DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

By: Cole Everson, Seinan Mandokhail and Colin MacQuarrie

For: Department of Surgery
Sponsor: Michael Dunbar

Department of Electrical Engineering

Bone Loss Volume Scanner

What is the Problem?

Replacement Knee Prosthesis Surgery entails replacing the knee prosthesis with a new one. This is done because the previous prosthesis was infected, did not function correctly or there was more breakdown of the knee. The Surgeons open the patient's knee then cut out the old prosthesis and then replace it with a new one. When the old prosthesis is removed there is still bone attached to it, making the patient lose bone volume. This bone volume loss needs to be counteracted by the surgeons. Thus, there is a need for a device that can quickly preform the volume calculations and give the shape of the removed bone.

Bone loss

XYZ Scanner

Design Process

Initially the XYZ scanner requires to be plugged in via 3.0 USB connection. Once the connection is established, the provided XYZ scanner handy software and intel SR300 camera drivers can be installed. The user is then able to see live video from the scanner via the XYZ scanner handy software. It's important for the scanner to lock on to the targeted object to avoid any sort of glitches and errors or to lose sight of the object. It is possible to manually go around the object while scanning however depending on size, for smaller objects it's best to use a spinning device for best scans. Finally, the object is reviewed in XYZ scanner handy software and any non-essential objects or errors are removed, and the object cad file is exported. Once the object file is obtained, it needs to be analyzed via 3D imaging software. 3D viewer is also a good program for quick reference back to the original file. For data analysis we investigated several different options and we found that Inventor met our requirements the best. The goal here is to measure bone loss from the removal of the inserted prosthesis. For the most accurate results a scan of the bone before damage is done is required. This scan would simply be kept on file in the case a revision is needed. Then when performing the revision surgery, once the affected area is taken care of and the original implant is out, the physician will scan the bone again. The two files are then imported into Inventor and are used to create an assembly. This allows for the bones to be overlapped and the damaged bone will be subtracted from the original scan and results in a model and volume of the bone lost due to the procedure. We realize that this process will only work for people who have not yet had either of the procedures done. What about obtaining a model with one scan? We can do this by inserting a typical full bone scan or a model that covers the affected area and overlapping them, resulting in the negative space model and calculating the volume. All three scans can be seen to the right.

Details of Design

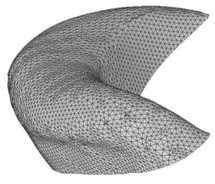
The XYZ scanner comprises three sensors, first the RGB camera which is essentially a colour camera. The second are two infrared projectors which emits infrared light, and the third is two infrared cameras which are capturing depth. The RGB camera combined with infrared projector light allows the camera to see in dark or low light areas. The object CAD file is created by a combination of data from all three sensors, which includes texture, colour, shape, size, length and geometry details. What is essential to understand about the XYZ scanner is its assignment of coordinates to an object based on geometry which allows it to track the object while it is scanning the object in 360 degrees. Basically, it creates a frame of references, however this sort of method does not work for round or spherical objects because according to the frame of reference created the scanner is not moving. Other than a perfect sphere or cylinder objects, the scanner work great. The XYZ scanner can be seen in a picture below.

Scan of Bone and Steak

Scan of Bone and Fake Blood

Scan of Bone Before Cut

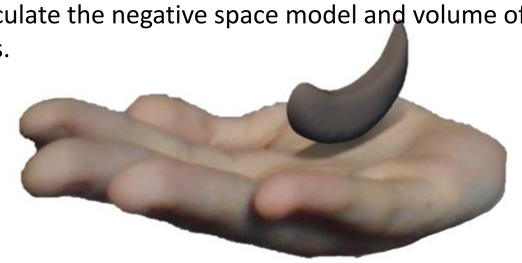
Scan of Bone After Cut



Model of Negative Space

Conclusion

With a variety of tests such as, geometry, colour, light level, texture, hole, accuracy and bone. We can conclude the following, the scanner can scan any geometry besides, perfect spheres and cylinders, can scan all colours but has trouble with accuracy with dark black, can scan in bright and dim environments, can scan flesh, fat and blood covered objects as seen in the pictures to the left, can scan holes depending on the diameter and depth, if the diameter is small (>1cm) then the depth needs to be small as well. The scanner has a volume % error of 2.18%, which is a typical difference of 1.844cm^3 when scanning different geometry's, and for the bone test we got a % error of 5.14%, which was a difference of 0.55cm^3. With the information and knowledge, we have now we know that in order to make this method more accurate a $300 scanner is not enough, and in order to proceed with a design that is more accurate a higher-grade scanner is required. But even with a new scanner our method would work for getting the negative space model and volume of a cut bone. As seen below, our method also can be easily put in virtual reality. In conclusion our project found a method to find and calculate the negative space model and volume of bone loss.



VR Model of Negative Space on Hand

References

Chung-Kay Choi, A. (2015, July 2). *2D/3D image scanning and compositing*. Google Patients. https://patents.google.com/patent/US9786080?oq=photo+3d+scanning

Liu, Y. (2005, May 27). *High speed 3D scanner and uses thereof*. Google Patent. https://patents.google.com/patent/US20060269896?oq=3d+laser+scanning

Migdal, A. (1996, July 12). *Portable 3-D scanning system and method for rapid shape digitizing and adaptive mesh generation*. Google Patent. https://patents.google.com/patent/US5870220?oq=3d+laser+scanning

何. (2016, April 30). *3D laser scanner based on unknown environment detection*. Google Patents. https://patents.google.com/patent/CN105953742A/en?oq=3d+laser+scanning

(n.d.). Retrieved December 07, 2020, from https://www.xyzprinting.com/en/product/3d-scanner-2-0

Bongartz, G. M. (2015, March 3). *3d scanning device and method for determining a digital 3d-representation of a person*. Google Patents. https://patents.google.com/patent/EP3064894A1/en?oq=photo+3d+scanning