True Posture

Sponsored by Alcon-TrueVision

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Project Description

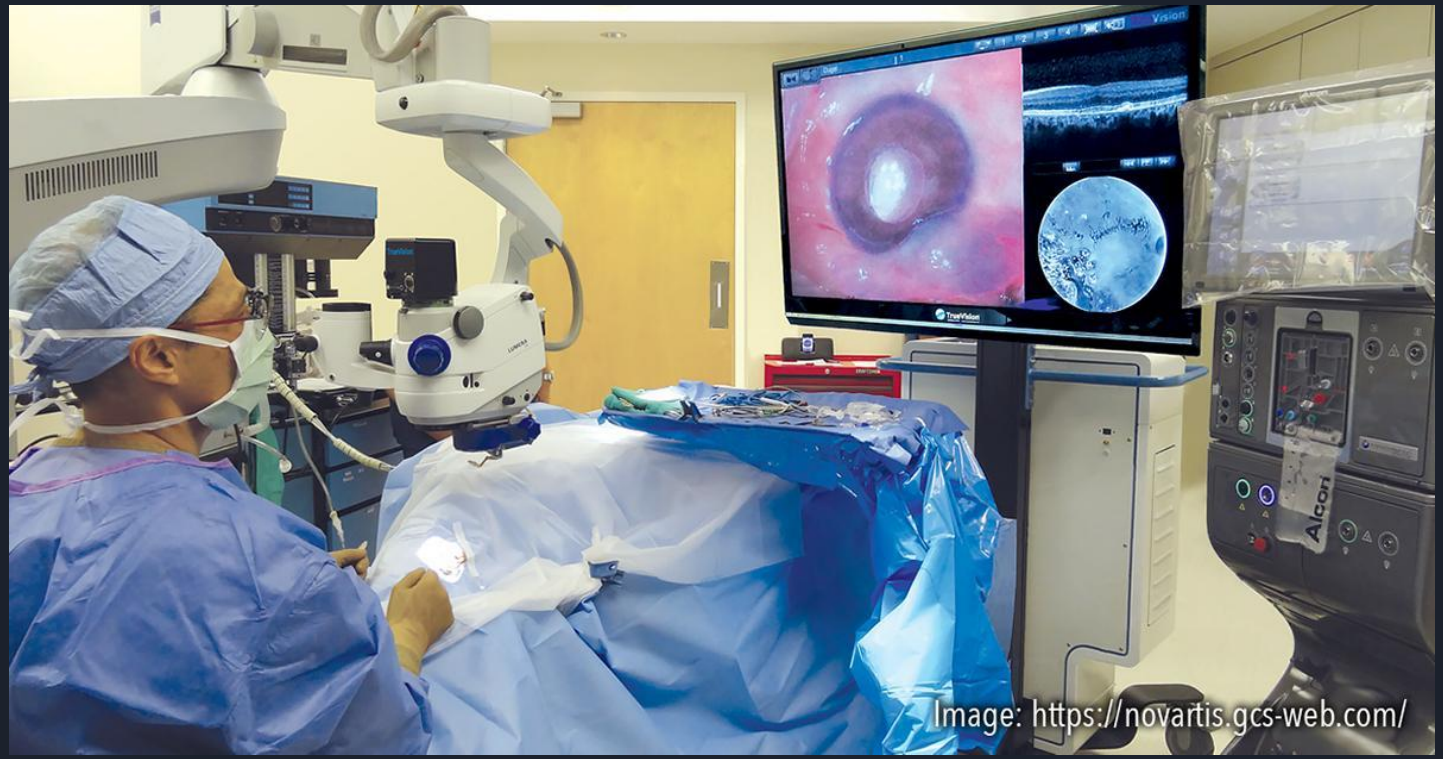
Alcon TrueVision invented the innovative heads-up heads-up, three-dimensional imaging technology to assist in microsurgeries. Traditionally, surgeons have to do microsurgeries in a hunched posture because they need to look closely into the microscope.

The goal of this project is to quantify the muscle fatigue level difference between the two postures of hunch and heads-up by capturing EMG signals from back and neck muscles.

Traditional Microsurgery

http://thetelityellowpages.com/listing/vijaynagaraj-superspeciality-eye-hospital/

NgeNuity 3D Visualization System for Digitally Assisted Vitreoretinal surgery from Alcon TrueVision

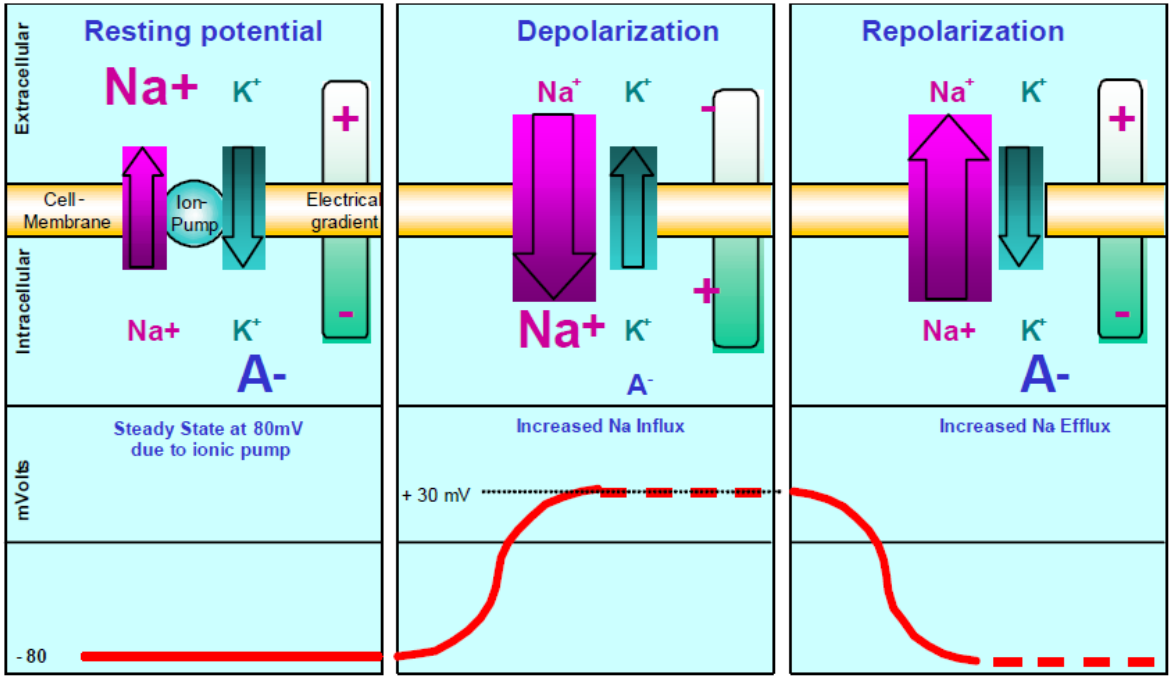


EMG Signal Origin

Semi-permeable Membrane

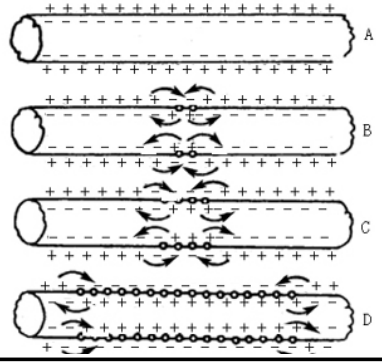
An ionic difference between the inner and outer spaces of a muscle cell forms a **resting potential** at the fiber membrane (approximately -80 to -90 mV).

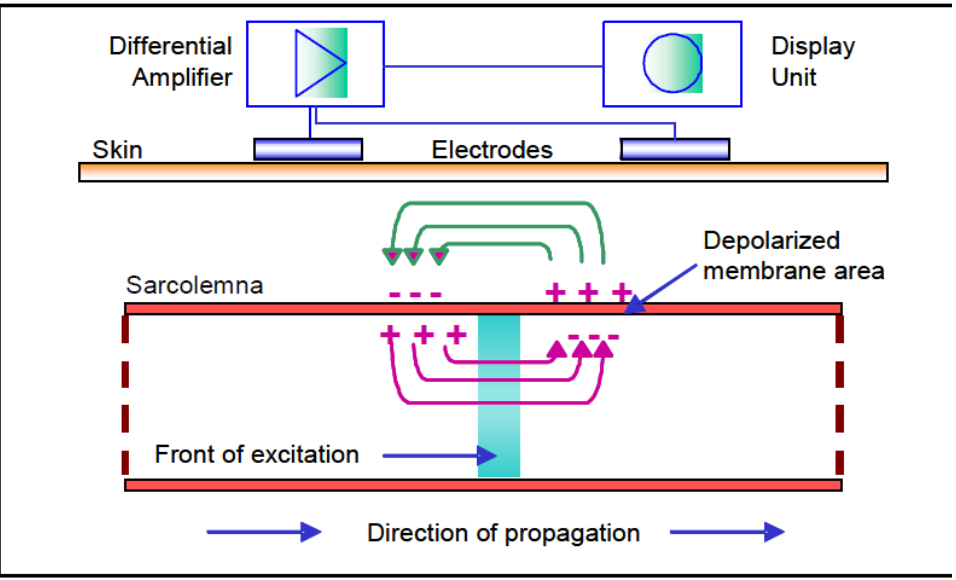
This difference in potential, maintained by ion pump, results in a negative intracellular charge compared to the external surface.

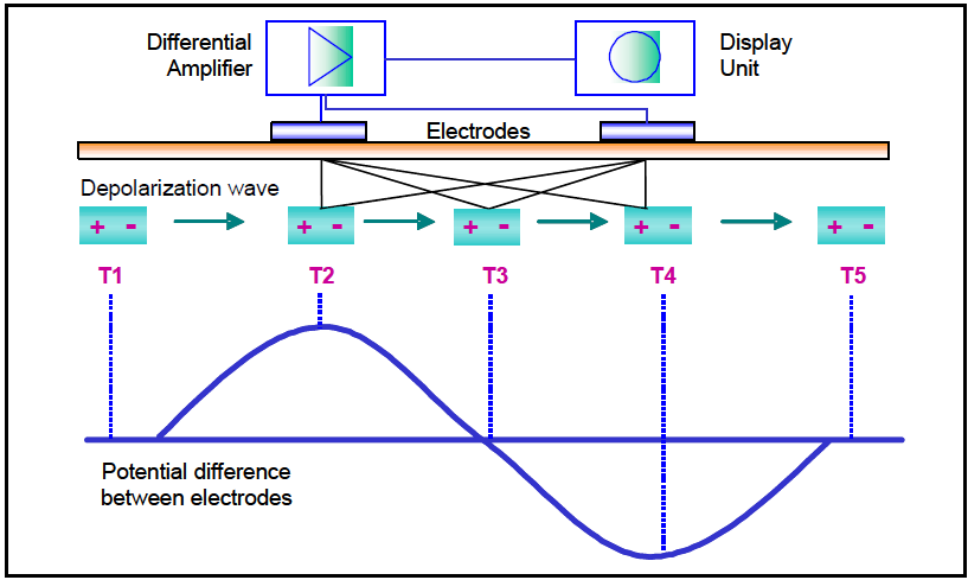


Depolarization and repolarization cycle within excitable membranes

Signal Propagation







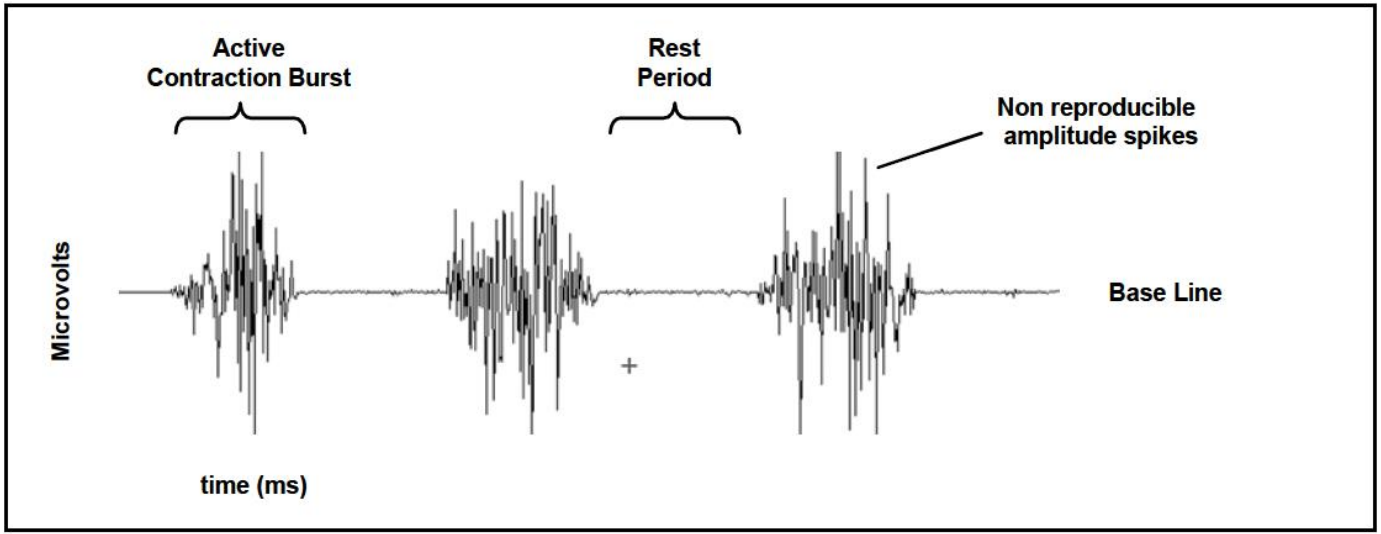
Left. Depolarization zone on muscle fiber. muscle fiber membrane

Right. Wandering electrical depole on

Raw EMG Signal Sample

An unfiltered and unprocessed signal detecting the superposed motor unit action potentials is called a raw EMG signal.

Raw sEMG can range between +/- 5000 mV and typically the frequency contents ranges between 6 and 500 Hz, showing most frequency power between ~ 20 and 150 Hz.



The Raw EMG recording of 3 contractions bursts.

Muscle Fatigue

Due to recruitment of motor units, the amplitude shows an increase, whereas the frequency based mean or median frequency of the total power spectrum show a decrease over contraction time.

The latter ones decline because, besides other reasons, the conduction velocity of the motor actions potentials on the muscle membrane decreases.

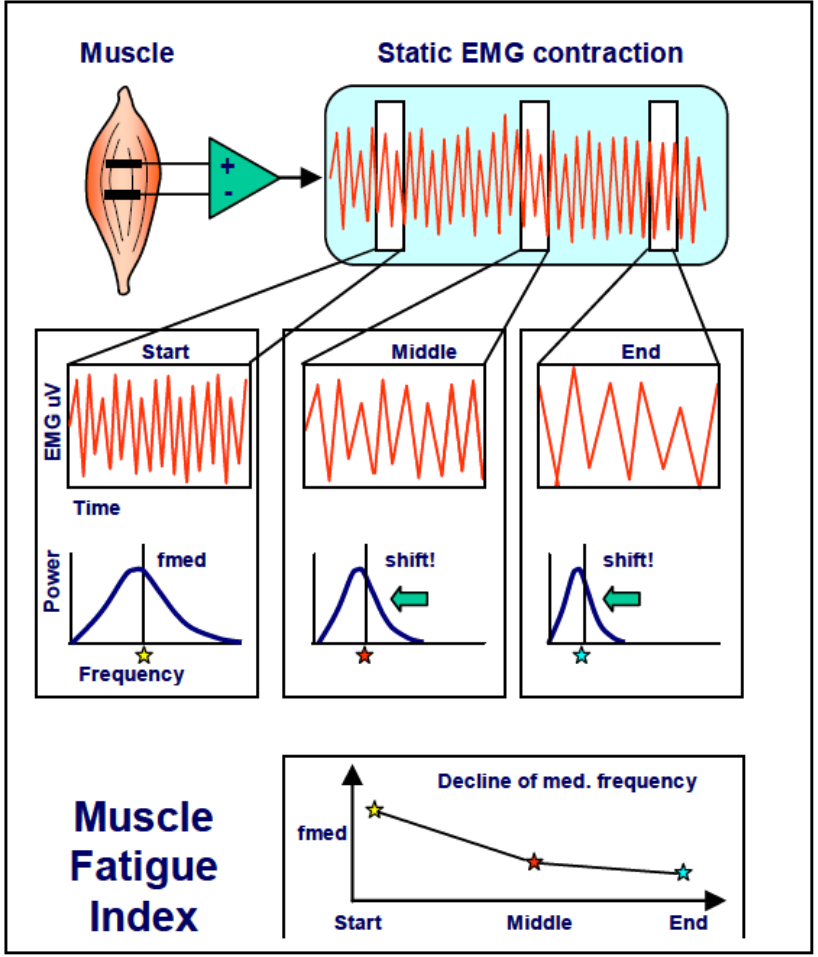
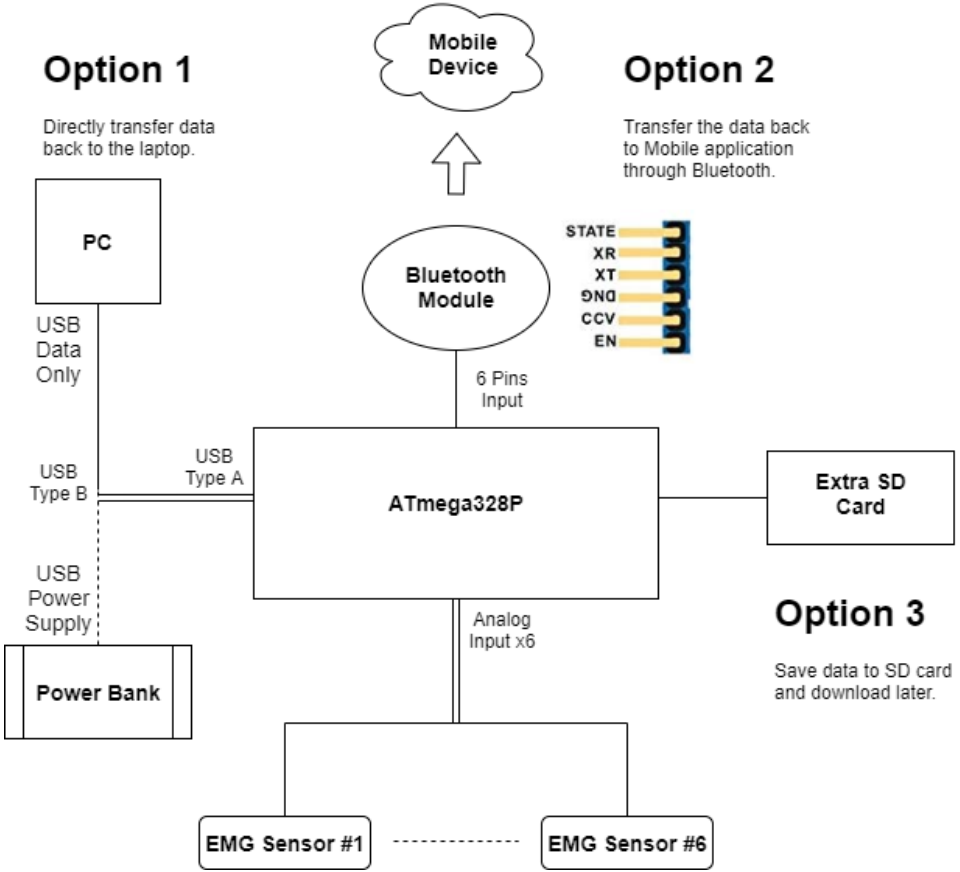


Fig. 77: Schematic illustration of the frequency shift towards lower frequencies in sustained contractions and calculation of the muscle fatigue index. Adopted and redrawn from De Luca

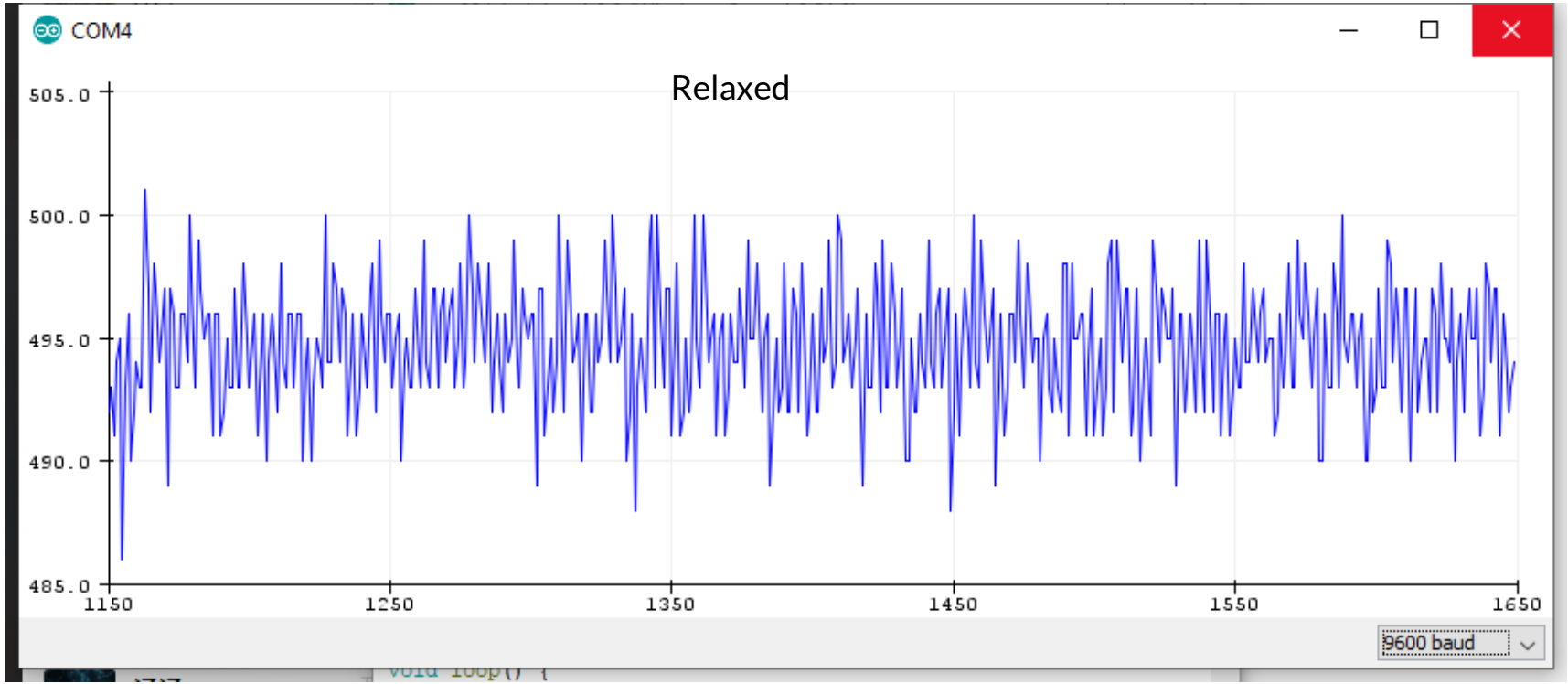
Circuit Block Diagram



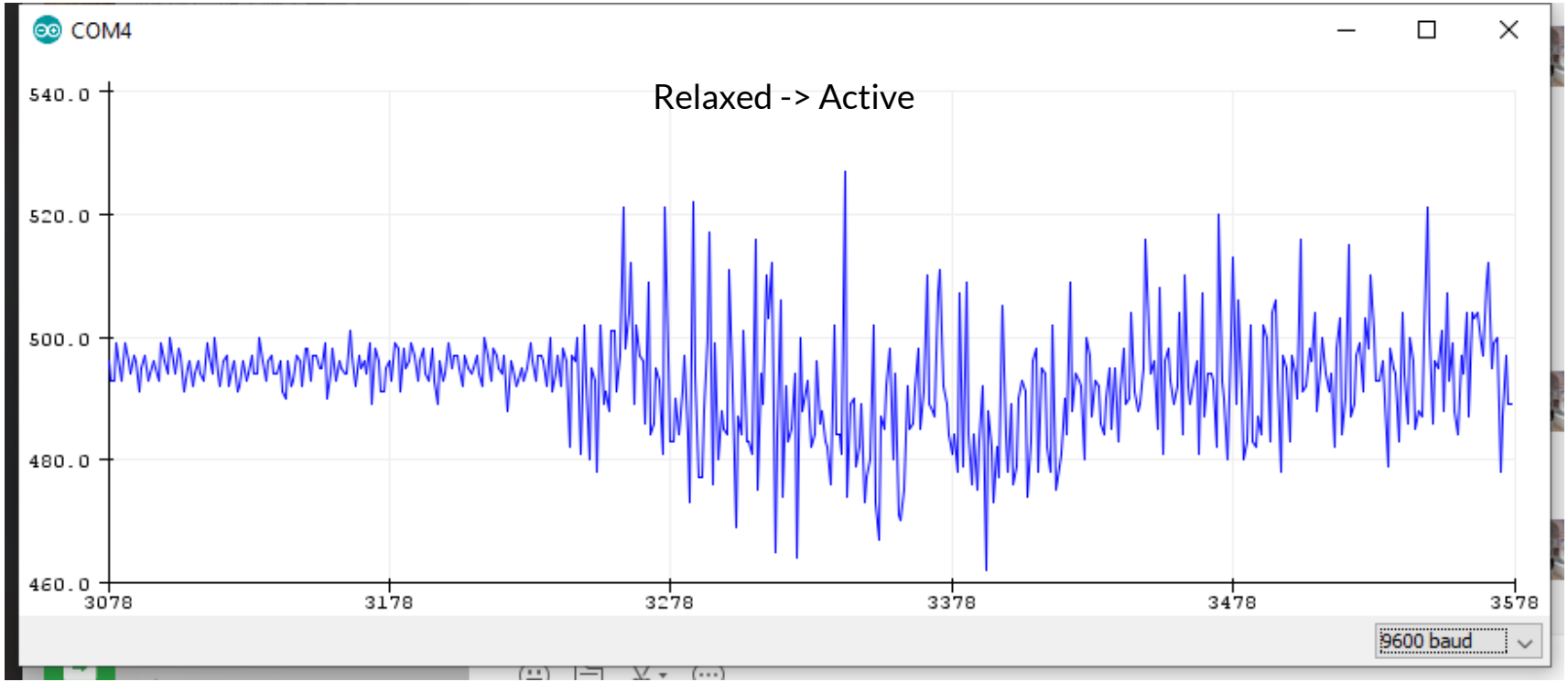
Circuit takes USB power bank as the power supply.

Three options to collect EMG signals.

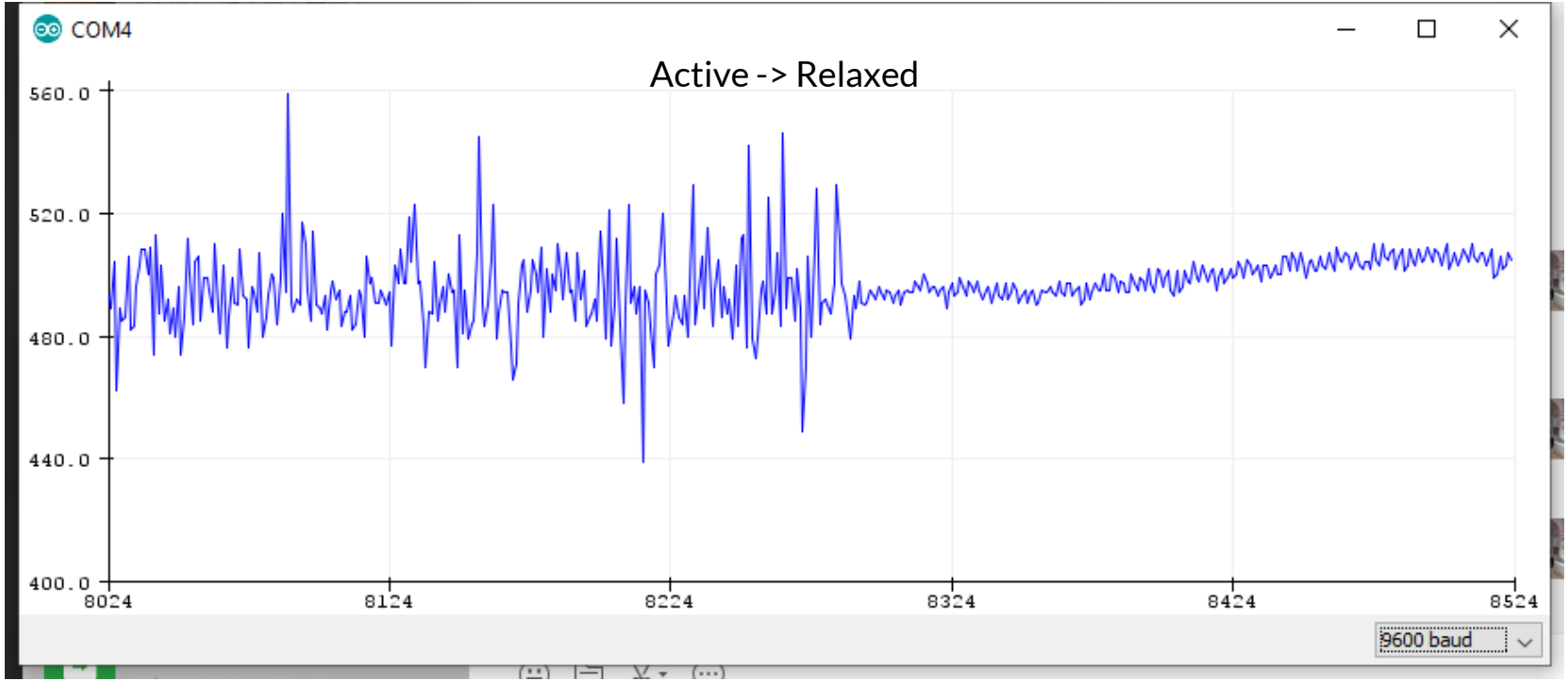
Sample Signal (Raw)



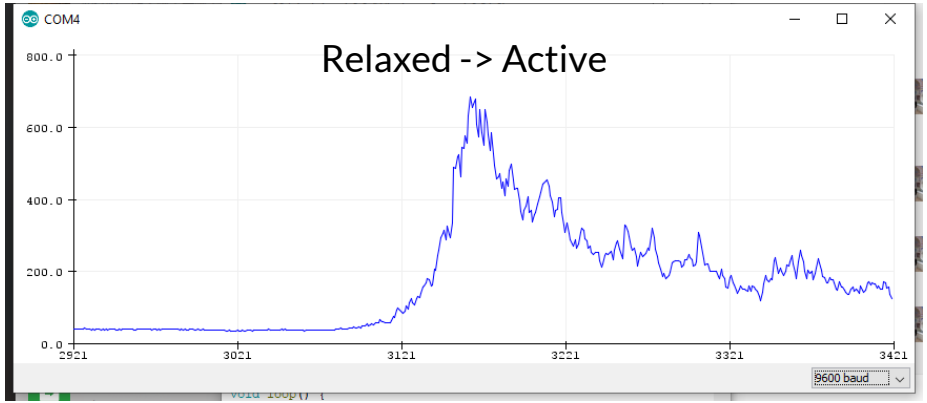
Sample Signal (Raw)

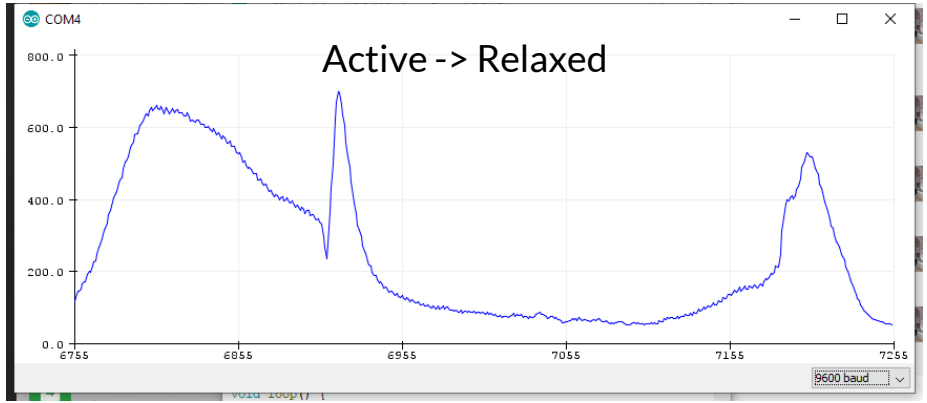


Sample Signal (Raw)



Sample Signal (Rectified & Integrated)



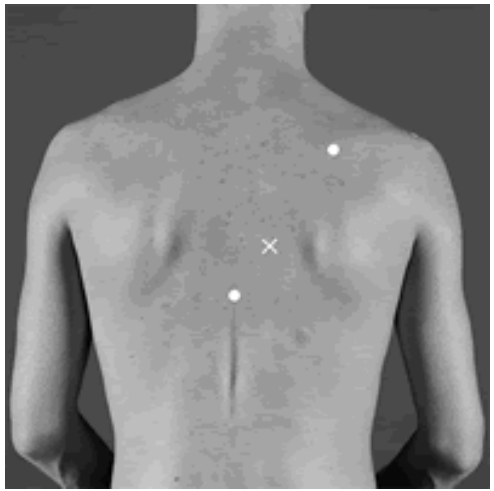


Experiment Objective

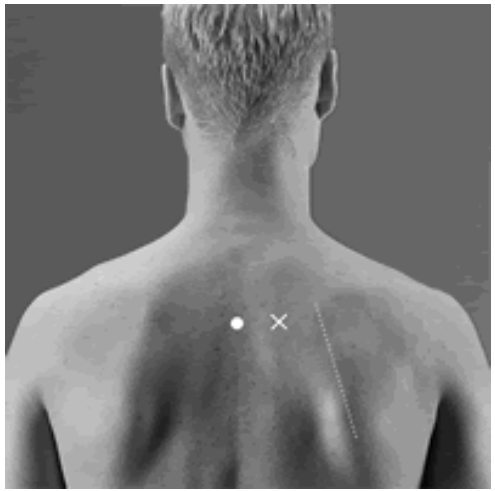
Measure the EMG signals for both postures before, during, and after surgery, since muscle fatigue causes EMG signal to increase the amplitude and decrease the frequency. Compare the changes in EMG signals in two postures and make a conclusion.

Trapezius Sensor Placement

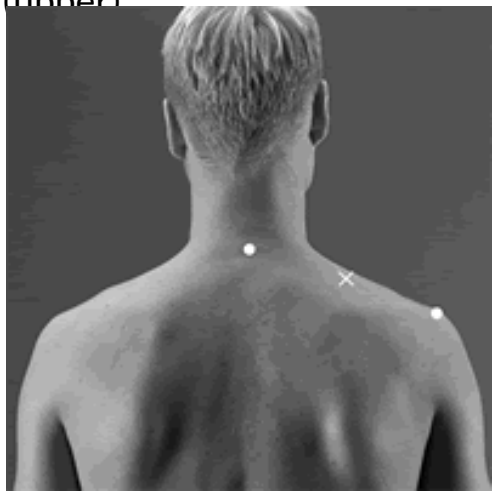
Trapezius Ascendens (lower)



Transversalis (middle)



Trapezius Descendens (upper)

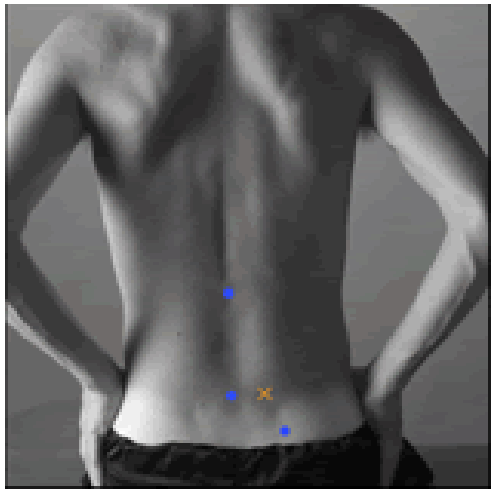


Reference to Seniam.org

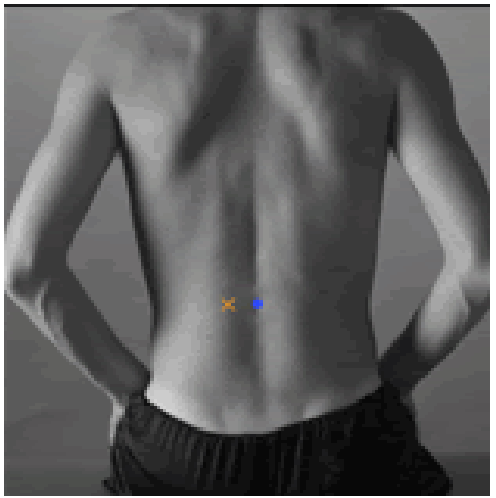
Trunk & (lower) Back Sensor Placement

Iliocostalis

Multifidus



longissimus



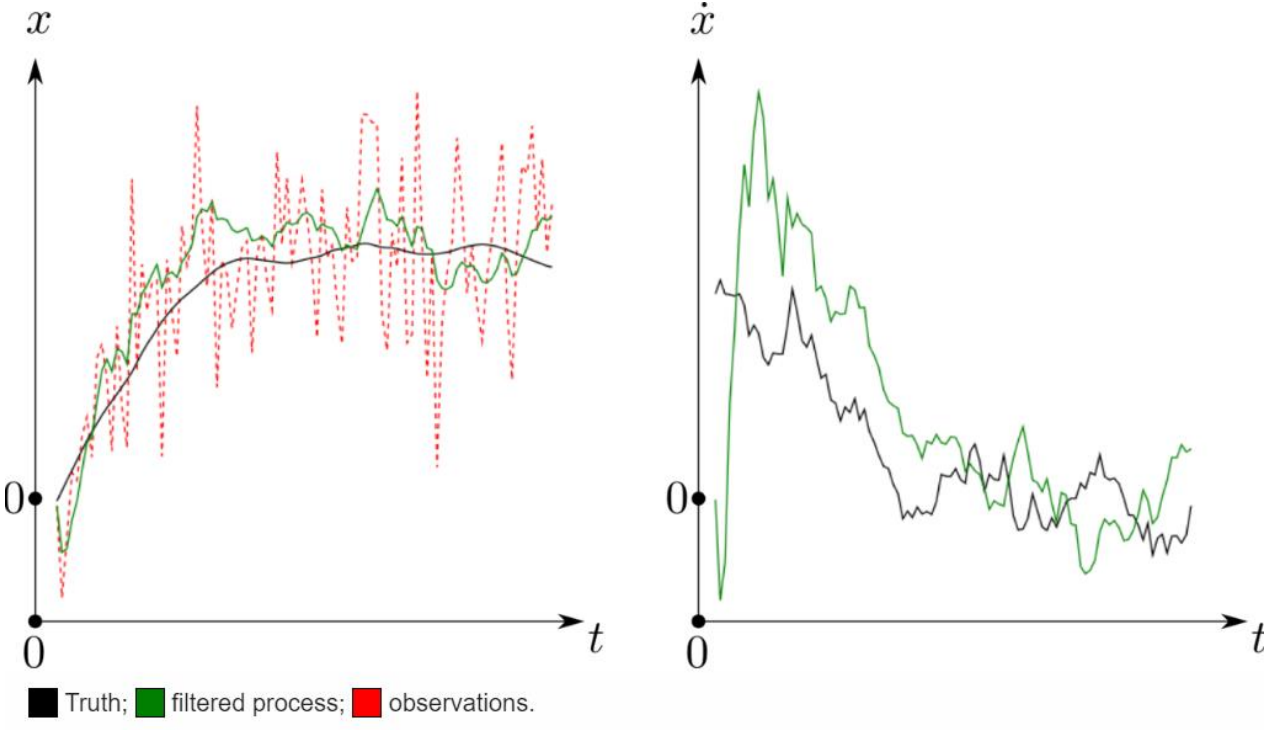
Reference to Seniam.org

EMG Processing and Classification

(Machine Learning)

Kalman filter

- Recursive Estimator
- Takes imprecise measurements and computes the estimate for the current state
- Kalman filter deals effectively with uncertainty from noisy sensor data
- Uses a weighted average, as values with better (smaller) estimated uncertainty are “trusted” more



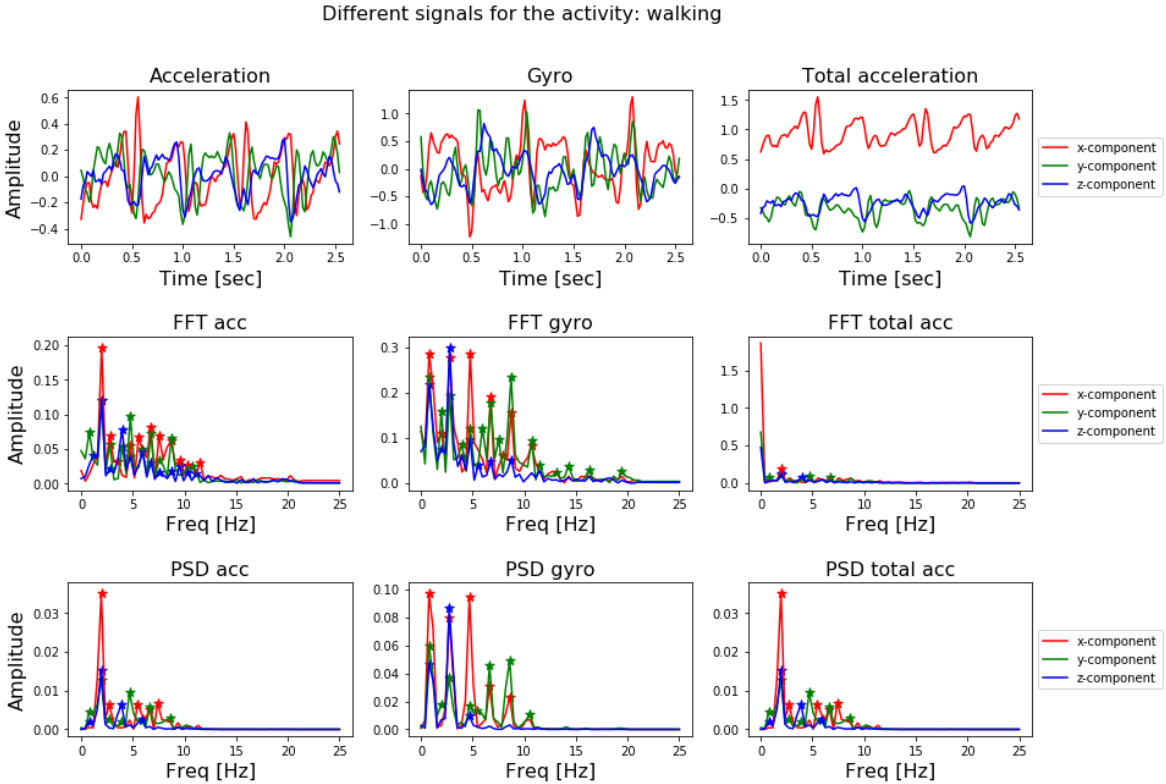
Naive Bayes

- Simplest classifier used in Machine Learning
- Based on Bayes' theorem with strong (naive) independence assumptions between features
- The assumption might not be true, hence the name *Naive* Bayes classifier
- Adapts quickly to changes in a smaller training set

Random Forest

- Learning method for classification and regression
- Constructs decision trees during training and outputting the class (classification) or mean prediction (regression) of the trees
- Individual trees are usually grown deep to learn irregular patterns (and overfit training set) [low bias but high variance]
- Random forests average multiple decision trees on different parts of the training set

Sample EMG classification



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“Random forest.” Wikipedia, Wikimedia Foundation, 20 Nov. 2019, en.wikipedia.org/wiki/Random_forest

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