Ultrasound 3D Tomography

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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 patient's' 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 borders. This makes further analysis and processing of the images difficult and may increases the possibility of failure when building 3D models of the eyes.

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.

[2] Maysam Shahedi (2020). imshow3D (https://www.mathworks.com/matlabcentral/fileexchange/41334-imshow3d), MATLAB Central File Exchange. Retrieved January 27, 2020.

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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 synchronize the camera with the rotation of the servo motor.

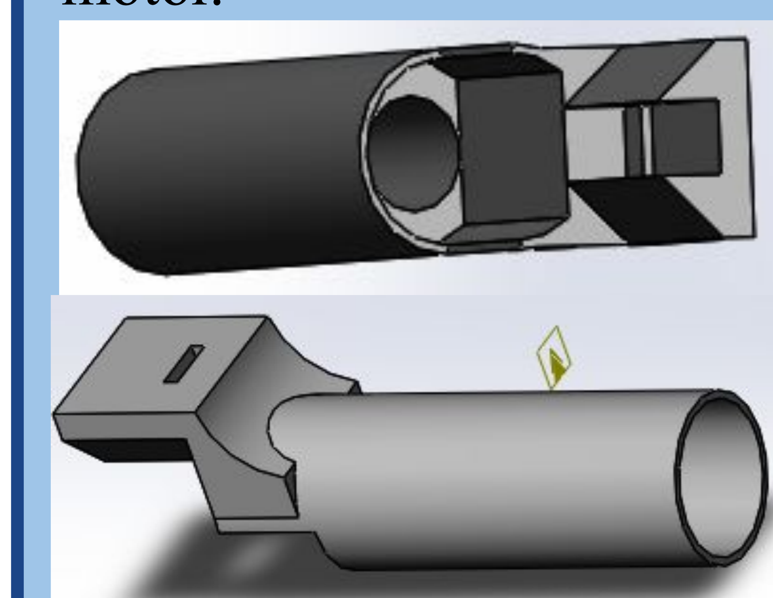

Fig.1: Model of probe case

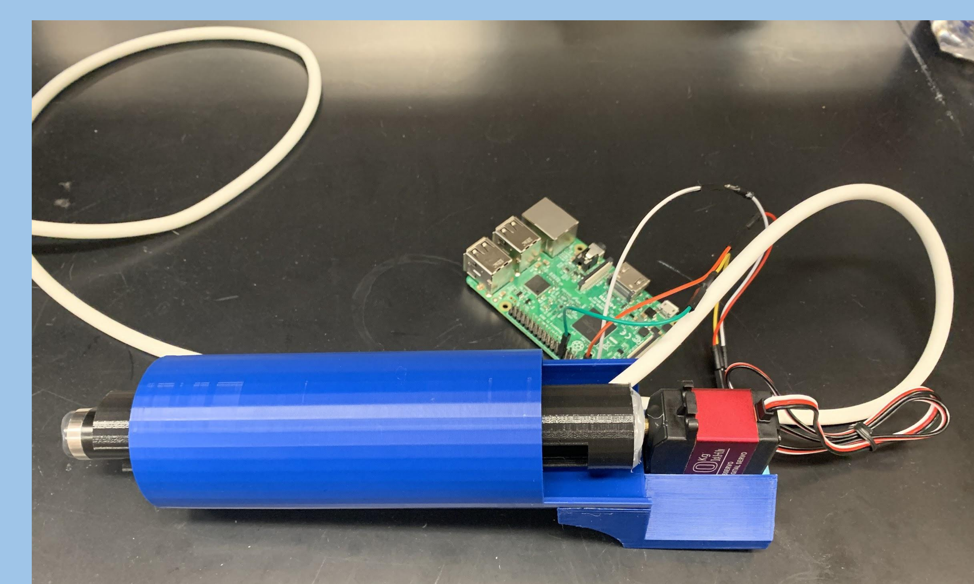

Fig. 2: 3D-printed probe case

Phantom

The phantom is used to simulate an eyeball and it will be made by injecting PDMS material into a 3D printed mold [1]. The features on 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. The acquired 3D model will be compared with the SolidWorks model of the phantom to calibrate and optimize the Matlab program for 3D modeling.

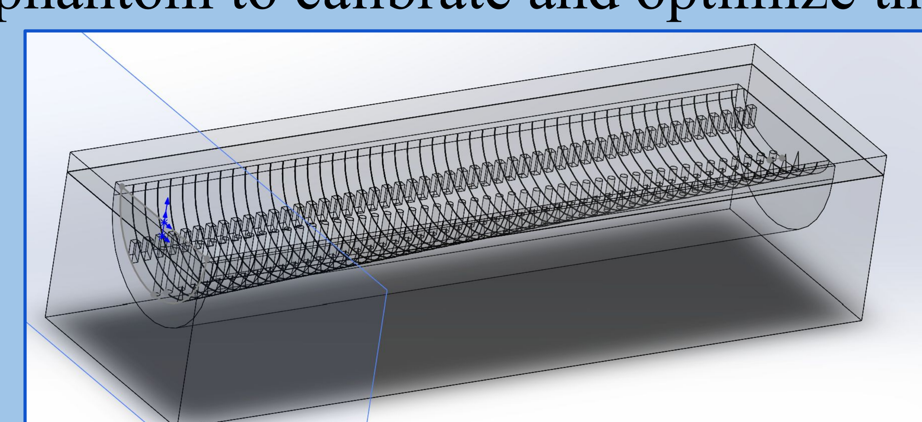

Fig.3: SolidWorks model of phantom mold

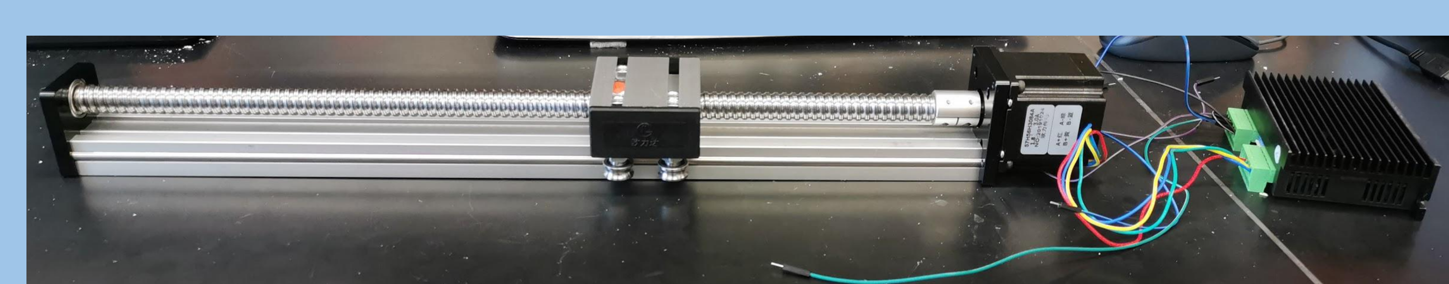

Fig. 4: Linear actuator used to scan the phantom

Software Implementation

3D Model Generation

In 2D-to-3D phase, with the input of around 80 2D ultrasound images, the relevant MATLAB codes was written and implemented to generate a viewable 3D model volume. The core algorithm inside is the 'images interpolation' and '3D Model Visualization [2]' in Fig. 5.

3D Model Optimization

In 3D-to-3D optimization phase, an open-source software called 'elastix' is used to quickly configure, test, and compare different registration methods for 3D ultrasound model images and moreover combining them. After this, the quality of 3D model volume would be enhanced much more than before. The algorithm inside is based on the well-known Insight Segmentation and Registration Toolkit (ITK).

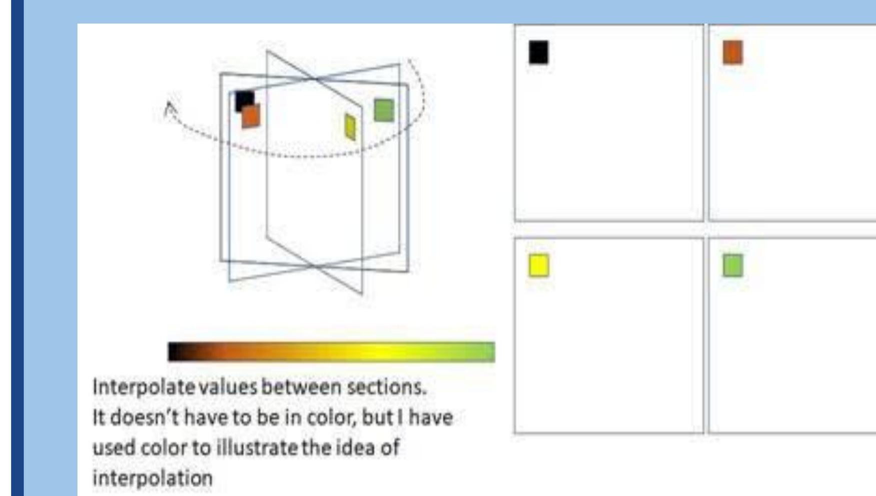

Fig.5: Images Interpolation

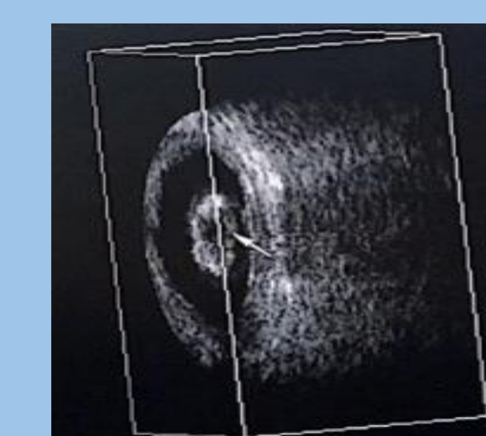

Fig.6: Final 3D Model Sample

Milestones

Hardware

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: Complete final assembly and testing with completed software program.

Software

Week 1-5: Complete the algorithm of polar coordinate interpolation. Be able to use MATLAB codes to generate the simple 3D model (sphere). Combine the phantom linear testing images together.

Week 6-10: Combine different 3D models from different angles for a less distorted model. Complete the algorithm of polar coordinate interpolation.