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Conversion Of 2D Medical Images Into Virtual Reality Model - Survey

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Abstract: Virtual reality (VR) is a trending, widely accessible, contemporary technology of increasing utility to biomedical and health applications. Any kind of medical situation can be simulated using VR, to allow the students to deal with it as in real life. VR can be used to help medical professionals visualize the interior of the human body, thus unveiling otherwise inaccessible areas. Computer graphics have made it possible to recreate any part of the body in great detail, with extreme faithfulness to reality. Moreover, training can be offered using scenarios that closely mimic common surgical situations. The objective of this review is to analyze the advances available in the field of converting 2D medical images into Virtual Reality model. The steps involved in conversion are discussed.

Keywords: Virtual Reality, medical images, 3D Reconstruction, segmentation.

1. INTRODUCTION:

The diagnosis of brain pathologies usually involves imaging to analyze the condition of the brain. Magnetic resonance imaging (MRI) technology is widely used in brain disorder diagnosis. Minimally invasive procedure is an important developing trend of any surgery. It features some outstanding advantages compared to traditional open surgery with significantly reduce tissue traumas and decrease recovery time. In the process of minimally invasive operation, in order to provide the operation accuracy, computer aided diagnosis (CAD), robotic surgery, virtual, augmented reality techniques will be incorporated. There are various number of imaging systems presently utilized. Imaging modalities are often categorized by the method in which images are generated: ultrasound, radiation such as x-rays, MRI (Magnetic Resonance

Imaging), CT (Computed Tomography), PET (Positron Emission Tomography), SPECT (Single Photon Emission Computed Tomography). Ultrasound images are created using sound waves and are able to gather real-time images of both anatomy as well as function (heart valve opening and closing). The imaging modalities used in biology and medicine are based on a variety of energy sources, including light, electrons, lasers, X-rays, radionuclides, ultrasound and nuclear magnetic resonance. Real-life surgical procedures can first be filmed from multiple angles with stunning quality and then combined with models of the body site being operated on, to allow the student to 'operate' in VR. Understanding how fractures occur and are aggravated in real life is of immense use to orthopedic surgeons in training. Since minimally invasive surgery is of great benefit in reducing operative costs, complications and recovery time, simulation-oriented VR-based training is a very effective method of transferring skills to would-be laparoscopic surgeons.

2. Methodology:

The procedure of converting 2D medical images into virtual reality model is shown in Figure 1.

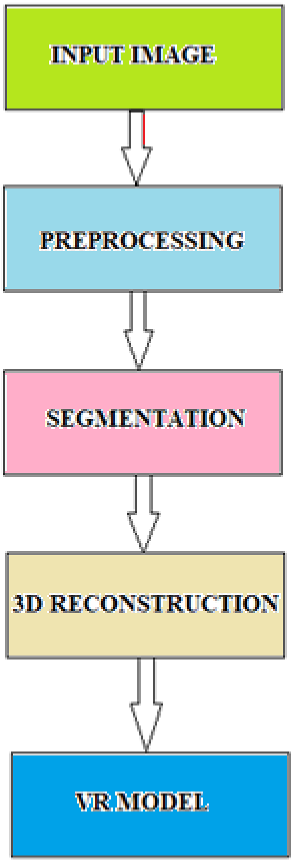
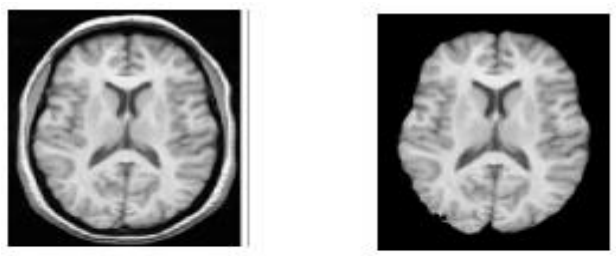


Figure 1: flow of chart for converting 2D medical images into Virtual Reality Model

The steps involved in conversion are pre processing, segmentation, 3D reconstruction and VR model development.

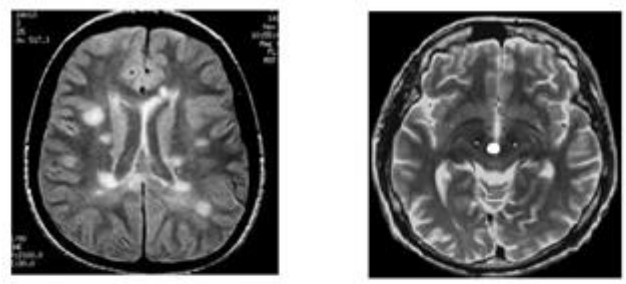
2.1 pre processing:

Pre processing is a fundamental step to assure the success of any quantitative analysis pipeline. Such operations can be composed of different processes, each of them aimed either to improve image quality or to standardize its geometric and intensity patterns. In a wide variety of image processing applications, it is necessary to smooth an image while preserving its edges. Remove the film artifacts and skull portions from the Brain MR/CT image is known as skull stripping. The MRI/CT image consists of film artifact or labels such as patient name, age and marks. Removing these details is an essential procedure while stepping over with subsequent image processing operations. The images captured can be corrupted by artifacts, such as noises, bias and intensity degradation. These can affect the quality of the image. Several filters, histogram techniques are used in removing these artifacts. Pre processed images are to be made more suitable for further processing in CAD systems. The resultant of several pre processed image is shown in figure 2, 3, 4 and 5.



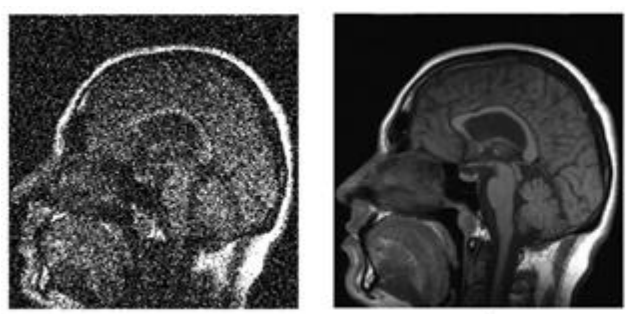
(a) (b)

Figure 2: (a) without skull stripping, (b) skull stripped image



(a) (b)

Figure 3: (a) with patient details, (b) without patient information



(a) (b)

Figure 4: (a) noisy image, (b) noise removed image

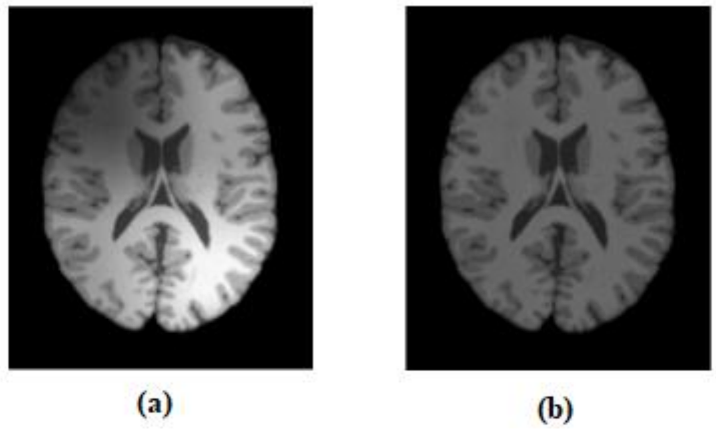
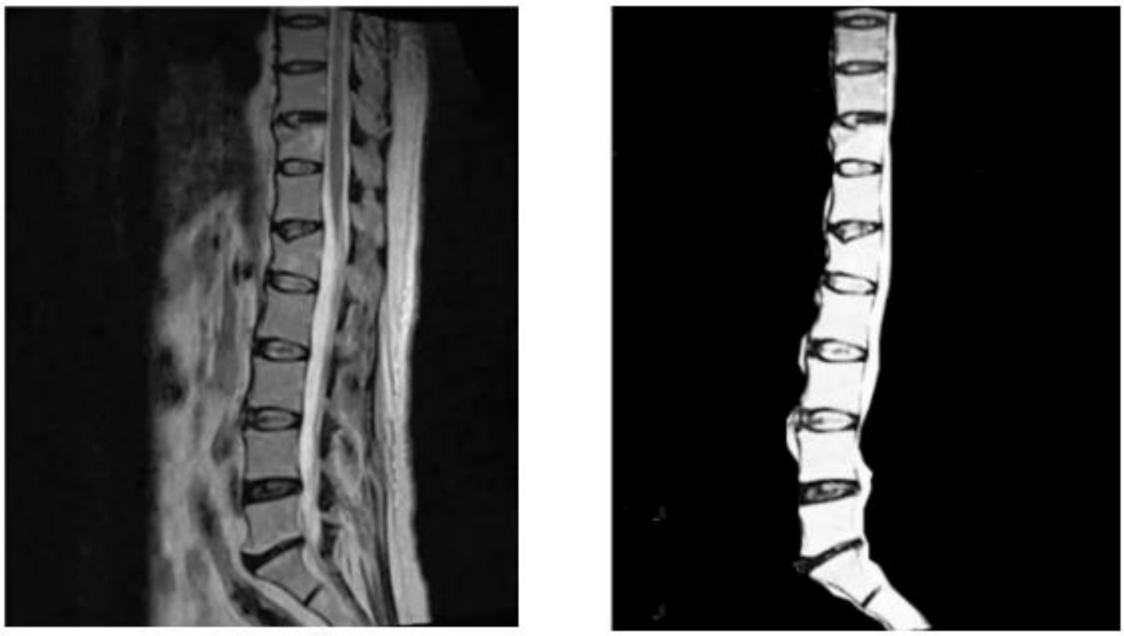


Figure 5: (a) Bias corrupted image, (b) Bias corrected image

2.2 Segmentation:

Medical image segmentation involves the extraction of regions of interest (ROIs) from 3D image data, such as from Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) scans. The main goal of segmenting this data is to identify areas of the anatomy required for a particular study. One of the key benefits of medical image segmentation is that it allows for a more precise analysis of anatomical data by isolating only necessary areas. There are several segmentation techniques available such as, threshold based, edge based, region based, watershed based and neural network based segmentation[1-3]. Thresholding methods are the easiest methods for image segmentation. These techniques divide the image pixels with respect to their intensity level. The edge based segmentation methods are based on the rapid change of intensity value in an image because a single intensity value does not provide good information about edges. Edge detection techniques locate the edges where either the first derivative of intensity is greater than a particular threshold or the second derivative has zero crossings. In edge based segmentation methods, first of all the edges are detected and then are connected together to form the object boundaries to segment the required regions. The region based segmentation methods are the methods that segments the image into various regions having similar characteristics. There are two basic techniques based on this method [4] [5] [6]. The region growing based segmentation methods are the methods that segments the image into various regions based on the growing of seeds (initial pixels). These seeds can be selected manually (based on prior knowledge) or automatically (based on particular application). Then the growing of seeds is controlled by connectivity between pixels and with the help of the prior knowledge of problem, this can be stopped. The region splitting and merging [7] based segmentation methods uses two basic techniques i.e. splitting and merging for segmenting an image into various regions. Splitting stands for iteratively dividing an image into regions having similar characteristics and merging contributes to combining the adjacent similar regions. The clustering based techniques are the techniques, which segment the image into clusters having pixels with similar characteristics. Data clustering is the method that divides the data elements into clusters such that elements in same cluster are more similar to each other than others. There are two basic categories of clustering methods: Hard clustering and soft clustering. Hard clustering is a simple clustering technique that divides the image into set of clusters such that one pixel can only belong to only one cluster. In other words it can be said that each pixel can belong to exactly one cluster. These methods use membership functions having values either 1 or 0 i.e. one either certain pixel can belong to particular cluster or not. The soft clustering is more natural type of clustering because in real life exact division is not possible due to the presence of noise. Thus soft clustering techniques are most useful for image segmentation in which division is not strict. The watershed based methods uses the concept of topological interpretation. In this the intensity represents the basins having hole in its minima from where the water spills. When water reaches the border of basin the adjacent basins are merged together. To maintain separation between basins dams are required and are the borders of region of segmentation. These dams are constructed using dilation. The watershed methods consider the gradient of image as topographic surface. The pixels having more gradient are represented as boundaries which are continuous [8]. The artificial neural network based segmentation methods simulate the learning strategies of human brain for the purpose of decision making. Now days this method is mostly used for the segmentation of medical images. It is used to separate the required image from background. A neural network is made of large number of connected nodes and each connection has a particular weight. This method is independent of PDE. In this the problem is converted to issues which are solved using neural network. This method has basic two steps: extracting features and segmentation by neural network [9].



(a) (b)

Figure 7: (a) Spine MRI, (b) Segmented spine image

2.3 3 D Reconstruction:

It is difficult to acquire a clear stereo perception of 2D image, because it is only limited to images with incomplete information description and relative position of organs in the space is fuzzy. Thus people require to optimize 2D medical images by develop them into 3D. Medical image 3D visualization technology means to develop 3D model from series of 2D medical images. Doctors can know more about data, have a wider view, and make accurate diagnosis if computer 3D reconstruction technology is used. The 3D reconstruction method is classified under two categories surface and volume rendering. The algorithms used to construct a 3D models are volume 3D, Marching cube, ray casting, marching tetrahedral and maximum intensity projection. Some software packages are utilized for 3D Reconstruction such as 3D slicer, OSIRIX, MIPAV, Radi Ant DICOM viewer etc [10][11][12]. Each technique uses different strategy for constructing 3D model. The different 3D models constructed using different algorithms are shown in Figure 8, 9, and 10.

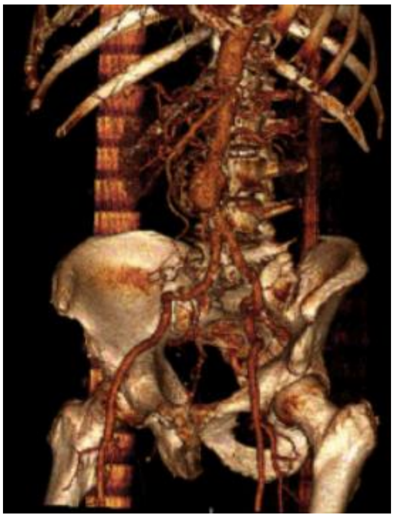


Figure 8: constructed 3D spine model using OSIRIX software

Figure 9: constructed 3D head model using3D Slicer software

Figure 10: constructed 3D chest model using maximum intensity projection

2.4 Virtual Reality

Virtual reality(VR) is special kind of graphical user interface which presents a computer-generated, three-dimensional, interactive environment that is accessed and manipulated using stereo headphones, head-mounted stereo television goggles, and data-glove. There are 3 primary categories of virtual reality simulations used today: non-immersive, semi-immersive, and fully-immersive simulations [13][14][15]. Non-immersive virtual reality is a type of virtual reality in which helps to interact with a virtual environment usually through a computer where you can control some characters or activities within the experience, but the virtual environment is not directly interacting with the real environment. Fully immersive virtual reality is the opposite of non-immersive virtual reality. It ensures a realistic virtual experience. The observer fully immersed in the artificial environment, didn't are physically present in the virtual world. A semi-immersive virtual reality is something in between non-immersive and fully immersive virtual reality. Using a computer screen or VR glasses, both real and artificial environment can be experienced. Augmented Reality is a type of virtual reality that lets the user see the real world usually through a phone screen and make virtual changes to it on the screen. The cave environment is used to provide full immersion. The Windows on World (WoW) is used to provide non immersive level of immersion. The Iterative closest point algorithm and Simultaneous Localization and Mapping (SLAM) are used to provide semi immersive environment. The example of non immersive, semi immersive and full immersive is shown in Figure 11,12 and 13.

Figure 11: Example of Full Immersive Environment

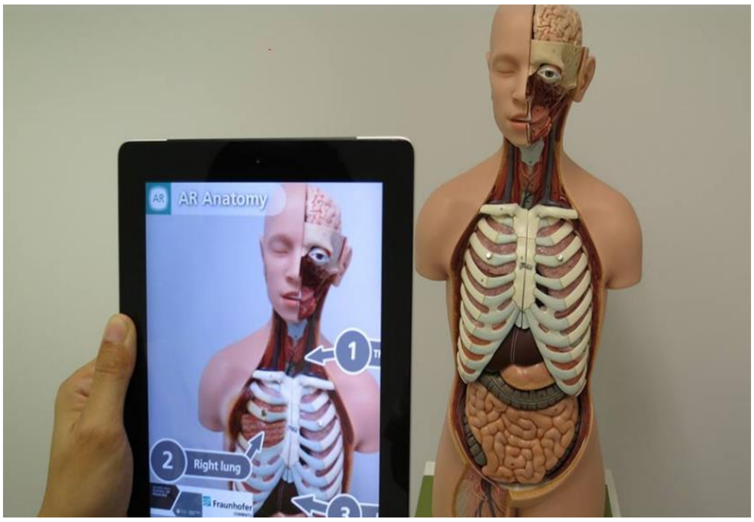


Figure 12: Example of Semi Immersive Environment

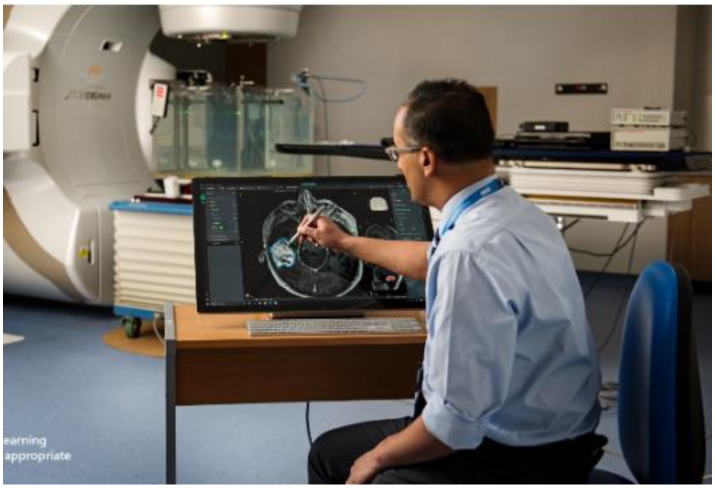


Figure 13: Example of Non Immersive Environment

3. CONCLUSION:

Past few years have witnessed Virtual reality (VR) taking the world by storm and this trend is only getting popular with every passing day. Rapidly evolving technologies around us are changing the way we see the world and how different industries operate. The main motivation behind this work is to portrait the steps involved in the process of converting 2D medical images into virtual reality model. VR is mostly used in Medical Education, Disease Diagnostics, Mental Illness Treatment, Pain management, Physical Fitness and Therapy, Surgery and Human Simulation Techniques.

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