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

Image: https://novartis.gcs-web.com/
EMG Signal Origin
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**
EMG Signal Generation

Signal Propagation

Left. Depolarization zone on muscle fiber.

Right. Wandering electrical depole on muscle fiber membrane
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.
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 takes USB power bank as the power supply.

Three options to collect EMG signals:

**Option 1**
- Directly transfer data back to the laptop.

**Option 2**
- Transfer the data back to mobile application through Bluetooth.

**Option 3**
- Save data to SD card and download later.
Sample Signal (Raw)

Relaxed
Sample Signal (Raw)

Relaxed -> Active
Sample Signal (Raw)

Active -> Relaxed
Sample Signal (Rectified & Integrated)

Relaxed -> Active

Active -> Relaxed
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

Different signals for the activity: walking

