Deep learning for hand prosthesis piloting based on sEMG signals

Project proposal

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Context

Active, handy and cheap hand prosthesis conception is currently a challenge. It's limited by the complexity of the movements of the human hands, and by the interpretation of the user's will.

The problem is often stated as a classification problem [4], where the goal is to find the movement desired by the user among a set of gestures and then execute it. But this formulation of the problem is really limited by the number of gestures considered, and does not grant an intuitive control over the prosthesis. Some recent results seem to show that, with the recent breakthroughs in deep learning, the regression problem could be adressed. (Guessing directly all the relative positions of the hand from the user's will.) It brings a much more intuitive control over the prosthesis and is not limited by a set of pre-defined gestures.

The question is on which data can be based the user's will extraction ? One of the cheaper approach is to rely only on surface electromyography (sEMG) signals acquired from the forearm muscles. These signals are cheap to extract but hard to exploit in order to predict the hand movements.

Our goal will be to use Recurrent Neural Networks (RNNs) in order to exploit the temporal dependencies of sEMG and predict the positions of the hand.

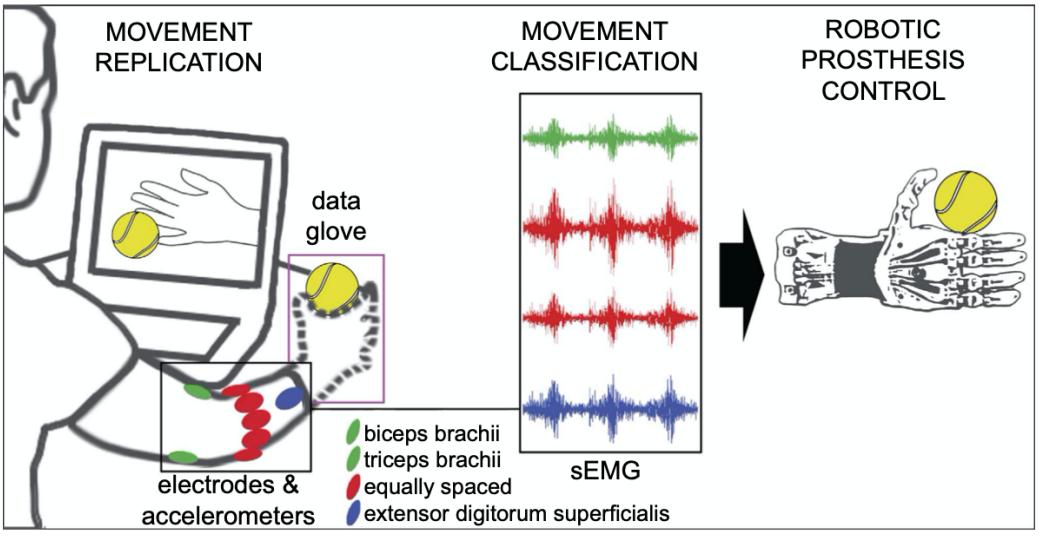

FIGURE 1 – Prosthesis control from sEMG and a gesture classification processus. [2]

Methodology

A review of the literature found that RNN-based approaches are promising for solving the regression problem [3]. In this project, we would like to implement RNNS to solve it. A reasonable objective is to reach the same performance found in the literature.

Our methodology is the following :
- Extract a dataset relevant to the problem such as one (or several) Ninapro database(s) [1].
- Implement a recurrent neural networks with the use of LSTM cells (Long-short terms memory). We plan to test several architecture to reach the best performance.
- Validate our results with the evaluation method detailled in the following section.

Evaluation

The Ninapro Database [1] is one of the most commonly used database in the field. It records sEMG and the general position of the hand (resumed by 22 positions of sensors placed on it) during the realisation of some specific gesture. It can therefore be used both for classification, where the goal find the gesture, and regression, where you guess the positions of the hand.

Our objective is to create and learn a network able to predict the positions of the 22 glove's sensors for each time t knowing the sEMG signals of the previous times. The database will provides us the 22 positions at each time, allowing us to train and evaluate a RNN model.

It could also be nice to modelise in 3D the hand from the 22 positions and therefore to show some results on a 3D model. The point would be to see the impact of the errors on the reconstructed hand.

Références

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