Development of a display system for visualization in medical Applications

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Abstract. Imaging capabilities have been enhanced by scan modality. A review and comparison of some of the most effective open source libraries and medical application development has been implemented. A system composed of Ultrasound-Diagnostic-Machine-CMS600B2, a core i7-9750h Intel laptop processor, an easy-to-use capture tool for converting ultrasound analog images to digital images stored in a laptop and VR receiver to imagine a full organ. The understanding of 3D medical information earned very little consideration when it was intended to look at the ability of investigators to solve problems in 3D space. The aim of this research is to develop powerful computational techniques for integrating, interpreting and analyzing images for creative use in clinical practice. It's turning into extra common to speak regarding 3D, 4D images formed by modern imaging techniques. The potential will be demonstrated by the evolution of medical imaging and VR systems that led to this system.

Keywords. Ultrasound, 3D Slicer, Virtual Reality, 3D reconstruction, Volume rendering.

1. Introduction

An excellent international endeavor to establish a scientific ultrasound involving thousands of people in the second half of the 20th century was thus insufferable to some outstanding participants in the short term. Current technology has been used for imaging since the preceding century (1).

Ultrasound imaging is mostly used for medical diagnosis because it is a reliable and non-invasive method for real-time imaging. The study of three-dimensional structures is the wish of any health professional. The use of one or two dimensional arrays of ultrasound sources with receivers transmitting and receiving strikingly directional, short radio frequency pulses with a bandwidth of less than one octave) can produce these images. Rather of concentrating solely on the individual features of the body, it would be helpful to be able to capture and process 3D data in a systematic manner. Many 3D imaging systems are designed to work by running a series of 2D scans to create a 3D tissue record. It would also be important to create a 3D imaging system that uses true 3D geometry instead of only incorporating data from individual 2D slices. The 3D will provide additional data to the user, but repetitive movements in tissues are fast compared to image processing and usually take several seconds to a few minutes to generate images. It would therefore be useful to create a device that would be able to display time-varying 3D images (4D-images) quickly enough to perform this complex task (2).

The open source navigation device freehand 4D US with standard hardware equipment shall be built on the basis of the specifications described above.

Data provided by 2D ultrasound is compatible, in the majority of the cases, with data generated by 3D/4D volume datasets alone (3).
Monitoring 2D ultrasound images will execute scanning in a low resolution image. Subsequently, the volume reconstruction will be carried out within the area of interest until a sufficient image density is obtained. In the Slicer IGT extension, we introduced the workflow as an open-source 3D Slicer framework module. Real time 3D visualization can be used and manipulated on a virtual reality system called HTC vive.

Research could contribute to the solution of a practical problem faced by several practitioners in the field, such as the purchase of overpriced devices designed to show 4D imagery.

1.1. Literature review survey
In 2013, Muzhir Al-Ani and Shokhan Mahmoud projected a study algorithm for estimating the surface rendering of a single-view image. Initially, the angiography image is expanded and after that the segmental image is divided into separating methods using an adaptive K-mean algorithm based on gray scale level color. In order to make efficient use of medical image data, it was important to develop and recognize concepts for an effective framework that is the main objective of 3D image visualization. The obtained results suggest a good 3D Reconstruction process resolution. Surface evaluation methods are equipped with a single image to construct 3D image graphic illustration. The obtained results revealed that the 3D reconstruction procedure is in better resolution. This algorithm is based on medical images and also supports entirely different kinds of image format (4).

In 2013, Fritz J. ET. al., Revealed MR-guided 1.5 T navigation biopsy in conjunction with the development version of augmented reality image control system, in human pelvic and bone spine cadavers. A total of 16 lesions were used for osseous biopsy in four human bodies with osseous metastases. Digital biopsy paths, lesion testing, and drill positioning navigation used MR images in the built version of the 3D Slicer open-source software package medical data used for analysis and visualization. Maneuvering the drill on the MR image is used in the osseous drill biopsy containing the virtual biopsy path to the target. The location of the drill as well as the final destination of the drill were tracked by interrupted MR imaging (5).

In 2014, Laura Brattain presented a collection of improved display techniques for US 3D real-time visualization. ICE catheters can be used for visualization in heart beat procedures. The approach is extremely achievable and therefore accelerates parallel programming on computer graphics cards with the least amount of effort, the researchers say. They seemed to be ready to achieve an accuracy of 2.2 mm RMS in position and 0.8 in angle throughout the equipment tracking process. The design of the system is based primarily on a formula that collects details in each local structure and its orientation with respect to US incident waves. The machine provides a volumetric representation of the local work area and helps to assess the precise position of the edge (6).

In 2016, Drăgan OC et al. Created a reconstruction project of an MRI incorporated with human root canal of the dental morphology. The orthodontic system of a newly extracted wisdom tooth, preferred for its well-known anatomical variations, was instantaneously formed using a hybrid approach. When it was washed, the tooth was immersed in a recipient containing saline solution and magnetic resonance imaging simultaneously. The Bruker Bio spec Magnetic Resonance Imaging Scanner was powered at 7.04 Tesla and focused on Avance III Radio Frequency Technology.

The 3D reconstruction including its tooth scanned volume was used in Vesalius software. The latest ex-vivo experiment demonstrates the precise 3D volume of one of the reconstruction of the internal and external morphology of the human removed and endodontically managed tooth using a collection of images obtained by magnetic resonance imaging (7).

In 2017, Gomes JP, Et al., Surgical performance enhancement was provided using a three-dimensional (3-D) volumetric study of tumor images of ghost cell odontogenic carcinoma that infiltrates the maxillary sinus via the palate to be analyzed using 3-D reconstruction techniques. Methods for volumetric reconstruction and tumor analysis were used in Vesalius, which will be fitted with surgical lesion treatments. For this case study, the volume of tumor tumors is measured using a visual technique to better predict surgical outcomes. Increasing the sense of depth and boundary by increasing the color of the segmental volume image will help visualize the tumor in three dimensions (8).
In 2017, Jan Egger ET. al., Displayed a successful software integration with the evaluation of the HTC Vive headset performed with the C++ implementation of the MeVisLab Image Processing Module research prototyping framework via the Free VR library. The program is fast and simple to use as it can provide information for medical datasets in a number of formats and is independent of the client and the manufacturer and may also be used with different systems in order to be linked to existing MeVisLab networks or tailored to new ones. Data outputs under MeVisLab could be connected to the device input to transfer the data to the HTC Vive headset and display it using the drag-and-drop tool. The headset modules of MeVisLab can also view translation, rotation, segmentation, etc. and other database operations and manipulations (9).

In 2017, Jinglu Zhang ET. al., Presented VR focused primarily on surgical simulation applications. The quantitative anatomical model can be provided by patient-specific medical image data such as ultrasound, MRI or CT, which is part of the Patient Specific Modeling (PSM). This project launches a review of existing technologies, such as providing a practice of surgery to a single patient for surgeons, which would improve patient care by increasing the quality of diagnosis and treatment through predictive capabilities of the VR simulation system by concentrating in single on real-time soft tissue simulation and patient-specific modeling. A variety of problems introduced to the method, such as the identity of the patient and his or her ailments and the nature of the human anatomy model (10).

In 2018, Haleem A and Javaid M Discussed the development of different steps used for the three-dimensional Additive Manufacturing System using CT and MRI scans. The development of 3D physical objects from the digital model has been facilitated by the use of AM technologies that have helped improve patient anatomy for treatment and educational purposes. Characteristics such as color, texture, length, size and actual form can be seen in the AM model using this approach. The actual patient was used to provide a personalized device for each orthopedic patient. AM technologies were used to print the standard triangular language (STL) format obtained from 3D CAD info. Bone-like objects would organize the model while the patient's anatomy could be illustrated by the Crossing of the physical model made (11).

In 2018, Rudiger Gobel et al., presented a Software-based ultrasound processing platform has the potential to make basic ultrasound imaging research available. The basic framework, which promotes a regular processing pipeline, allows for versatile developments. It is demonstrated that the processing steps implemented offer image quality that is significant compared to the clinical system. In addition, the run-time analysis demonstrates SUPRA's real-time capabilities. The permission under which SUPRA is distributed permits for each study and industrially adapted production (12).

In 2018, Zhenping Chen and Qinghua Huang developed a real-time data collection method that could retrieve volume and visual information using an ultrasound imaging tool. Development of corresponding parallel computing techniques Based on both Bezier post-processing algorithm and squared distance weighted discretization SDW in the application of data to the GPU to display and reconstruct the tissues scanned by the VTK simulation toolkit. The result showed that the device could use the standard B-scan image size of $302 \times 268$, the acquisition rate of $25$ Hz, the preset scale of $90 \times 81 \times 192$ and the visualization speed of up to $32$ and $119$ frames per second to maintain real-time US cumulative reconstruction visualization for Bezier algorithms and SDW (13).

In 2019, Samantha Horvath et al., Developed (US) guided renal biopsy virtual trainer to help individuals develop their technical knowledge of renal biopsy using real-time ultrasound guidance. The program uses 3D Slicer, a free software visualization and digital simulation database, and iMSTK, an interactive medical simulation toolkit and low-cost operating systems, both accurate and cost-effective. A pre purchased 3D ultrasound volume used to cut a 3D Slicer image based on a realistic needle rendering and the location of the probe. The contact between the virtual tissue and the needle was modeled by the simulation engine in iMSTK. User holding the needle can have physical effects that may have visible defects in the tissue. App resilience the simulated quality images showed a good result in the initial study. The tactile feedback was stimulated by a physical doll that learners encounter when scanning a real patient and creating trainees with the US scanning plane's spatial knowledge of the
patient's anatomy. Clinical techniques used extensively to construct the biopsy needle and the ultrasound probe have been used for simulator interactions (14).

2. RESEARCH METHOD
The system includes the effects of the reconstruction of multiple images processed from video taken in a laptop from an ultrasound device to build an organ volume that will be visualized in a VR space from a 3D Slicer program as illustrated in Figure (1).

![System block diagram](image1.png)

Figure 1. System block diagram.

The utilized method to transfer images from US machine to a computer, is via an analog connection and a frame grabber (easy capture devise) as shown in Figure (2).

![Ultrasound to laptop hardware connection](image2.png)

Figure 2. Ultrasound to laptop hardware connection.

VLC is a free media player that supports several types of video Files that have been used to convert video to TIFF series of images (15).

Professional DICOM Conversion Software is a program that can convert TIFF images to DICOM format, with the most common image formats supported (16).
The system encountered three different forms of computers as illustrated in Table (1).

Table 1. Specifications of computers used (17)(18).

| Model         | CPU          | GPU          | RAM        |
|---------------|--------------|--------------|------------|
| LENOVO (B50-80) | i7-5500U     | AMD-Radeon HD8500M | 8.00 GB DDR3-1333 |
|               | 2.40GHz up to 3.00 GHz | 2GB memory |            |
| LENOVO (I330) | i7-8550U     | NVIDIA MX150 | 12 GB DDR 4-2400 |
|               | 1.8GHz up to 4.0GHz | 4GB memory |            |
| LENOVO (Y540) | i7-9750H     | NVIDIA GTX1650 | 16 GB DDR 4-2666 |
|               | 2.6GHz up to 4.5GHz | 4GB memory |            |

Currently VR-ready laptops are eligible to operate virtual reality devices such as the HTC Vive Cosmos. And because it tested a lot, we know the ones will drive the VR goggles that will give us all of our spectacular 360-degree video experiences. The core i7-9750h Intel processor with 16 GB of RAM and NVidia GTX1650 4 GB of GDDR5 memory is used for all the tests we have currently used (17). The other two computers afford us lesser numbers.

Communication using a VR head-mounted device (HMD) with a 3D Slicer scene is a new way for medical practice, Figure (3); perform surgery planning; or identify trends patterns and data outliers.

![Figure 3. Virtual reality (VR) connected to 3D slicer.](image-url)
3. RESULTS AND DISCUSSIONS
The final results of the implemented systems in Figure (4) shows an Easy Cap devise comes with software program “Honestech” that will allows to record, edit and save ultrasound video in real time.

![Flow diagram of flow of data from medical device to virtual reality (VR).](image)

VLC is a program that could replicate as many video frames as needed and save them as image files automatically, such as JPEG or PNG or TIFF (19).

Choosing TIFF format is because it is the best option for multi-page documents and secure storage of multiple images.

Due to the DICOM converter, researchers will be able to change the format of the standard medical image file to various output choices and vice versa.

After importing a sequence of horizontal, sagittal and coronal DICOM images, Volume rendering is currently being prepared to construct a real-time volume organ.
Figure 6. Manipulation of elbow in VR system.

4. CONCLUSION
The use of real-time 3D US imagery in clinical trials has been broadened due to the potential to represent geometric anatomy in real time. Guidance has been given for the creation of an effective tool for practical use. This 4D ultrasound reconstruction system is particularly useful for intraoperative imaging, as intraoperative MR or CT is typically not feasible, whereas fluoroscopy and X-rays do not provide 4D
data. 4D ultrasounds may be used in the operating room as part of the identification process between the preoperative image and the intraoperative patient.

1- Image method is used by our system, most of the CT, MRI, X-ray, etc. imaging methods can be used by our system. The notable difference is the hardware connection

2- Taking linear measurements the Annotation module helps us to gather linear measurement of each part of the organ using ‘Fiducially’ tool that adds markers and a ‘Ruler’ to take the measurements, measurements value can be found on the left menu of the program.

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