Hand Gesture Recognition Using Electromyography (EMG) and Artificial Intelligence

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Introduction

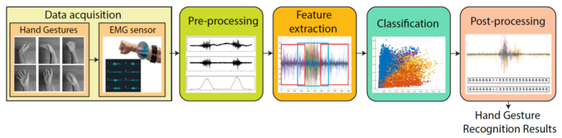
A gesture can be considered as a symbol that communicates expressions or physical behavior. The development of a hand gesture recognition model is a challenging problem because it requires high accuracy to identify the class of a given movement, the instant of time when it happens, and its duration. Moreover, characteristics like portability and usability are so important in order to work under limited computational resource (like smart phones or home PCs).

Problem

How can a computer recognize the following gestures of the hand in real time and with high accuracy?

Proposed solution
Develop new gesture recognition models to recognize 5 or more hand gestures using EMG signals and artificial intelligence techniques with high accuracy and low computational cost (i.e. real time response).

Flowchart of the proposed model



Emg Hand Gesture Dataset (EMG-EPN-612)

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A dataset that contains EMG signals of 612 people. The data was obtained by recording, with the Myo armband, EMG signals on the forearm while users were performing five hand gestures: wave-in, wave-out, pinch, open and fist.

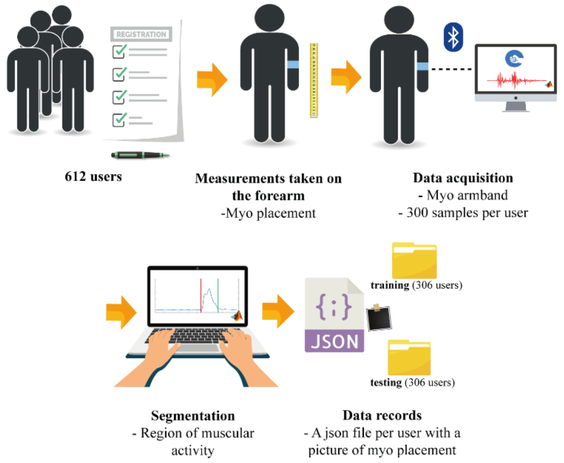

Fig. EMG-EPN-612. Dataset estructure

Evaluation protocol (classification and recognition)

Classification only identifies the class of a given hand movement from a predefined set of gesture classes. In other words, the classification only returns a label that identifies the gesture (which class); whereas the recognition returns the label as well as its timestamp (when it is produced and how long it lasts).

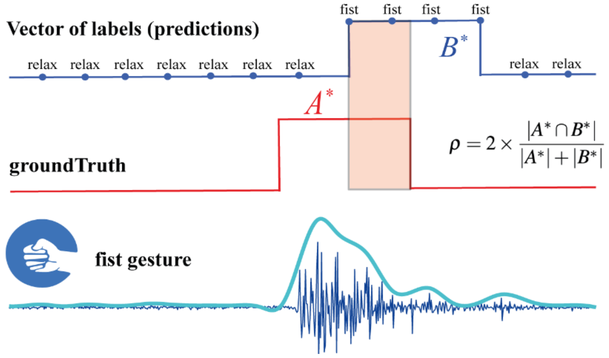

Fig. Evaluation of recognition. Recognition is correct when the overlapping factor, ρ, is greater than or equal to a threshold $(\rho \geq 0.25)$.

Fields of Application (human-human interface)

A HHI is a system that may enable the transfer of skills using EMG. This is one of the many fields of application (like robotics, human machine interfaces, etc) that can take advantage from hand gesture recognition. Even more, it could be also applied on amputees!

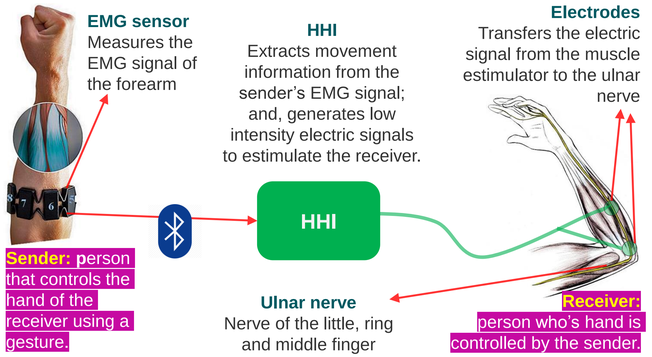

Fig. Diagram of the human human interface (HHI)

Results

Table 1. Hand Gesture Recognition models comparison

Model	Class.	Class. Std.	Recog.	Recog. std.
DTW_ANN	93.89%	9.03%	89.34%	11.49%
ROT_SVM_SPECIFIC	94.96%	5.6%	94.2%	6.36%
ROT_SVM_GENERAL	**81.22%**[1]	11.58%	80.31%	11.78%

	Targets						Predictions Count (Precision%)
	waveIn	waveOut	fist	open	pinch	noGesture	
waveIn	**6651**	138	336	302	725	217	8369 79.47%
waveOut	207	**6550**	83	416	264	139	7659 85.52%
fist	359	29	**6614**	262	656	160	8080 81.86%
open	147	849	391	**6165**	1034	162	8748 70.47%
pinch	95	30	126	295	**4424**	95	5065 87.34%
noGesture	191	54	100	210	547	**6877**	7979 86.19%
Targets Count (Sensitivity%)	7650 86.94%	7650 85.62%	7650 86.46%	7650 80.59%	7650 57.83%	7650 89.9%	45900 81.22%

Fig. [1]Confusion matrix from ROT_SVM_GENERAL

More details at: aplicaciones-ia.epn.edu.ec

Cientific contributions

1. "An Energy-Based Method for Orientation Correction of EMG Bracelet Sensors in Hand Gesture Recognition Systems" (journal, **Sensors MDPI**, *under revision*).
2. "Feature Evaluation of EMG signals for Hand Gesture Recognition based on Mutual Information, Fuzzy Entropy and RES Index" (congress **CSEI 2020**).
3. "A User-Specific Hand Gesture Recognition Model Based on Feed-Forward Neural Networks, EMGs and Correction of Sensor Orientation" (congress **ICPR 2020**, *under revision*).
4. "Building a benchmark dataset for electromyography hand gesture recognition" (journal, **Scientific data-Nature**, *under revision*).

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