Facial Electromyography (fEMG)

Technical Note

TN 27072018

PHYSICAL ACTIVITY | TASK DESCRIPTION

All motor tasks executed by a human being are resultant from the coordinate activity of neurons (control structures) and muscles (actuators).
Each motor neuron, can be connected to various muscle fibers, forming this set of “entities” a motor unit.
In order to a muscle fibre contract, a nervous impulse should be generated by the motor neuron that regulates the activation of the muscle fiber.
This nervous impulse will propagate along the motor unit axon, through a cascade of successive depolarizations and repolarizations of the axon membrane.
When the impulse reaches the muscle fiber, it promotes the release of calcium ions from the sarcoplasmic reticulum [1], which will bind to troponin, promoting the movement between myofilaments and ultimately the contraction of the muscle fiber.
The nervous impulse responsible for contracting a muscle, can be registered with superficial sensors, placed at the skin surface, because when the electric potential wave propagates along the muscle membrane it will also reach the skin surface.
Muscles are spread along the body and of course they are also present at face, being essential for expressing emotions.
Human face is composed by 43 muscles [2].
The fEMG signal is characterized by muscles activation segments, due to summation/interference of the electric potentials collected during the simultaneal activity of different motor units [3].
Activation periods seems a little bit anarchical and random due to the its interferential origin.
The fEMG signal sample, referent to the present technical note, was acquired at ***buccinator*** muscle for a period of 48 seconds, in a controlled environment where noise sources were minimised.

SIGNAL CHARACTERISTICS

Typical Frequency Band [4], [5]**:**

- 50 to 150 Hz [More Restrictive]
- 5 to 500 Hz [Recommended]

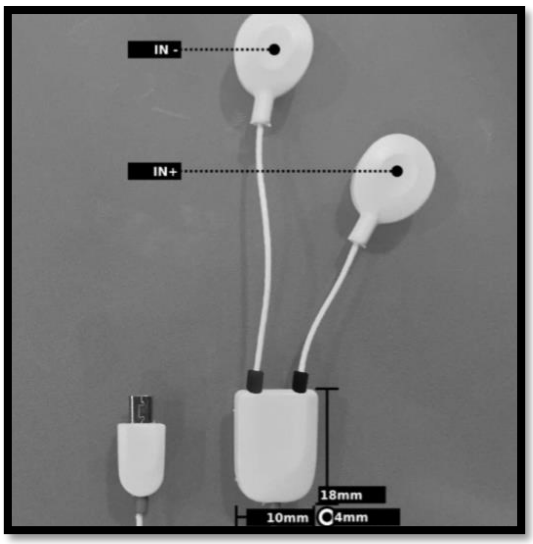

Fig. 1. Sensor Overview

Fig. 2. Ground Cable

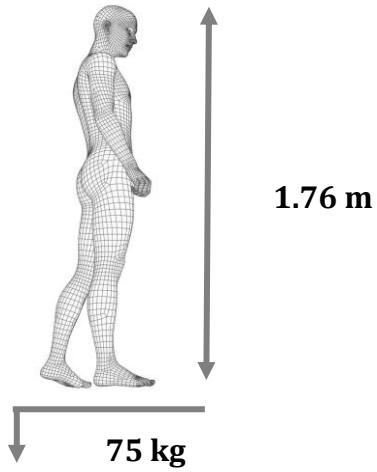

Fig. 3. Anthropometric Measures

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SENSOR AND HARDWARE DESCRIPTION

The two exploratory electrodes should be placed at the longitudinal direction of the muscle under study (*Fig. 1*).

The distance between sensor needs to be near 2 cm.

Additionally, there will be a reference electrode, connected to a bone structure, in order to function as the ground level (*Fig. 2*).

SUBJECT DESCRIPTION

Healthy male subject with 40 years old and non-smoker (height: 1.76 m; weight: 75 kg - *Fig. 3*).

PROTOCOL OF ACQUISITION

The subject is comfortably seated in a chair during the protocol execution.

Steps enumeration:

1. Clean of the sensor application zone (skin) with alcohol, in order to guarantee a better adherence of the sensor and a wright electric conductivity;
2. Placement of the two exploratory electrodes in the facial muscle under study (*Fig. 4*);
3. Turn off external sources of noise and disconnect some relevant devices from the current source (computer and the *Plux's* acquisition system);
4. Start of the acquisition;
5. Near 1.2 seconds the volunteer should smile (*Fig. 5*);
6. Repetition of step 5 at the time instant of 8 seconds;
7. Repetition of step 5 at the time instant of 10.5 seconds, but with a more accentuated facial expression during the smile;
8. Between 12.5 and 15.1 seconds the volunteer simulate a smile with spasms (quick succession of contraction and relaxation of facial muscles);
9. During the next second the volunteer repeated step 5;
10. Until 21.8 seconds was executed a contralateral movement of the mouth (*Fig. 6*);
11. Between 21.9 and 26.0 seconds a sequence of three intense contractions occur;
12. In time interval 26.2 to 31.5 seconds a sequence of three smooth contractions take place;
13. End of the acquisition at 40.70 seconds;
14. Removal of the electrodes and cleaning of the skin surface where the electrodes were placed;
15. Storage of generated files in the desired folder (*Fig. 7*).

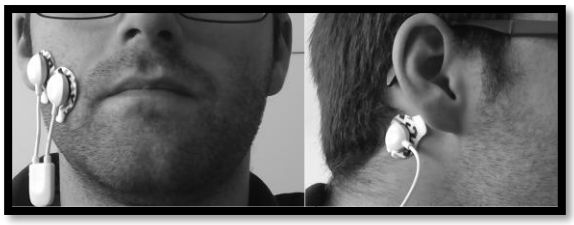

Fig. 4. Sensor Placement at facial muscles (left) and ground electrode (right)

Fig. 5. Smile movement

Fig. 6. Contralateral movement (sequence of images)

Fig. 7. Signal Storage Operation

NOISE EVALUATION PROCEDURE

Signal to Noise Ratio (SNR) is an important metric that classifies objectively the quality of the acquisition, and like the name suggests the relation between the intensity of the signal and the undesired noise in the acquired data ($acquired$), which is defined by:

$$SNR = \frac{V_{pp}^{signal}}{V_{pp}^{noise}} \quad \textbf{(1)}$$

being V_{pp}^{signal} and V_{pp}^{noise} the peak-to-peak amplitude of the $signal$ and $noise$ component, respectively.

In order to SNR be determined the following steps were followed:

1) Division of the acquisition in temporal segments/windows (each segment will contain a muscular activation period and its two adjacent inactivation periods - *Fig. 8*);

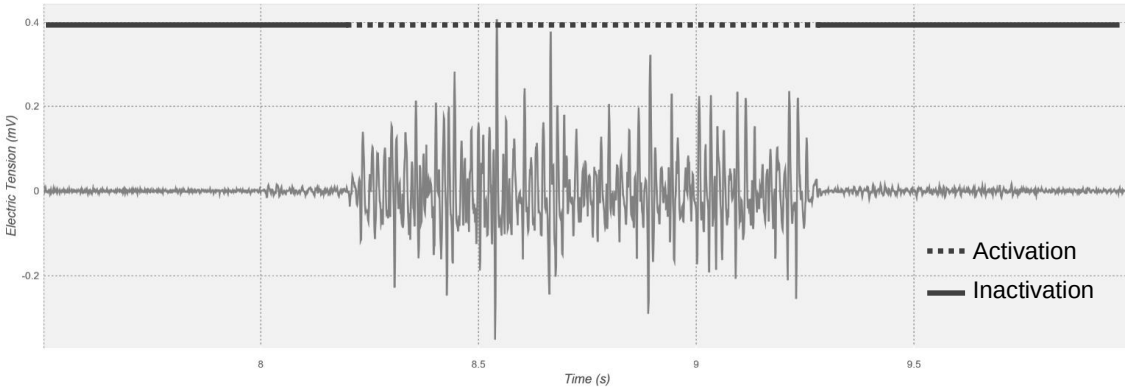

Fig. 8 - Segment with an activation period and its previous and subsequent inactivation zones

2) For each segment:

a. Determination of V_{pp}^{signal} from the activation period under analysis (*Fig. 9*);

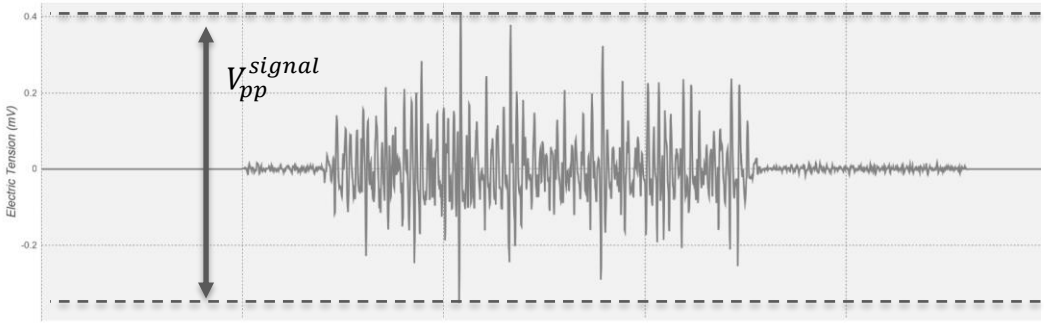

Fig. 9. Activation Period (signal component) peak to peak amplitude

b. Isolation of the noise component by excluding the activation period samples from the segment under analysis (*Fig. 10*);

c. Determination of V_{pp}^{noise};

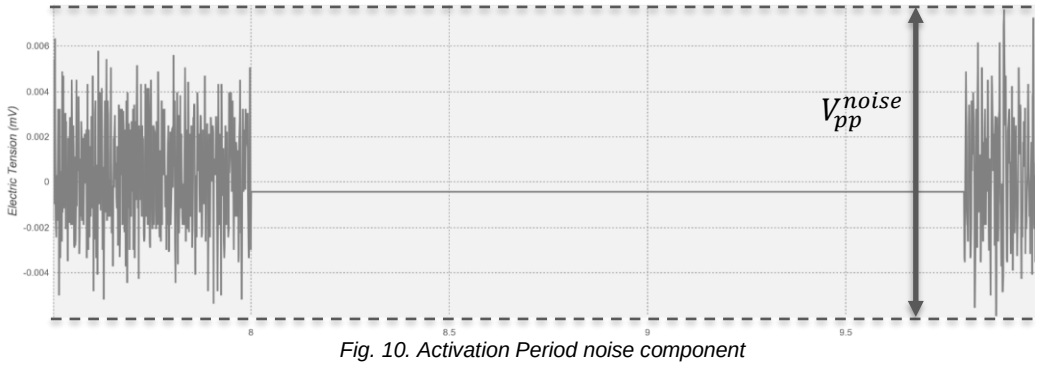

Fig. 10. Activation Period noise component

d. Estimation of SNR for the present segment.

3) Average of the SNR values and the respective standard deviation.

$$SNR_{avg} = 41.55 \qquad SNR_{std} = 27.55$$

$$SNR_{avg}^{dB} = 32.37 \pm \frac{4.42\ dB}{9.45\ dB}$$

REFERENCES

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