

## Notes on how to apply Deep learning to classify neural signals:

A nerve impulse is defined by a sequence of action potentials sent by a sensory organ to the brain. An action potential can be studied as a waveform so we are dealing with a series of waveforms separated by a possibly static or variable delay. Each waveform composing a nerve impulse may also slightly differ from another.

I wish to develop software which will use neural network based algorithms to classify nerve impulses and provide two 3D modelizations. One will be of a nerve impulse as a "wave" made of a series of action potentials waveforms, the other one will be of the neural network significant branches and neurons' bias used to classify those signals.

This software will also allow the user to compare two such 3D models and see how the neurons value differ when the signal is processed to help identify the important parts of the neural network we can use to optimize it. It will give us the possibility to establish the sections of a message defining its nature and to classify them.

Those messages eventually encode information such as the origin of the nerve impulse and its nature (pain, pleasure, touch, sound, etc) according to the brain. If those details are added to the signals by neurons in the nerve between the brain and the sensorial organ we will need datasets recorded near both ends to compare readings.

These individual waveforms could also be readable as an addition of simple waveforms. Fourier's work could be used if a spectral analysis appears to give better result.

Multiple similar theses can be found but they all were constructed around the fact that we need to extrapolate how many neurons are involved in the process and what are their values. Various models have been hypothesized and proved to partially work but are always lacking to determine exactly what characterize the signal.

The difference is that I intend to give raw data as much as possible to the neural network and adjust its width and deepness or even separate it in multiple networks to let it classify by itself without being impeded by human misconception. The models to classify must be established by the neural network, not by us.

Based on my experiences at work and the courses I followed during my master's degree last year in voice processing and data management using deep learning, I'm confident in my abilities to determine a protocol about developing software to help managing neural networks in A.I. field, focused on signal processing.

I will need information about the format of the data obtained by the laboratories specialized in neurosciences and once the software will be sufficiently developed, waveforms read as such or modified or created using this software will be exported in a format compatible with a signal generator.

I wish to obtain nerve impulses data where the source sensory organ and the nature of the signal is known in order to improve the software, analyze those messages and correct the reading errors/corrupted data we can get when acquiring them.

The last step would be to reproduce and transmit such messages through the skin with electrodes and find a way to communicate those messages to the brain using the standard wiring in the human body, nerves. It could be possible to elaborate non invasive methods such as adjusting the voltage to get the signal going through the myelin sheath. For this part, neuroscientists and biologists intake will be necessary.

This research could lead to the development of a new human-machine interface, mapping the human nerve impulses would make it possible to change the life of amputees. Their prosthesis could be equipped with a system letting them feel what they touch. A deaf person could hear again just by receiving the correct nerve impulses over their skin. With a lot of work over picture encrypting and nerve impulses decrypting not only a blind person could see through a camera but also anyone could see without needing a visual interface.

Nowadays researchers work over enhanced reality and virtual reality. In both cases a visual interface is absolutely needed such as the Google lens or the oculus rift, with the mapping of nerve impulses it would be possible to compute the screen picture into a nerve impulse understandable by the brain as if it was information sent by the eye.

Even movies and video games could show us a different world with such an interface, whether it is the sight, taste, hearing, smell, touch, feeling of gravity or anything not related to our thoughts, everything is encrypted from a sensory organ and sent to our brain through nerve impulses, knowing how to construct such a message could revolutionize those media. It's not necessary to know how the brain understands those signals as long as the message we send is correct but it could help researcher specialized in neuroscience when studying brainwave.

I wish to work with researchers over this project, to hear their thoughts about the way I intend to develop my software and the interfaces they can develop to send electrical signals through a nerve via a non invasive method.

### **Primary major objectives:**

I wish to set the foundations to develop a new kind of HMI (Human Man Interface) based on nerve impulses. To do this I identified 3 essential phases:

- Determine how we can decode the information contained in neural signals.
- Define if it's possible to transform this signal to send it to any part of the body (non invasive methods if possible) and keep the information characterizing them untouched. The purpose is to have the brain not noticing any difference between this artificial signal and a natural one, thus the message will be processed normally.
- Finally, to create such neural signals with a chosen data encoded (sight, smell, hearing, taste, touch) that will be decoded by the brain and adapt this signal to keep it interpretable by the brain if we send it from any part of the human body we select. I intend to base my work on style transfer methods used with Convolutional Neural Networks.

### **Methodology:**

Deep Learning/Neural Networks use to classify existing signals and create neural signals with desired data.

Develop software in Python to manage and redesign the neural networks I will use to analyze those signals and link them to a database to easily bring out differences and similarities.

The language doesn't matter but I think Python is a good choice as it is simpler than most languages and well known even in science communities not specialized in coding.

### **Objectives adjusted to ensure my work will be usable in other similar fields:**

Based on my experiences I think it's important to keep, as much as possible, my work compatible with similar situations, even more within the research community.

Since the main work in this project is about signal processing using Neural Networks (NN), I think I should reevaluate the primary objective to:

Develop software which will support the user when creating NN and redesigning existing ones dedicated to the classification of pseudo-periodic signals. It must be also possible to manage easily the associated data.

### **Preparatory work:**

- Establish a network of contacts specialized in Deep Learning and signal processing.
- Contact laboratories specialized in neural signal processing to obtain as much data as possible and share my work with them.
- Contact other laboratories who possess and need to classify a lot of data containing pseudo-periodic signal. My Neural Network managing software has to be usable in similar fields so I will need this kind of data to test it (seismology, astronomy, meteorology, etc).
- Establish what data are essentials to the NN amongst those available.
- Create scripts to standardize those data as soon as I obtain samples.
- Research how work biological neural networks depending certain situation to develop a better NN algorithm.
- Collect researchers work over style transfer using Deep Learning and see how to adapt it to my project. It will be necessary to get our NN to construct signals based on the data we want to be understood by the brain and what the NN learnt.

### **Software development:**

Develop a Neural Networks management application with 3D modeling of NN significant parts (neurons' bias and branches):

Management of NN: selecting part of a NN, editing its values, reset their learning state, save/lock, paste it to another NN.

Creation of a new experimental Neural Network which won't process the information in one pass, going from the start to the end of the tree representing the NN.

This NN will do a work similar to a Convolutional NN but rather than giving it the entire data in one time, it will be partially sent over multiple pass. As for a real neural network, I will add branches to the neurons connected to themselves (recurrent axon collateral) and maybe to neurons from a precedent layer. Also, at each pass the value retained in each neuron will be slightly reduced before being modified.

I believe this kind of NN to be more efficient and letting the possibility to overprint significant data as it happens in biology.

Backup steps in the teaching phase to get an overview that will help editing/locking some part of the NN when resetting the teaching phase.

Profile implementation to select and record networks dedicated to the field observed (biological signals, seismic waves, any specific type of pseudo-periodical signal)

-Over the months multiple additions to the application will be necessary and possibly asked by other laboratories such as the possibility to set the location of data on another computer or setting a distant server dedicated to Deep Learning computation and so on.