University of Pennsylvania

AI-Augmented Surgical Visualization - 3D to CT

By- Reva Bhatt

Mentor -

Dr. Chamith Rajapakse

HYPOTHESIS

A software solution can be effectively utilized to enable the automated generation of precise anatomical models for augmented reality visualization using bone CT scans.

QUESTION

Can a software solution be created to effectively create anatomical models for guiding surgeries using augmented reality?

EXPECTED OUTCOMES

Overall, I am expecting a successful outcome. I believe that implementing TotalSegmentator into an application, 3D Slicer, can effectively create anatomical models. Through my research, I have found that this segmenting tool, allows the user to segment a given CT scan within minutes, as doing it manually takes several hours. I have confidence that implementing this tool within the application will allow users to have a compatible file to easily upload to their augmented reality devices (such as Microsoft's HoloLens).

PROCEDURE

Research on what file types is compatible with augmented reality devices and research about TotalSegmentator

Implement TotalSegmentator into 3D Slicer

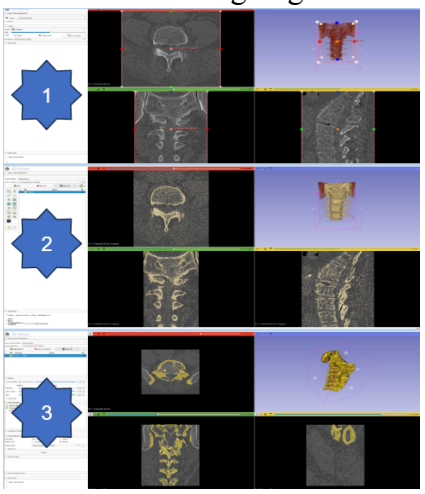
Segment the spinal bone CT scan file into multiple slices

Convert the nrrd file of slices into the file type compatible with the augmented reality devices

Record data and compare the scans between the conversion through,
1) this software solution and
2) by conversion by hand (256 slices)

DATA ANALYSIS

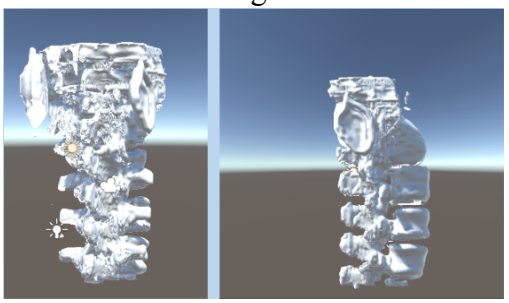
With the results below, the scans are completely 3D in the stl file format. The scans are proportionate to its sizing and are accurate anatomical models to the CT scan. The scans have undergone volume rendering to remove unnecessary tissue that might have been visible on the scan. This is done, so that only the bone is now visible in the 3D view. Below are the images of the scans undergoing the volume rendering.



These images above show the volume rendering within this CT scan. The scan can also be cropped to the area that is being looked at. The order of these images show how at first there is a rough look (1), then the cropped image (2), then the final scan showing the 3D image (3).

TRIALS

The trials began by testing to see if this new file will easily load into the HoloLens (the images to the. left are what the HoloLens look like). In collaboration with a UPenn professor, who has access to this device, the files were checked to determine its compatibility. The images below show what is seen through the device.



The images above show that the stl file is now a compatible, 3D version, of the original CT scan. The file was easy to upload and quick. This trial shows a success in the use of the stl file.

ABSTRACT

The project is aimed to develop a software solution which will create anatomical models to help guide surgeons during surgeries using augmented reality. It has the potential to change surgical procedures by using 3D visuals that can be utilized during the

procedures. In 2019, researchers found that around 5 people died on the operating table every 30 days. Augmented reality can prevent this mortality. The 3D Slicer application allows users to view a 3D model of a CT scan in a real-time during their surgeries, which will reduce errors and potentially save lives. This application is augmented by adding TotalSegmentator. This program segments CT scans show only the bones. It allows the creation of the nrrd file of the CT scan, thereby allowing the CT scan to become a 3D version. Using 3Dslicer, the nnrd file is put through volume rendering, discarding any additional tissue that TotalSegmentator could have included. Originally, the goal was to convert the nnrd file into a str file, which couldn't happen because they weren't compatible. The plan then became to convert the nrrd file into a stl file. Its difficult to convert the nrrd file straight to a stl file, so first the nrrd file was converted into a DICOM file, then into a stl file which is proven to be compatible with augmented reality devices. Ultimately, the CT scan was seen as a 3D model. This study shows how TotalSegmentator can be implemented to create a 3D version of a CT scan. The software solution is a practical tool that can be used within many surgeries to minimize errors so that the surgeons can minimize the surgical errors and potentially save lives.

IMPACT

Nearly
4,000
surgical errors
occur each year
in the U.S.

Source: NCBI

The project was set out to create specialized software that uses augmented reality (AR) in order to potentially save lives during surgeries while also improving surgical safety. The technology advancement known as augmented reality, which adds digital information to the physical world, has shown hope in resolving the various issues faced by doctors when performing procedures.

The urgent need for effective solutions was shown through the heartbreaking statistic that nearly 4,000 surgical errors occur each year in the US. That is around 333 monthly errors surgeons have made during surgeries.

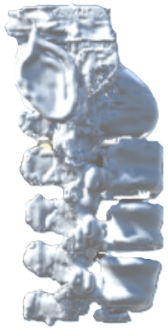
The application that has been produced is an important development in the medical area. By providing surgeons with these 3D models created from CT images, this tool is a valuable resource. The primary goal is to lessen the probability of errors resulting from the basic restrictions on surgeons' visibility during complex procedures. The surgeons having a greater knowledge of the operating area, leads to fewer errors. This application can also be used for trainees. It allows practice on a surgical area prior to a real patient. Furthermore, AR has been used to give surgeons information about the position of internal organs and the adjustments needed for needle biopsy. This can prevent curiosity to

where things could be in the patient. This can also lead to a faster procedure as surgeons can study these scans better to create a better plan.

Not only can AR be used in surgical procedures, it can also be used within dentistry. Dentists can study the teeth bone structure prior to their work. It allows them to simulate their dental treatment beforehand leading to a better result.

RESULT

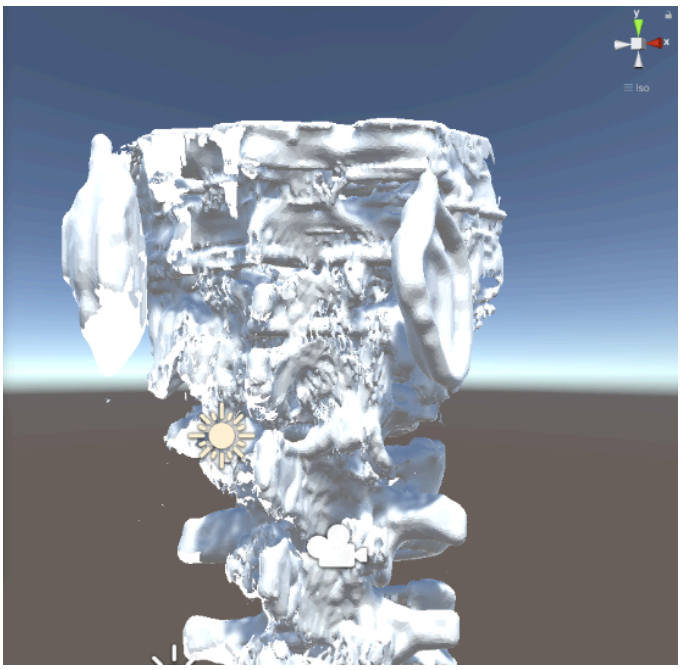
The project's results show that it was a success, the solution through using the implementation of TotalSegmentator into 3D Slicer allowed the CT scan to be in a 3D format. It has the capability to effectively create automated generation of precise anatomical



models. This QR code to the right, shows a video which is a demonstration of how the bone will look in the lenses. It shows that the spine can be moved around by the touch of a hand. It can be rotated around and pinched to become smaller or bigger as well. All these changes are happening in real time. This demonstrates how these glasses can be worn during surgery too. The device still allows users to have view of the surroundings which permits the surgeon to still be focused on the patient during the procedure.

CONCLUSION

The hypothesis, a software solution can be effectively utilized to enable the automated generation of precise anatomical models for augmented reality visualization using bone CT scans, is accepted. The data that has been provided shows that the transformation of the CT scan has successfully become a 3D file that is compatible with augmented reality devices.



FUTURE DIRECTION

These results were very encouraging. For a future direction, the scans can be focused more on a specific specialty. If a specific specialty is chosen, the software could become perfected since it would focus on one section of the body. There could possibly be a collaboration with someone in an OR to test it out as well.

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CT scans are provided from Penn Medicine Laboratory for Structural Physiologic and Functional Imaging through Chamith Rajapakse