target organs in a single window with aligned view axes [5].

3.1.1 Corresponding AR configuration

We can use a combination of VR and AR switchable navigation procedures which consist of visualization and position tracking. In position tracking the transformation coefficient between the camera and the patient is calculated by an optical tracker and is updated in real time. The visualization can be any open source visualization library and graphical processing unit (GPU) to display translucent objects based on depth peeling technique.

3.1.2 Corresponding Results

By moving the virtual camera around target objects, the user will move from AR to VR, giving image depth of patient anatomy. Fig. 3 shows the scheduled surgical navigation scheme VR and AR switchable. The surgical navigation system is operated in AR mode once the virtual camera is placed within the varying camera picture. It is operated in VR mode otherwise. Additionally, the depth which suggests the minimum distance between the tip of a medical instrument and also the nearest purpose of the target is additionally displayed on the screen.

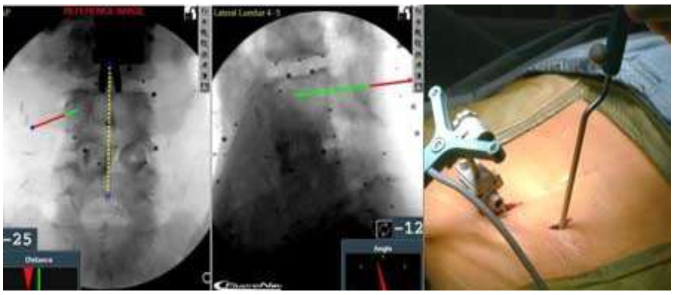

Fig -3: Proposed AR and VR system for spinal surgery

3.2. Sinus Surgery

Sinus operation is an endoscopic operation. The primary issue is the difficulty of finding a surgical instrument through the endoscope to a particular object [7]. Due to the complexity of the access path to paranasal sinuses, problems such as blindness and cerebrospinal fluid leakage may happen owing to orbit and skull base harm. An embedded system composed of an AR-based surgical navigation system and endoscope holder was created to fix these issues [8].

3.2.1 Corresponding AR configuration

The suggested sinus surgery AR navigation system was comparable to those used in standard surgery. The suggested scheme consists of three procedures: registration of patient images, camera calibration, and camera-based monitoring supplied by paired point registration, pinhole-based calibration, and perspective n-points algorithm, respectively. The endoscope holder scheme comprises of a stackable parallel mechanism of 3 degrees of liberty (DOF) and an end-effector of 2-DOF. The parallel stackable 3-DOF system coupled a five bar with two parallelograms, and the end-effector 2-DOF governed the position of the endoscope. A brake was also included in the scheme to keep the endoscope anywhere the surgeon wanted [8].

3.2.2 Corresponding Results

Fig. 4, the suggested AR navigation system, displays 2D multi-planar reconstruction (MPR) pictures (axial, coronal and sagittal planes) along with views of the AR and VR. Functions for adjusting warning and automatic transparency were also introduced. If a goal is too near to the tip of the surgical instrument, an alert noise is produced.

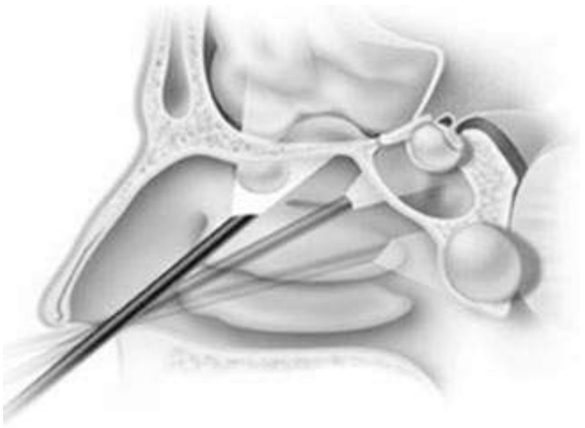

Fig -4: AR based model can help detect accuracy and precision of the instrument used

3.3. Cardiac Surgery

To guide chronic complete occlusion intervention, a surgical navigation scheme was suggested. Conventional intervention for the coronary artery's permanent complete occlusion is extremely dependent on 2D X-ray images and the experience of the surgeon. Large displacements between the hand-eye coordination of the surgeon can therefore be caused by discrepancies in the patient's position or orientation and the acquired images [9]. This may result in the coronary artery being misidentified or the stenosis being incorrectly positioned on the coronary artery [10]. The scheme suggested combined the 3D CT angiography model with X-ray images to provide the surgeon with 3D anatomical data [11].

3.3.1 Corresponding AR configuration

The position of markers connected to the patient and C-arm device was tracked using a commercial optical monitoring scheme. Using a transformation matrix, the various system coordinates were unified.

3.3.2 Corresponding Results

The angiograph of the CT is superimposed on the X-ray picture and the pictures of the VR are placed next to it. We expect surgeons to be able to readily comprehend anatomical data contained in the initial X-ray picture, as well as the vascular anatomy and relative place of the tool using the suggested prototype scheme. As fluoroscopy is less needed than standard surgery, the scheme can also minimize X-ray exposure and injection of the contrast medium.

4. PROPOSED SYSTEM

The scheme proposed is intended to create high-quality manuals for 3D video using AR. A camera is used to track fiducial objects (Image Targets) and the 3D models are mapped to the target. These 3D models represent a product or idea that can be seen on your screen by the user. The user can communicate with these 3D models and watch the animations to see the processes.

4.1 Smartphone / Holo Lens / Computer

4.2 Vuforia

4.3 Unity

4.4 Storage and processing server

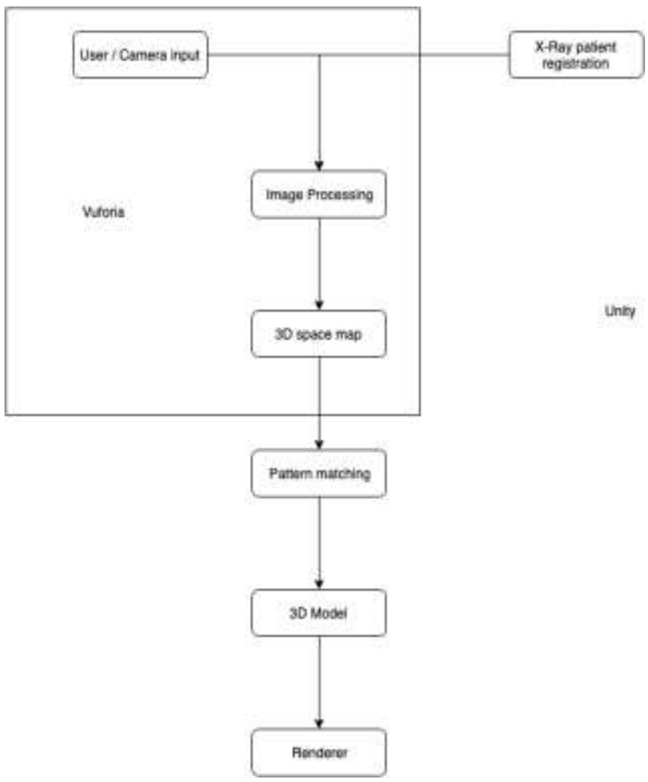

Fig -5: System Architecture

Unity

Unity is a graphics and physics engine used to construct apps that can be constructed with the same codebase for various platforms. Supported platforms include Linux-x86/x86-64, Mac-x86/x86-64, iOS, Android and WebGL.

Vuforia

Vuforia offers cross-platform Augmented Reality assistance through a single API for Android, iOS, and UWP devices, enabling developers to write their applications once and operate them using the highest key technology available.

User Defined Targets allow you to use a camera picture shot as the goal to position content in the actual globe. Users can generate objectives in their setting from pictures and surfaces.

Object Targets are 3D objects that can be scanned for recognition and tracking of 3D objects. Object Recognition operates best with objects that have surface information and are geometrically stable.

5. CONCLUSION

We will create a scheme using AR technology to enhance the learning and comprehension of surgical procedures. Our scheme will assist doctors and surgeons to efficiently visualize and improve their precision of operations. Our scheme seeks to help and develop a better and interactive training environment in the field of medicine.

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