An intention-based human-exoskeleton EMG interface by using Discrete Wavelet Transform and Principal Component Analysis for sit-to-stand training in gait rehabilitation

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***Abstract*— Assisted robotics and biomedical signal processing are currently two technologies with promissory results worldwide. In that sense, this project proposes to combine both technologies through the development of a human-robot interface based on the acquisition, featuring and pattern recognition of myoelectric signals to control a lower-limb exoskeleton for sit- to-stand training. The aim is to detect the movement intention to set the joint actuators controller by using discrete wavelets packets transform (DWPT) and principal component analysis (PCA) in the developed pattern recognition neural network algorithm. Sit-to-stand movement is the first challenge in gait rehabilitation.**

I. Methodology

A. The sEMG and torque measurement

Due to the small amplitude of the sEMG signal, an acquisition circuit was designed and developed. It consists of: a protection stage, an instrumental amplifier, a filtering stage, a final amplification stage, and an analog-digital converter. The digitalization was done using a DAQ-6002 from National Instruments. For the joint torque measurement, people performing the sit-to-stand movement were video recorded [1].

B. Feature Extraction and Dimensionality Reduction

The purpose of this part is transforming the raw sEMG signal in digital informative signs of the system. The 3-channel signal is decomposed through a 4 level DWPT. In order to obtain time-frequency data of this processing, wavelet energy, root mean square (rms), mean absolute value are chosen features to characterize the joint's torque [2].

Since there are 18 features (16 wavelet energy, RMS, MAV); a dimensionality reduction technique was carried on. PCA is a popular and easy-to-use algorithm to achieve this task. In Table I. is shown the amount of variance lost, if a threshold of 99% of retained variance, 15 would be the output vector dimension.

TABLE I. Variance lost porcentage due to the usie of dimensionality reduction

Output Vector Dimension	Variance Lost %
12	3.33
13	2.26
14	1.44
15	0.7

C. Non-Linear Torque Prediction

In order to model the non-linear relationship between sEMG signals and torque, a time delay neural network (TDNN) was developed [3] by using a 70 ms window length and three time shift input vectors, ending with a 60 input vector dimension.

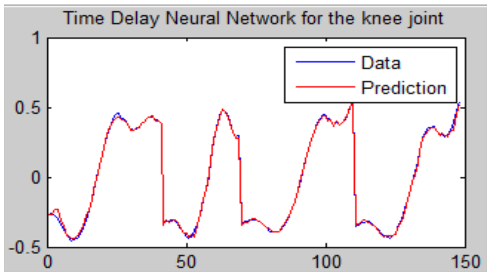

Figure 1. Results of the trainning of the TDNN

II. Conclusion

A sEMG system was developed to predict the joint torques of the lower limbs. The proposed methodology successfully reduces the complexity and allows better performance in the prediction stage.

*Research supported by Instituto de Investigación of the Mechanical Faculty of the Universidad Nacional de Ingeniería, INIFIM UNI, Lima, Peru.

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