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Prosthetic hand movement using artificial neural network

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ABSTRACT

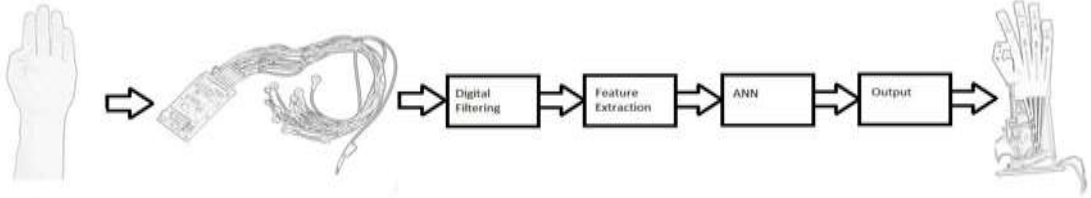
Artificial neural networks (ANNs) were used to classify EMG signals from an arm. Using an amplifier card from the Smart Hand project or prosthetic hand, 16-channel EMG signals were collected from the patients arm and Filtered. After time-domain feature extraction, simple back-propagation training was used to train the networks. During the training, the patient moved his Fingers according to a predefined pattern. After the training, the patient could move an artificial hand by duplicating the movements made during training. Artificial hands are nothing new. One of the earliest mentions is of a Roman general that fought with an iron arm back around the year 50 AD and many of researches have done on this project. Hopefully, this work will show that this approach to the problem of controlling hand prosthesis is viable and that it has benefits over other methods previously used.

Keywords: *Artificial intelligence, Neural networks, EMG signals, Digital filtering, Feature extraction etc*

1. INTRODUCTION

Artificial intelligence (AI) and increasingly scope of Artificial Neural Network currently influence our lives and our civilization more than ever. The areas of AI application are diverse and the possibilities extensive: in particular, because of improvements in computer hardware, certain AI algorithms already surpass the capacities of human experts today. As AI capacity improves, its field of application will grow further. In concrete terms, it is likely that the relevant algorithms will start optimizing themselves to an ever greater degree—maybe even reaching superhuman levels of intelligence.

Many of the things we do in daily life, we do with our hands. It is therefore of greatest importance that we can replace a lost hand and restore as much functionality as possible, to ensure that the affected individual can continue to interact with the world. Several research projects around the world are in this moment working on a solution to this problem, and this report will describe how artificial neural networks (ANNs) can be used to help replacing a lost hand, by learning to recognize muscle signals that should have controlled the missing hand, and sending them to a new prosthesis .The project can be viewed as a chain of modules. Each module receives information from the previous, processes it in some way and sends it along to the next module. To make it easier to understand the rest of the report, an overview of this chain is given here. The first module consists of the arm of the patient. Most of the muscles controlling our fingers are located in the arm, and can remain functional even after a hand is lost. When they work they produce electrical signals which can be picked up by the 16 surface-mounted EMG sensors. The sensors are connected to amplifiers which in turn send the amplified signal via USB to the computer, where it is digitally filtered and features are extracted before the classification process begins. The classification is divided into two distinct phases. In the training phase, the patient performs a predefined set of motions, and the data collected is tied to these known desired outputs. The network is then trained to match those outputs with the features of the collected data. In the running phase, the trained network is used to classify any signal from the arm. This signal is then forwarded to an artificial hand, which mimics the patient's movements.



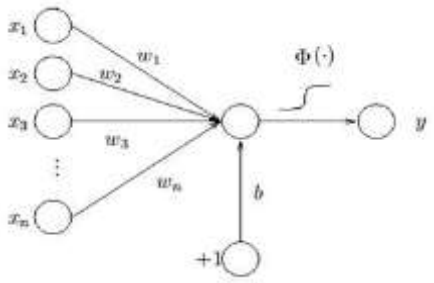
Important for this project is that the muscles which enables the hand to move can be divided into two groups, intrinsic and extrinsic. The intrinsic muscles are located inside the hand and control some movements of the thumb and the little finger, while the extrinsic muscles are all located in the lower arm and connect to the rest of the fingers by tendons. They control most of the rest of the functions of the hand, and since they are not removed if only the hand and wrist are amputated, they will remain in the body. This is essential for prosthesis control, since the nerves controlling the hand are still connected to these muscles, which can be used to control the prosthesis instead.

2. ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI, also machine intelligence, MI) is intelligence demonstrated by machines, in contrast to the natural intelligence (NI) displayed by humans and other animals. In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Colloquially, the term "artificial intelligence" is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving. Now days, Artificial Intelligence is also used in prosthetic limbs and artificial hands movements. Using the technology of EMG signals, back propagation method, digital filtering, feature extraction etc. a bionic hand movement is viable.

3. NEURAL NETWORK

An artificial neural network is a classifier modeled after how the human brain works, which is very different from how one usually writes computer code. A human brain contains an enormous amount of nerve cells, neurons. Each of these cells is connected to many other similar cells, creating a very complex network of signal transmission. Each cell collects inputs from all other neural cells it is connected to, and if it reaches a certain threshold, it signals to all the cells it is connected to.



In an ANN, this is achieved by updating the weights associated with the connections between the layers. There are several ways of doing this, and most involve initializing the weights and fed the network an example. The error made by the network at the output is then calculated and feed backwards through a process called "back-propagation". This process is then used to update the weights, and by repeated use of this process, the network can learn to distinguish between several different classes.

To make the training more efficient, techniques such as momentum can be used. Momentum is used to find the right update step for the weights.

Digital filtering

Every time a signal is gathered from somewhere there will be some amount of noise present. To remove this, one or more filters are usually needed. These can be hardware filters, built from for example amplifiers and resistors or software filters built from equations in a computer. Both have their advantages, but in this project digital filters were chosen, to minimize the hardware modifications. Just like with analog filters, digital filters come in several different types. The common ones are low-pass, high-pass, band-pass and band-stop. The names are rather self-explanatory. Low-pass filters stop frequencies over the cutoff frequency while high-pass stop the frequencies bellow the cutoff frequency.

Feature extraction

When dealing with large data sets, it is often impractical to work directly with the raw data. Not only because of the shear volume but also because information can be hidden in a sequence of data-points which is not visible in a single data point. For this reason, feature extraction is often used.

4. CONCLUSION

The end result was that the patient could move the muscles in his arm as if he was moving a finger, and the artificial hand would respond by mimicking that movement, as long as only one finger was moved at the given time. The hand is controlled via the signals from the patient's brain to the remaining muscles in the arm which should have controlled the missing hand. When the patient tries to move the missing limb, the muscles will contract and an Electromyography (EMG) signal is generated. This signal is then measured and interpreted; the prosthesis can move to match the desired movement. The Smart Hand project is a recently finished project in which hand prosthesis was created which looked and operated like a real hand, and which also gave the wearer back the sensation of touch in the missing hand.

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