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FACULTY OF ENGINEERING

Electrical Engineering Group 6:

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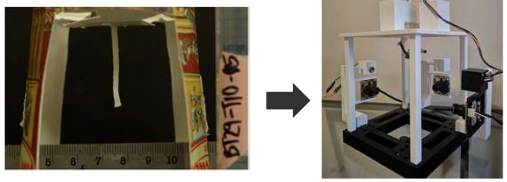
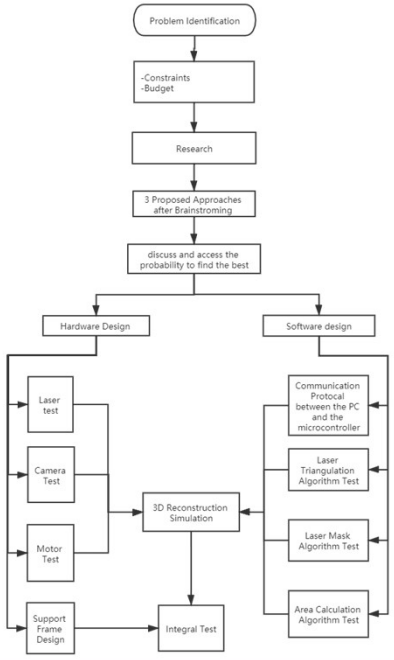
Cross-sectional Area Analyzer for Soft Tissue Samples

Introduction

The team from Veres Lab is studying the behaviour of tendons, specifically, the stress of tendons; it is essential to come up with a method to analyze the cross-sectional area of tendons. The tricky part of the technique is that physical contact with the tendons will introduce accuracy problems since tendons are soft. The current approach is to analyze images taken on different angles and calculate the area using the ellipse area equation at each level. The method we proposed is to use laser triangulation and 3D reconstruction to improve the accuracy and scan the entire tendon sample.



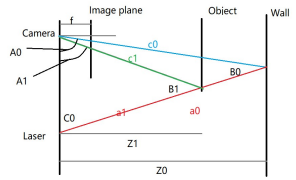
Design Process

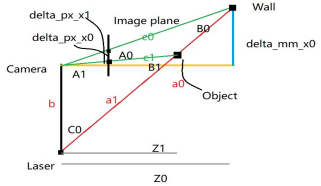


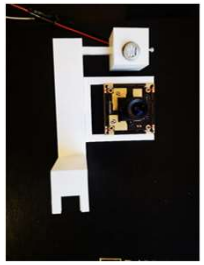
Details of Design

Laser Triangulation Algorithm

Main Idea: use camera focal length and pixel coordinate to evaluate the distance from laser point to camera plane.

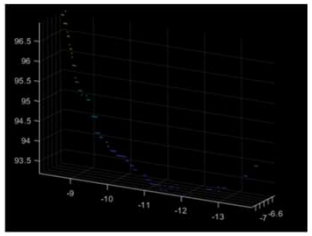


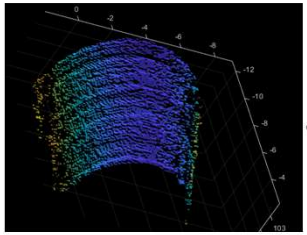




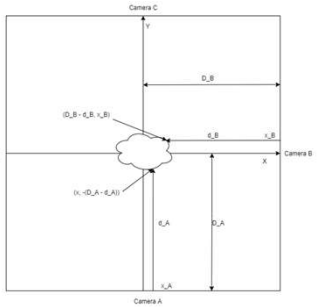
3D reconstruction:

Based on the calculated point from each camera, convert the points to a global coordinate and produce a point.



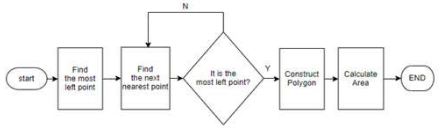


Global coordinate conversion:



Cross-Sectional Area Calculation:

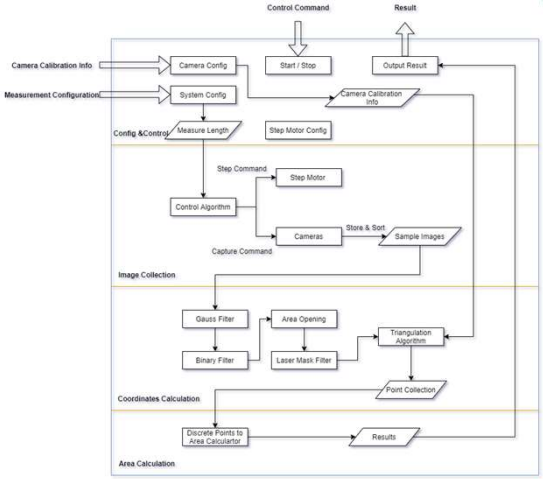
After point cloud of sample is generated. separating points to groups based on their z-axis location is the first step of area calculation. For each group, applied the area calculation algorithm showed below on flow chart.



Control Strategy

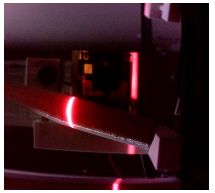
In summary, the system software can be divided into four layers; config & control layer, image collection layer, coordinate calculation layer, and area calculation layer.

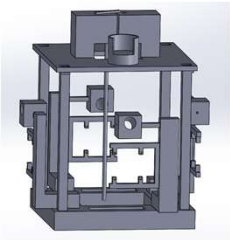
The camera are controlled via USB and OpenCV library; the lasers and step motor are controlled using microcontroller, which communicating with computer using serial port. All algorithms are implemented using C++, the used just need to drag and drop the system configuration data and the program will scan sample automatically.

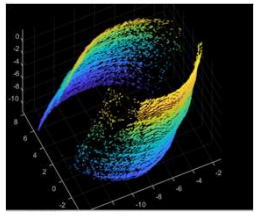


Conclusion & Recommendations

- **Results**
- Product frame design
- 3D Reconstruction from 2 cameras
- Basic algorithm verified
- Control software developed







- **Analysis**
- The result shows that the surface feature can be detected by the laser triangulation and the algorithm can provide enough 3D points for calculating the cross-sectional area.
- For a fully functional product, 4 cameras should all be used for collecting data points.
- The time it takes to complete a full scan can be controlled under 10 min.

- **Future Steps**
- Complete prototype with 4 camera
- Calibrate camera position to improve accuracy
- Optimize C++ algorithm and control program
- Optimize hardware configuration, eg camera and tendon sample holder

References

Alex Hayes, Katrina Easton, Pavan Teja Devanaboyina, Jian-Ping Wu, Thomas Brett Kirk and David Lloyd(2019). *A review of methods to measure tendon Dimensions. From* Journal of Orthopaedic Surgery and Research.