Meet the members

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Data Analysis

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Hardware Design
Project Background

For microsurgeries:

- Traditional — Hunched posture: microscope
NgeNuity 3D Visualization System for Digitally Assisted Vitreoretinal surgery from Alcon TrueVision

Now — Straight posture: 3D camera and monitor

- Goal: quantify the muscle fatigue level difference between the hunched and straight posture by capturing EMG signals from back and neck muscles
Overview

- Electromyography (EMG): an electrodiagnostic medicine technique
- Changes of EMG when muscle is fatigue: amplitude increase, median frequency decrease

We recorded, analyzed, and compared the EMG signals of the two postures: hunched and sitting straight for a specific period of time.
Briefly, four different cases can be distinguished:

(1) If the EMG amplitude increases and EMG spectrum shifts to the right, muscle force increases the probable cause,

(2) If the EMG amplitude decreases and EMG spectrum shifts to the left, muscle force decreases the probable cause,

(3) If the EMG amplitude increases and EMG spectrum shifts to the left, this is considered to be result of muscle fatigue,

(4) If the EMG amplitude decreases and the EMG spectrum shifts to the right, this is considered to be recovery from previous muscle fatigue.
Muscle Fatigue

Metrics to determine muscle fatigue

- Amplitude increase
- Median frequency decrease
- Frequency domain curve shifts to the left

Reason: The conduction velocity of the motor actions potentials on the muscle membrane decreases.
Experiment Design
Experiment Design

Sensor Placement:

We place EMG sensors in three main positions: multifidus (lower back), transversalis (upper back), and trapezius descendens (shoulder). The results we present here are the data collected from the multifidus (lower back).
Experiment Design

Experiment Format:

- Collect EMG signal data from six sensors simultaneously
- Straight Posture: Hold the posture for 30 minutes and collect data
- Hunched Posture: Hold the posture for 30 minutes and collect data
Experiment Design

Straight Posture

Hunched Posture
Metrics to Quantify Muscle Fatigue

Frequency distribution graph (Amplitude Spectrum)

1. Full width at half maximum (FWHM): the width of a spectrum curve measured between those points on the y-axis which are half the maximum amplitude.

2. Median frequency after eliminating noise signals.
Hardware
True Posture Block Diagram

- User mobility and safety
- Bluetooth module: wireless data transmission
- Power bank: reduce risk of current surge
Components

Microcontroller: STM32F401RET6 in LQFP64 package

- ARM®32-bit Cortex®-M4 CPU with FPU
- 84 MHz max CPU frequency
- 512 KB Flash and 96 KB SRAM
- 12-bit ADC with 16 channels
- USART/UART * 4
- I2C * 3
- SPI * 3
Components

EMG Sensor: Myoware Muscle Sensor

- Two output modes: Rectified and Integrated Signal / Raw EMG signal
- Single supply: 3.1 V to 5.9V
- Specially designed for microcontrollers
- Adjustable gain
PCB

PCB Layout

Final PCB
Signal Analysis
Signal Analysis

All the signals are processed through MATLAB.

1. Sanitize the raw data.
2. Generate the amplitude spectrum using Fast Fourier Transform (FFT).
3. Fit the amplitude spectrum then calculate the full width at half maximum (FWHM).
4. Examine the frequency shifting trends through the change of FWHM.
5. Eliminate failed data set (optional).

Issues

Hardware is not reliable sometimes.
Signal Analysis - Raw Signal

Voltage related raw data, collected from the Myoware EMG Sensors

Amplified and scaled raw signal
Signal Analysis - FFT

Amplitude spectrum generated from signal in 1 second.

FWHM of the best fitting curve is calculated for further trend analysis.
Signal Analysis - FWHM Trend

This is generated by the FWHM of every second of data collected over a 30 minutes period. Slopes of the linear fittings are recorded to show frequency shifting trends.
Conclusion

Blue Circles: Straight Posture FWHM.
Orange Circles: Hunched Posture FWHM.
Straight Slopes Avg: 0.0046883
Hunched Slopes Avg: -0.0028777

When the slope is negative, it means that muscles get more fatigued.
Conclusion

The straight posture’s slopes are almost positive and the hunched posture’s slopes are mostly negative, which means straight posture may rarely cause lower back muscles to be fatigued. With a head-up posture, surgeons can better protect their lower back muscles in the surgery.
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