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Machine Learning-Driven Deep Brain Stimulation Programming

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Master's Artificial Intelligence

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Background

- Deep brain stimulation (DBS) involves planting a neurostimulator to deliver electrical impulses to specific areas of the brain to treat movement disorders like dystonia.
- DBS programming is the process of adjusting the settings of the neurostimulator to optimize the therapeutic effects.

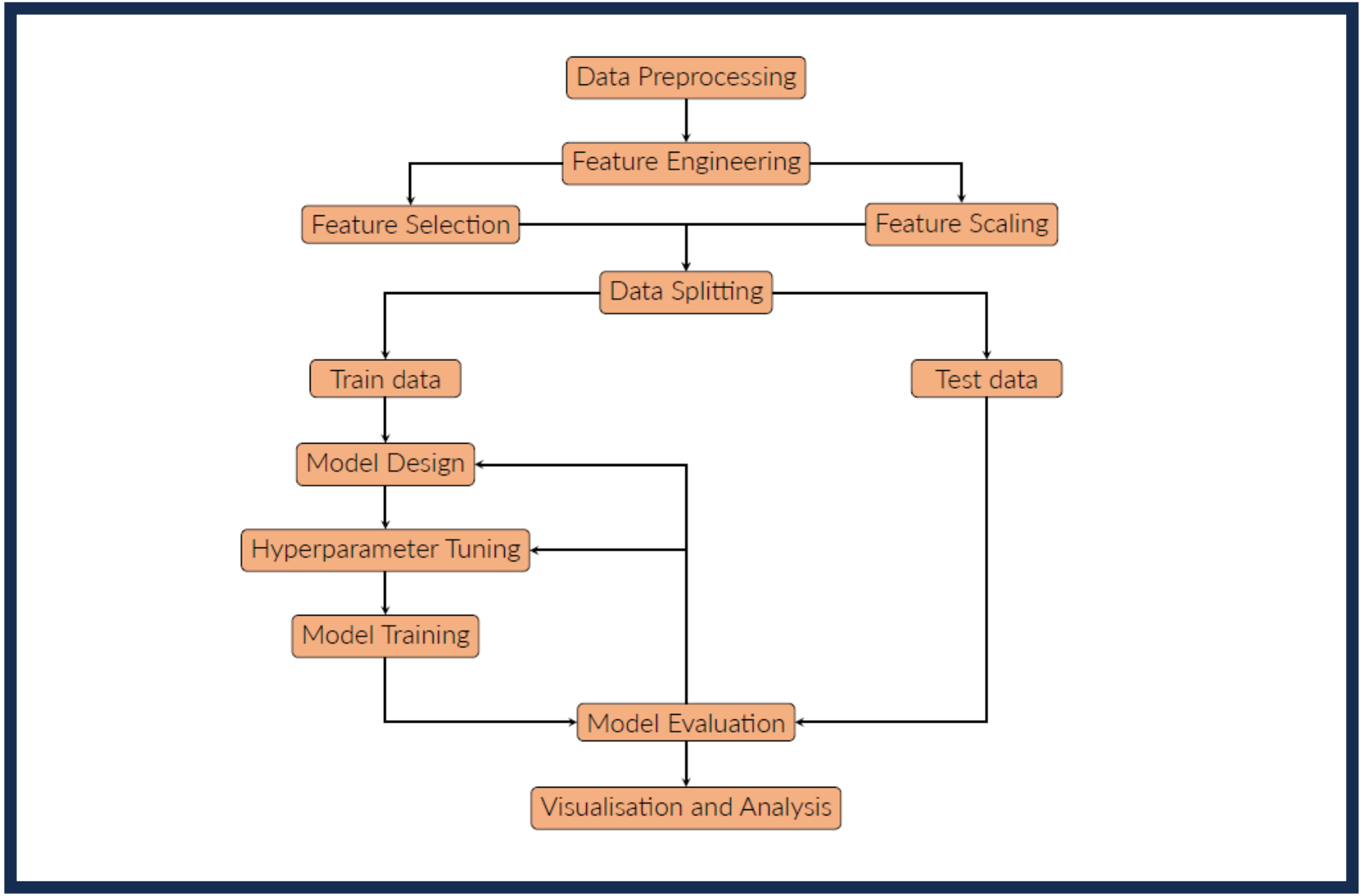
Problems

- DBS Programming is time consuming.
- It is a demanding trial-and-error process.

Solution

- Machine learning algorithm to predict optimal programming parameters that maximize the improvement of a patient's symptoms.

Methodology



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From Data to Optimal Therapeutic Effects: Machine Learning-Driven Deep Brain Stimulation Programming

Esther Ademola, Parviz Zandian
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Deep Brain Stimulation (DBS)

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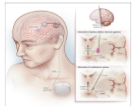


Figure 1: A lead electrode is implanted into the left and right hemisphere of the brain of patients undergoing DBS. Using the handheld DBS programmer, the current delivered is adjusted by fine-tuning multiple parameters (i.e amplitude, frequency, pulse width) in order to provide the best symptom relief [1].

Objectives

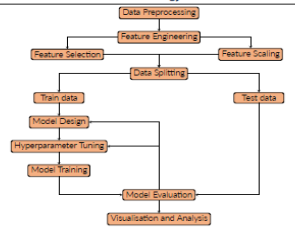
1. **Develop** a machine learning model to predict optimal programming parameters for DBS.
2. **Create** a learning aid to support medical professionals with their use of the developed model.

Data and Toolbox

Data
- **Description:** The dataset comprises records from 85 subjects diagnosed with dystonia who underwent chronic bilateral pallidal DBS. The data were collected from six different European DBS centers [2].
- **Preprocessing:** The dataset has undergone preprocessing, conducted by scientists in VisualDBS lab at the University Hospital Würzburg.

Toolbox
- **Source:** The preprocessing of the data was performed using a specialized toolbox, *Arena*, developed by the VisualDBS lab at the University Hospital Würzburg.
- **Description:** *Arena* encompasses a range of preprocessing and transformation techniques tailored for DBS data analysis. It includes functions for data cleaning, normalization, artifact removal, and feature extraction.

Methodology



Current Accomplishments

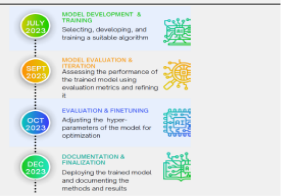
- Topic and dataset comprehension
- Literature review
- Conversion of code from MATLAB to Python

Challenges

Problem	Description	Solution
Lack of domain knowledge	Ignorance in neuroscience is an hinderance to developing an effective ML model in this domain	• Collaborate with medical professionals • Literature review
Limited training data	With a small dataset, there may be insufficient examples to capture the full complexity and variability of the problem	• Employ suitable models that can cater to the dataset size • Utilize cross-validation techniques
Comprehension of toolbox	Understanding the pre-existing implementation and code	• Consult with the developers

Project Repository

Future Work



Conclusion

- **Objective**: Develop a machine learning model to predict optimal programming parameters for deep brain stimulation (DBS) in neurological treatment.
- **Dataset utilization**: Leverage datasets to train machine learning algorithms for accurate parameter prediction.
- **Goal**: Maximize symptom improvement while minimizing side effects through precise parameter prediction.
- **Future focus**: Implement and evaluate the proposed machine learning model.
- **Significance**: Enhance symptom management and improve patients' quality of life.

References

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[2] Martin Reich, Andreas Horn, Florian Lange, Jonas Roothans, Steffen Paschen, Joachim Runge, Fritz Wodarg, Nikolo Rossi, Karsten Witt, Robert Hein, Laus Skousand, Siobhan Evans, Virgine Hellwig, Matthias Wittstock, Lars-Heiye Schneider, Volker Coenen, Philipp Mahlknecht, Werner Poewe, Wilhelm Eisner, and Jens Volkmann. Probabilistic mapping of the antidystonic effect of pallidal neurostimulation: A multicentre imaging study. Brain, 142:3756–3771, 09 2019.

[3] Jan Roediger, Tri Dembek, Johannes Ashkanin, Johannes Duesh, Anne-Pauline Krikmer, Katharina Faust, Carol-Heiye Schneider, Patricia Krause, Andreas Horn, and Andrea Kühn. Automated deep brain stimulation programming based on electrode location: a randomised, crossover trial using a data-driven algorithm. 13 2022.

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Thank you