Contemporary low cost EMG application and quality

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Introduction

Electromyography (EMG) is a field specializing in the use of electronic devices to measure the electrical activity muscles and analyze the data.

Three main applications of EMG in Ergonomics:
1) detection of muscle activation/deactivation;
2) estimation of muscular force;
3) fatigue assessment.

Constraints of EMG utilisation

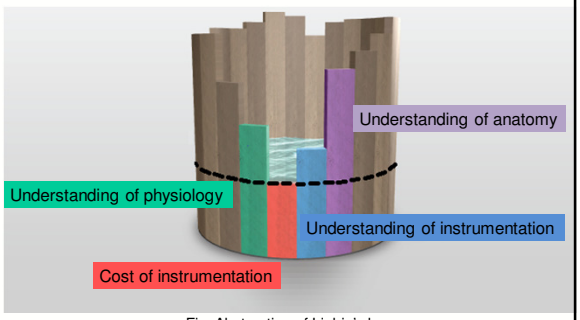


Fig. Abstraction of Liebig's law

Elements of instrumentation

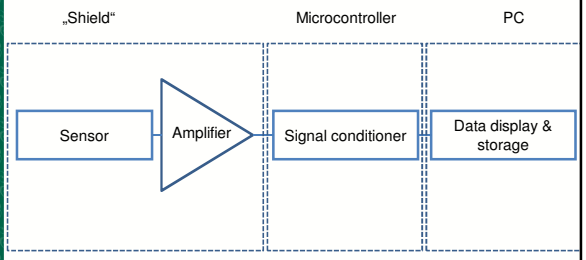
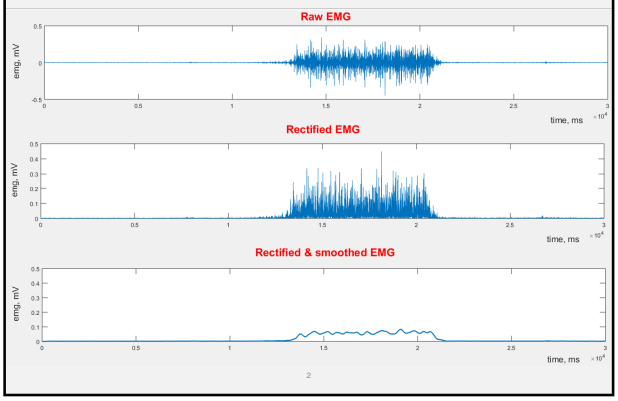


Fig. Generelisation of an instrumentation system.

The EMG signal



Low cost EMG shields

Manufacturer	Signal type	Filtering	Price
Advancer Technologies (Raleigh, USA)('v')	Rectified + smoothed	High pass fc= 106 Hz	€29.65 (discontinued)
Advancer Technologies (Raleigh, USA) ('MyoWare')	**Rectified/ Raw**	**No data**	**€39.95 (shield & cables)**
Olimex Ltd (Plovdiv, Bulgaria)	Raw	Low pass fc=40 Hz	€29.95 (shield + cables)
PLUX wireless biosignal (Portugal)	Raw	No data	€149 (shield ,cables & microcontroller)
Seeed Technology Inc (Shenzhen, China)	Rectified?	No data	$48 (shield & cables)
FlexVolt (Lebanon, USA)	**Raw / rectified by software**	**None**	**2CH - $115; 4CH- $150 (full product, free visualisation software)**

Methods of comparisons

Subjects (n = 10); (mean ± SE): age 24.9 ± 0.7 y ; weight 80.4 ± 3.3 kg; height 180.8 ± 1.1 cm; maximum grip force 397 ± 13 N

Apparatus

Two low-cost „shields“:

1) **Advancer Technologies' Muscle Sensor v3** (Advancer Technologies, Raleigh, USA)

2) **Olimex Shield EKG/EMG** (OLIMEX Ltd, Plovdiv, Bulgaria)

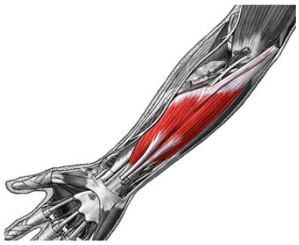
Reference device: **ME6000** (Mega Electronics, Kuopio, Finland)

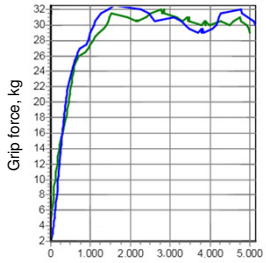
Bipolar dual Ag/AgCl disposable electrodes (Noraxon Inc, Scottsdale, USA) inter-electrode distance 2 cm. Electrode locations where marked.

Procedure

Isometric grip force and EMG activity of the m. flexor digitorum superficialis were recorded simultaneously.

Testing followed Caldwell regimen, contraction 5 s / rest ≥2 min





location of m. flexor digitorum superficialis

time, s

Data processing

Normalized EMG activity (EA) was used to compare the results between of the subjects (equation 1)

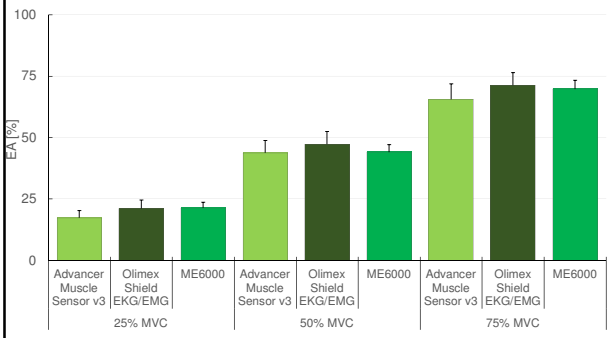
$$Normalized\ EA = \frac{EMG_{i,j} - MinEMG_j}{MaxEMG_j - MinEMG_j} \quad (1)$$

where $EMG_{i,j}$ is the actual 4 second root mean square (RMS) of EMG signal taken at submaximal exertion level i for subject j

$MinEMG_j$ is the RMS of EMG signal taken at relaxed state for subject j

$MaxEMG_j$ is the 4 second RMS of EMG signal taken from MVC for subject j

Results



EMG activity, normalized to MVC, on three submaximal contraction levels (mean + SE)

Reinvee, M., Vaas, P., Ereline, J., & Pääsuke, M. (2015). Applicability of Affordable sEMG in Ergonomics Practice. *Procedia Manufacturing*, *3*, 4260-4265.

Applications of (low-cost) EMG

1. Control of prostheses.
2. Biofeedback – muscle activity/in activity; activity level.
3. Physical Therapy: Increase motivation to complete Physical Therapy exercises at home by using muscle-based motivational games.
4. Education: learn about the signals generated by the human body (measure and visualise emg signal, study the properties of emg amplitude and frequency, learn about muscle functions).
5. Human-Computer Interaction: control a computer mouse.
6. Entertainment: make music, control motors, lights, etc.

User reviews of commercial EMG biofeedback devices :

'*It helps me to show all my customers how the finger tendon muscles respond to mouse finger clicking. It makes the relationship between the finger clicking and carpal Tunnel Syndrome so obvious*'.

'*This product helps me demonstrate force concepts to my class. The students really understand it when they can hear changes. I'm going to be using this to quickly show the effects of various lifting postures to my ergonomic assessment clients*'

Source: thehumansolution.com

'Pocket Ergometer' (Biomechanics Research Group, USA) **$ 430** (discontinued product)

'Myotrac T4000P' (Thought Technology, Ltd., USA) **$ 730** (lowest price)

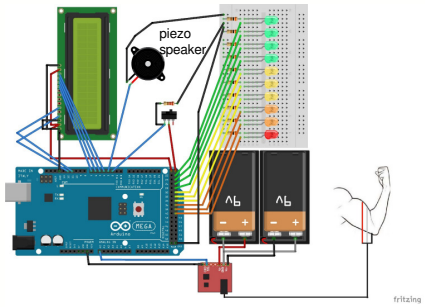
A low-cost alternative

Cost: € 90…130 - depends on the amount of feedback elements (LED, LCD, speaker) and type of microcontroller.

Functions: 1) caputres MVC and resting emg values during calibration
2) Provides sound or visual (LCD & LED) feedback about normalised emg activity (see slide 9).

Short demo: https://www.youtube.com/watch?v=2l5GvTqeB1E

Schematics



Arduino code provided on demand.

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Estonian University of Life Sciences

Lessons learned (so far)

1) Low-cost prototyping platforms (e.g Arduino) allow easy synchronous data capture from various sensors (e.g heart rate, emg, accelerometers) – the applications are limited only by designers imagination.
2) Lack of freeware for emg processing is the main disadvantage of low-cost emg devices. Data processing with MS Excel is very time consuming.
3) In the scope of ergonomics, primary use of contemporary low-cost emg devices should be limited with educational purposes: gain hands-on experience in emg measurements; increase student involvement in anatomy and physiology courses; demonstrate ergonomic principles, etc.

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Suggested readings

'As articles reporting SEMG results are often used by ergonomics practitioners as guidance in job design, the ability to interpret SEMG research is critical. Problems occur when researchers assume their readers have a greater familiarity with SEMG than actually exists, or when they make any of a number of SEMG-related research or interpretation errors.'

Ankrum, D. R. (2000). Questions to ask when interpreting surface electromyography (SEMG) research. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (Vol. 44, No. 30, pp. 5-530).

'The current state of surface electromyography is enigmatic. It provides many important and useful applications, but it has many limitations that must be understood, considered, and eventually removed so that the discipline is more scientifically based and less reliant on the art of use. To its detriment, electromyography is too easy to use and consequently too easy to abuse.'

De Luca, C. J. (1997). The use of surface electromyography in biomechanics. *Journal of applied biomechanics*, *13*, 135-163.