Ultrasound 3D Tomography

Huining Liu (EE), Xinyi Liu (EE), Ziqi Ding (CpE), Zhengyi Zhu (CpE), Zhi Luo (EE)
Advisor: Prof. William C. Tang, Dr. Andrew Browne,
Department of Electrical Engineering and Computer Science

Background & Goal

Ultrasound technology is currently being used to visualize the interior structure of the eye for locating abnormalities. However, there are few products on the market that can create a three-dimensional model of the patients' eye to diagnose intraocular diseases.

We are aiming to create a device that allows for the patient and physician to visualize and locate any abnormalities through a three-dimensional model of the patient's own eye. A probe case will be designed and created to help rotating the probe 180 degree. A raspberry pi camera will be used to take pictures of the B-scan video and transfer them to the laptop. Those pictures will be further processed to create a 3D eye model.

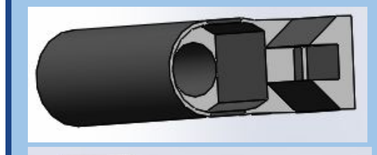
Challenges

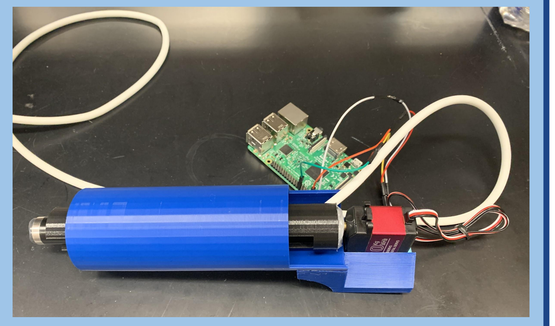
The ultrasound machine we used only provides low resolution B-scan images and the eye muscles are hard to recognize because of blurry boarders. This makes further analysis and processing of the images difficult and may increases the possibility of failure when building 3D models of the eyes.

Hardware Implementation

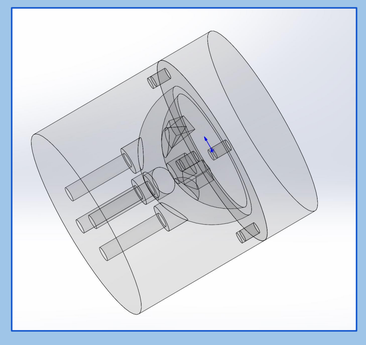
Images acquisition with automatic probe rotation

The 3D-printed probe case will automatically rotate the ultrasound probe for 180 degrees in order to collect clear B-scan images. A servo motor is placed on the case and it is connected to the inner shell of the case to rotate the probe. A Raspberry pi camera is used to capture B-scan image from the ultrasound machine screen and it is controlled by a Raspberry pi to sycronize the camera with the rotation of the servo motor.





Phantom



The phantom is used to simulate an eye ball and it will be made by injecting PDMS material into a 3D printed mold [1]. The features of the phantom can be detected by the ultrasound scan and the B-scan images of the phantom will be collected and further processed to build a 3D model.

Reference

[1] D. B. Weibel, W.R. DiLuzo and G.M. Whitesides, Microfabrication meets microbiology, Nature Rev. Microbiol. (2007), Vol. 5, No.3, pp. 208-218.

Software Implementation

We are using a open-source software called 'elastix' to quickly configure, test, and compare different registration methods for 2D ultrasound images and moreover buliding 3D models. The algorithm inside is based on the well-known Insight Segmentation and Registration Toolkit (ITK). We will later add the part of interpolation algorithm in polar coordinates in the source codes of the elastix in order to create the model for human's eyeball.

Timeline

Week 1-5: Finished redesigning of the case and completed testing and programming of the Raspberry Pi and camera.
Week 6-10: Designed and 3D printed the phantom mold.Assembled parts and completed testing and trouble shooting of the hardware circuit. Analyzed the component(color, bio struct, etc) of 2D ultrasound images and coded to assemble those images into a 3D model.

Future Work(Winter 2019)

Week 1-5: Collect data from actual eyeballs and optimize clip case for simpler assembly. Make the design more user friendly by adding more features to the design such as a switch.
Week 6-10: Combine different 3D models from different angles for a less distored model. Complete the algorithem of polar coordinate interpolation.

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