**Decoding the sensation of pain from brain signals**

CE902 Professional Practice and Research Methodology

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**Abstract**

Due to the nature of current biology, it is hard to recognize the definition of “pain”. Pain is the most common symptom of illness that results in frequent visits to physicians for a seemingly indecisive diagnosis. By utilizing some conclusive EEG results in which a patient submerges their hands in various water temperatures, we are able to tackle one of the most consequential problems in modern medicine. This article proposes the investigation of a machine learning solution to decoding Electroencephalogram data signals and detecting pain states. The approach uses an array of standardized open-source machine learning libraries as well as niche Python frameworks to visualize, interpret, pre-process and train classification models . Although the result may not be definitive for detecting pain, it could certainly be the infrastructure on which future Computer Scientists develop their own solutions.

**Keywords:** EEG (Electroencephalogram), Python, MNE, MATLAB, PSD (Power Spectral Density)

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# Introduction

With the technology sector making up around 7.7% [1] of the UK’s economy, it seems fitting that modern artificial intelligence start to frame the way we present solutions to global problems. Machine learning is a branch of AI that uses a plethora of data and algorithms to imitate the way humans behave without having to be programmed manually. The idea behind modern classification and regression is to memorize data and present outcomes based on the previous experiments. These outcomes are what drive decision making in many corporate businesses and impact financial growth metrics. Furthermore, machine learning; whilst ever evolving, is arguably complex enough to be able to estimate biological instances that humans struggle to dictate themselves.

As previously stated, the term “pain” tends to have a diverse range of meanings with no definitions being able to capture the entire state of the problem. Combined with either large health databases, or mere experimental study results, data scientists have the opportunity to train models to detect what humans can only infer; for example, to detect when someone is in pain. This could be done by utilizing EEG electroencephalogram data and training a classification model to recognize events deemed as a person being in a “pain” state. Although pain is counterfactual in that we cannot observe both treatments; experiments can be undertaken to simulate pain to the brain thus allowing us to evaluate the results of training a machine learning model.

The proceeding article can be categorised into six vital sections, the first of which will be a summarisation of background reading in regard to both machine learning and how the data used in this project has previously been used. It will feature some referenced research paper’s and provide a brief overview of the methodologies that have been adopted, as well as the results made from their efforts. As well as previous studies, the experiment used to frame this projects data is detrimental to its success. The project background will follow with a description of the experiment conducted, and some notes on the results that were taken from its output. The project objectives will then be stated making sure to outline the focus of this article, as well as the takeaways that should be reflected by its results. As with all research paper’s that focus on machine learning; this article has limitations in regard to its scope whether the focus be on computational power or deliverable dates that need to be met without deviation.

Arguably the most important section of this article, the technology and tools chapter will explore all the different software instruments proposed to complete the project. These range anywhere from small open-source python packages to hardware tools used to collect the data. A brief explanation into each’s inner workings will be given, as well as an insight as to how it will be used specifically in its implementation. The technology and tools will lead into a full evaluation of the proposed solution in which the author will state the project plan in the form of a Gantt chart. As well as visualizations of how the project is to be completed, the section will explore a more detailed description of the solution devised to detect pain states given our training data. Being that this project is early in its development, and no active steps have been taken to evaluate the potential success of its implementation, all the decisions made are subject to change at any point.

The final section of this article will investigate how we plan to evaluate the validity and accuracy of our conclusions; these include: the particular machine learning metrics, how we will optimize our hyperparameters and finally how we will test our classification model.

## Research Question and Hypothesis

The presence of a hypothesis in data science projects, is to predict what the author’s research will conclude. It starts by stating the problem that clearly defines the topic and producing a null an alternative hypothesis to shape the predictions of the project outcome. Typically a hypothesis determines the relationship between two variables; speculating whether they affect each other, however in regard to this investigation, the hypothesis is framed to predict whether the presence of a pain state can be detected from EEG signals thus can be interpreted as more of research question. The vital difference between a hypothesis and a research question, is that a research question is typically more debatable and will define a clear path for the implementation being suggested. Due to the scope of this project being extremely broad with a plethora of different possible outcomes, it is possible to derive a large number of research questions. This being said, it can be argued that two, well formed, concise research questions, benefit the investigation and it’s readers by defining a clear objective that everybody can track as the project progresses.

The research questions for this research paper are as follows:

* Blah Blah
* Bah Blah

# Project Background

## Research Paper One

## Research Paper Two

## Project Experiment

### EEG Data

# Project Objectives

## Project Goals

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# Technologies and Tools

## Tools

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## Gantt Chart

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## Hyperparameter Testing

## Results Testing

# References

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