Determination of static and dynamic properties of muscle from SHG sarcomere images
EE368 Project Proposal
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Introduction
Sarcomeres are the basic contractile unit of muscle. They consist of alternating myosin and actin protein filaments, and the length of sarcomeres, measured as the distance between the middle of two actin filaments, highly influences the amount of force a muscle can produce. Recently, in vivo sarcomere images have been recorded via Second Harmonic Generation (SHG) microendoscopy[1], [2]. The method measures an intrinsic signal resulting from the interaction of laser light and myosin filaments by means of second harmonic generation. An image is produced as the laser scans an area of the muscle.

There are two kinds of images collected, static images, where a 2D area is scanned, as well as line scan dynamic images, where one line is scanned repeatedly as the muscle is electrically stimulated in order to measure the displacement of features over time in response to a stimulus.

In the static images, we are interested in measuring the sarcomere lengths, while in the dynamic images, we are interested in fitting the response to an exponential equation[3] in order to extract the contraction and half relaxation times of muscle motor units. Because of the repetitive banding of sarcomeres, static images are easy to process with Fourier Transforms in images with strong signal. However, often the images have low signal and high noise, and other structures such as collagen also produce an SHG signal in the image, making the current algorithm unsuitable on those images. The dynamic images are currently fit to the exponential by tracing out the path by hand.

Goals:
This project will improve and speed up the processing of sarcomere images. Specifically, I will automatically determine the average sarcomere lengths of fibers in a sarcomere image, and automatically determine the time characteristics from curves in dynamic line scans.

Milestones:
Static Images:
1. Develop automatic 2D notch filter to reduce overall noise in image
2. Develop way to crop image so only areas with sarcomeres remain
3. Rotate the image so that the fiber axis is aligned
4. Measure sarcomere lengths using FFT in individual muscle fibers

Dynamic Images:
1. Apply median filter to reduce noise
2. Edge detection of the twitch trace
3. Pick one of the detected edges and fit it to the twitch equation.
Alternatively if edge detection is not adequate, a generalized Hough transform [4] for parametric curve detection, or shape extraction similar to described by [5] may also be used.

An android device will not be used.

References


