Ultrasound Imaging of Flexor Muscles for Finger Motion Tracking

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Background

During a surgical procedure, it is often helpful to evaluate the surgeon's technical abilities by observing the movements of their hands, allowing experts to identify techniques that improve an operation's chances of success. Computer vision algorithms have been used to track the positions of the hands but become less effective when encountering poor lighting or obstructions

The flexor digitorum tendons, located in the wrist, cause the index, middle, ring, and small fingers to flex. Using ultrasound imaging, the muscles attached to these tendons can be seen contracting when the fingers are curled, potentially allowing a computer program to calculate the position of the finger based on the width of the muscle at any point in time. By placing an ultrasound device on a surgeon's wrist, it would be possible to track the fingers with no dependence on lighting or obstruction conditions.

Purpose of Study

We propose a method of determining the positions of the index finger by using ultrasound to monitor the contraction and relaxation of the flexor digitorum superficialis

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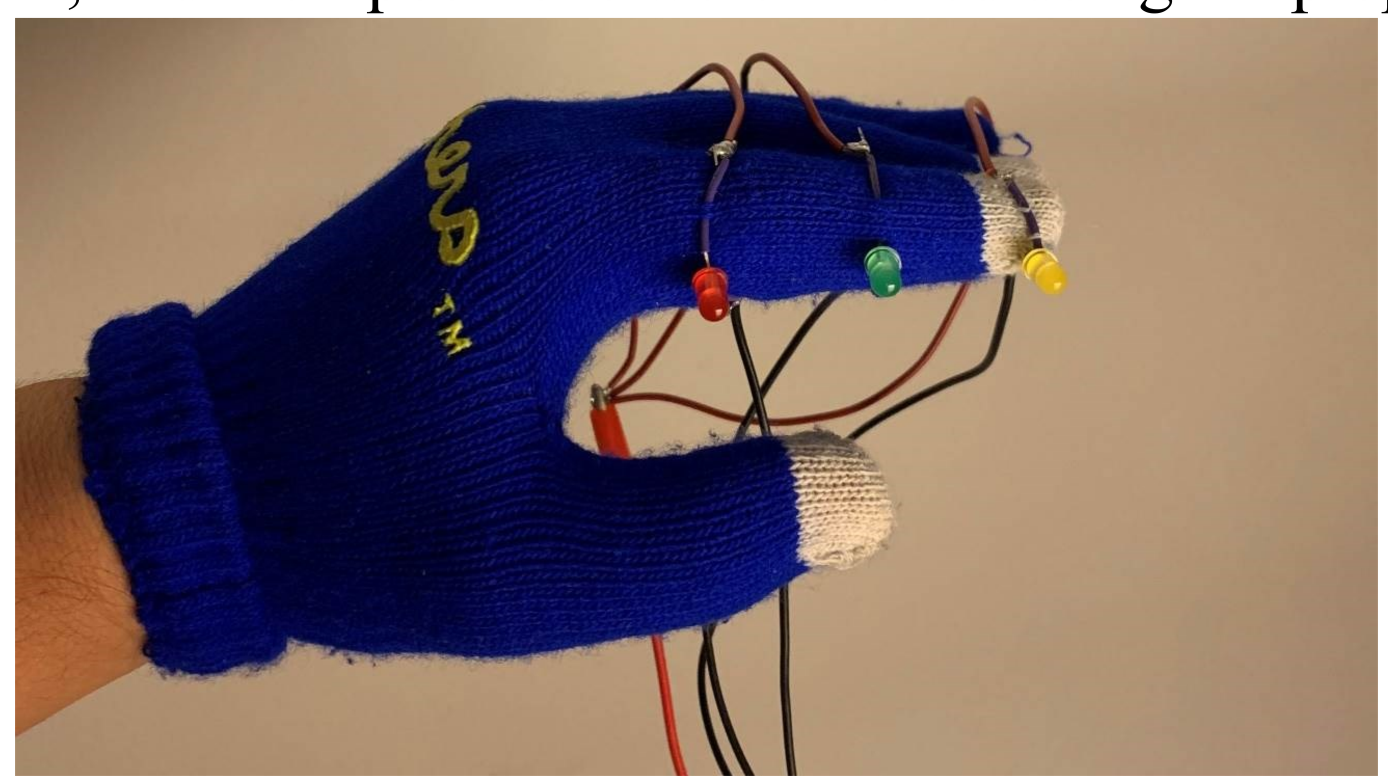
Methods

Imaging of the flexor tendons was accomplished using a Terason t3000 ultrasound system, which provided a real-time video feed from an ultrasound transducer imaging the wrist. The motion of the index finger was tracked to create a ground truth by means of three LEDs attached to the index finger. The LEDs were placed at the center of each phalanx, and their positions were tracked using a laptop webcam.

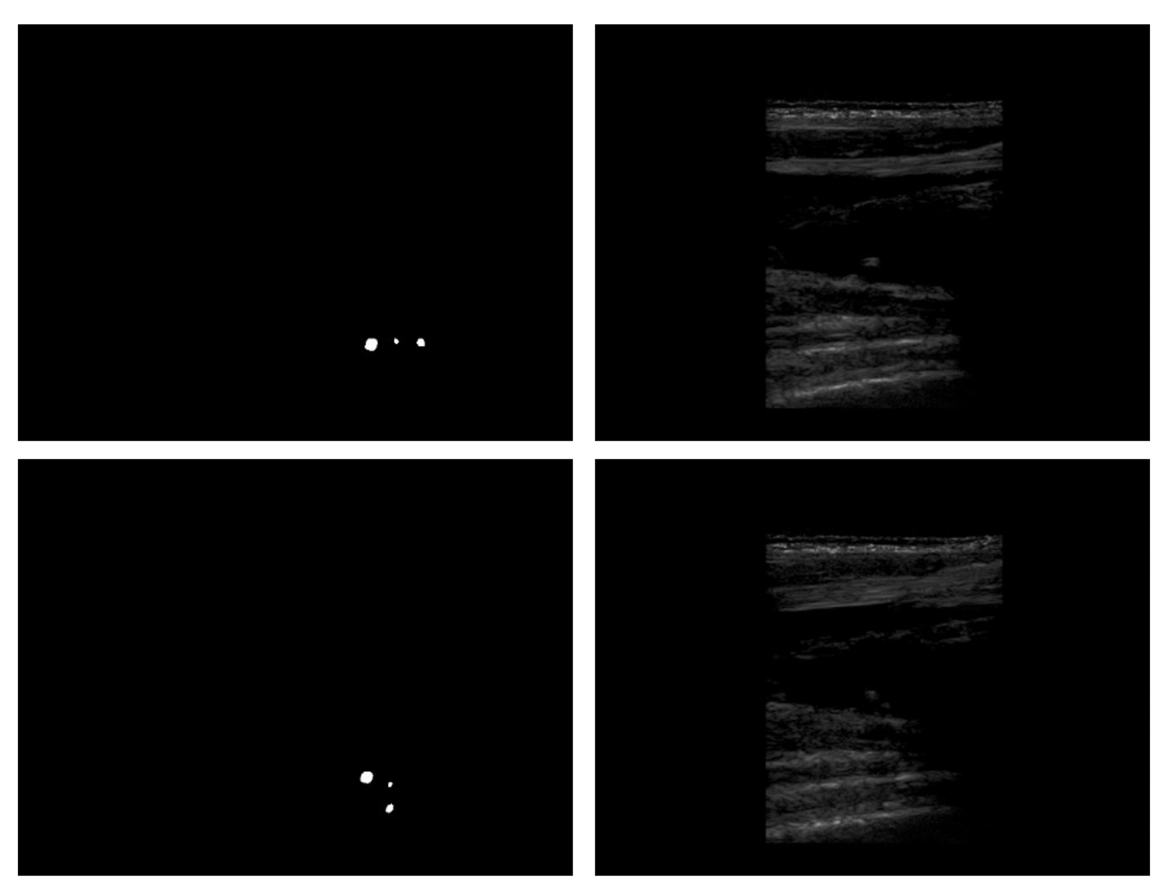


OpenCV was used to capture video frames from both the Terason and the webcam, creating two concurrent video recordings in which the index finger was repeatedly flexed and extended. The videos were recorded for 89 frames. For each ultrasound frame, the flexor tendon was identified, and the width of the muscle was recorded. In each frame of the webcam video, the position of each LED was determined, and the angle between them was calculated.

Webcam image *Ultrasound image*

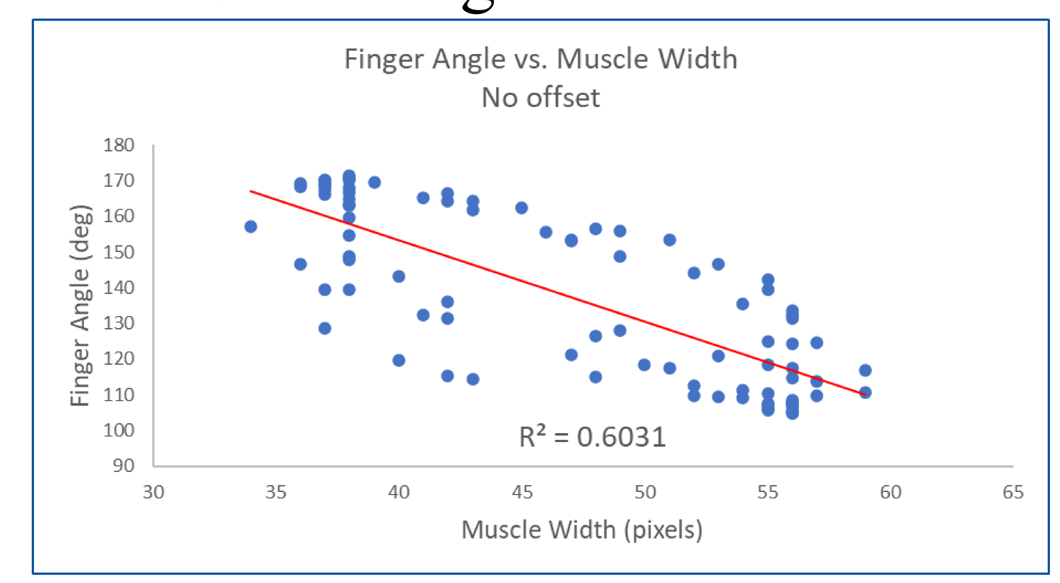
Finger extended

Finger flexed

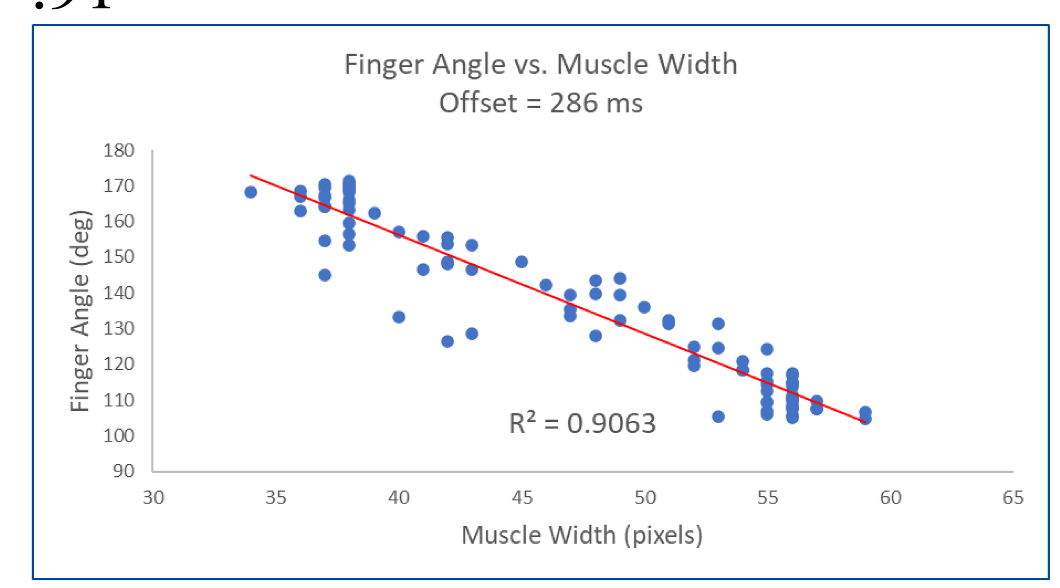


Results

A negative correlation can be seen. The scatter plot also suggests a significant lag between the movement of the tendon and the movement of the finger.



After offsetting the data by 286 milliseconds, $R^2 = .91$



Conclusions

These results suggest that it may be possible to determine the position of a finger using only ultrasound imaging of the muscles in the wrist. We are encouraged to identify and prevent causes of lag. We are currently developing machine learning methods to more accurately predict finger position from ultrasound image sequences.

Acknowledgements

Funding was provided by the Swanson School of Engineering, the Center for Medical Innovation at the University of Pittsburgh, the Office of the Provost, and the Department of Bioengineering.