Research Assessment #5

Objective: To explore how computational neuroscience methods, especially machine learning, are applied to Alzheimer's disease diagnosis, and to understand how techniques like XGBoost and evolutionary computation enhance model optimization in the field of computational neuroscience.

How Computational Neuroscience is relevant to me:

The journey since I began ISM in August has been a transformative one. When I first started, I had a budding interest in biomedical engineering but knew almost nothing about the field. Fast forward to December, and I now have a clearer understanding of the advancements being made and a more focused perspective on what I want to explore in the future.

Initially, I was drawn to the neurological aspects of biomedical engineering and was curious about how the brain could be studied and improved through technology. As I began thinking about my original work for ISM, I envisioned creating an informational website for students like me—those who have no idea where to begin with biomedical engineering. My plan is to document my journey and, using platforms like Fusion360, design a medical device that could inspire others.

However, I soon realized that even "neuroengineering" was too broad a term for the specific area I wanted to pursue. During my research, I discovered the niche field of computational neuroscience. This discovery resonated with me because it combines my interest in the brain with cutting-edge technology and problem-solving.

What is Computational Neuroscience?

The Organization for Computational Neuroscience defines the field as "an interdisciplinary field for development, simulation, and analysis of multi-scale models and theories of neural function from the level of molecules, through cells and networks, up to cognition and behavior." In simpler terms, the brain is a complex part of the body with millions and billions of electrical signals that are constantly performing various functions. Computational neurosciences provides a way to analyze the brain with a scientific framework to study and understand its processes. This method of study uses maths to zoom into singular nerves, molecules, cells or smaller networks to thoroughly analyze what is happening. This field bridges biology, mathematics, and computer science, making it a powerful tool for advancing neurological research and developing innovative solutions in healthcare.

Key Lessons from Workshop:

1) **Data Handling and Kaggle Usage**:
   Acquisition and processing of relevant data is one of the first steps in computational neuroscience. During this workshop, the Alzheimer's biomarker dataset was introduced, including participant demographics and biomarkers. Being able to structure and manipulate that data with tools like Kaggle is an important part of developing the models. Learning to split the

data into training and testing sets will enable machine learning algorithms to generalize and make predictions about unseen data.

2) **Machine Learning for Alzheimer's Diagnosis**:
   Machine learning, more specifically supervised learning, stands at the core of computational neuroscience. This workshop focused on a classification task: predicting the probability of a patient having Alzheimer's disease based on biomarkers. To enhance the predictive accuracy, models like XGBoost are applied, which is one of the most famous boosting algorithms. This directly links to how computational neuroscience can aid in understanding brain health by translating large-scale biological data into meaningful predictions.

3) **Optimization via Evolutionary Computation**:
   Model optimization is crucial in computational neuroscience for the improvement of predictions. It was introduced as one of the methods of hyperparameter tuning, inclusive of genetic algorithms, which are under the category of evolutionary computation. This lets researchers tune the machine learning model to make finer predictions. It was shown in this workshop that optimizing these models with such algorithms may lead to more reliable outcomes when diagnosing Alzheimer's disease, an application very much related to health and computational neuroscience.

4) **Feature Importance Analysis with SHAP**:
   Being able to understand which features in the model contribute most to its predictions is crucial to model interpretability. This section has used Shapley Additive Explanations to help illustrate how different features influence a model's output. With regard to diagnosing Alzheimer's disease, it points to

the most relevant biomarkers-age, gender, or specific brain scans-which are more informative for making predictions about the disease.

Assessment:

I truly enjoyed this workshop; it gave me a clear picture of how computational neuroscience finds its application in healthcare on the ground, especially in the diagnosis of Alzheimer's disease. Integrating machine learning into brain health research is something very interesting, and I could see how this field was transforming the way neurological disorders are studied and treated. I am excited to dive deeper into computational neuroscience and explore its potential further. The hands-on experience with tools like Kaggle, XGBoost, and SHAP has sparked my curiosity, and I look forward to learning more about the computational methods used to decode complex brain functions. This fits right into my area of biomedical engineering, and I look forward to the continued pursuit of innovative technology being used to better neurological health.

Work Cited:

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