Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Integrative Analysis of ADHD Using Graph Kernels on UK Biobank Multimodal Data

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Project details:

Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental condition marked by challenges with inattention, hyperactivity, and impulsivity. Globally, it affects about 5% of children, with 30–50% continuing to experience symptoms into adulthood, leading to challenges in education, employment, and relationships. In the UK, the National Institute for Health and Care Excellence (NICE) estimates that ADHD affects around 3–4% of adults. Despite its widespread impact, the precise etiology of ADHD remains elusive, necessitating comprehensive research to unravel its complex biological underpinnings.

The Imperative of Data Integration: ADHD's etiology is multifaceted, involving genetic, environmental, and neurobiological factors. Analyzing each data modality in isolation may overlook critical interactions and lead to inconclusive findings. The UK Biobank provides a comprehensive biomedical dataset from half a million participants, invaluable for ADHD research. It spans multiple modalities, including demographic information, cognitive assessments, genetic data (SNPs), proteomics, metabolomics, and neuroimaging. This dataset supports holistic analyses of ADHD's multifactorial etiology. Integrating these diverse datasets is essential to enhance signal detection amidst the inherent noise of biological data. A unified analytical approach can uncover complex relationships and provide a more comprehensive understanding of ADHD's pathophysiology.

Model integration: Graph Kernels and Graph Neural Networks as a Flexible Approach to Multimodal Data Integration Graph-based methods effectively model complex biological systems by representing entities as nodes and their interactions as edges. Graph kernels enable comparisons by capturing structural similarities and can be tailored to specific data modalities: modeling SNP interactions in genetics, protein and metabolite networks in proteomics and metabolomics, epigenetic patterns, and brain connectivity in neuroimaging. Integrating these modality-specific kernels creates a comprehensive model to uncover ADHD biomarkers and therapeutic targets. Furthermore, feature descriptors derived from each graph kernel can be integrated using deep graph neural network techniques, enhancing the model's capacity to learn complex, non-linear relationships across diverse data types.

Research Objectives: This PhD project aims to:

1. Develop Modality-Specific Graph Kernels: Design and implement graph kernels tailored to each data modality within the UK Biobank dataset.

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2. Integrate Multimodal Data: Combine these kernels to create an integrative model that captures the complex interactions underlying ADHD.

3. dentify Biomarkers: Utilize the integrative model to discover biomarkers predictive of ADHD diagnosis and progression.

4. Enhance Understanding of ADHD Pathophysiology: Provide insights into the biological mechanisms contributing to ADHD, informing future research and therapeutic strategies.

5. Work alongside an advisory group of people with lived experience to inform and shape the research project**

Expected Outcomes: The proposed project aims to develop an analytical framework that integrates diverse biological data to elucidate the complex etiology of ADHD. Anticipated outcomes, suitable for dissemination through scholarly publications, include:
1. Development of customized graph kernels for different data modalities, highlighting their utility in ADHD research.
2. Integration of these kernels into a unified model using graph neural networks (GNNs) to identify biomarkers and understand ADHD's pathophysiology.
3. Evaluation of the integrated model's predictive accuracy for ADHD diagnosis and progression using UK Biobank data, compared to single-modality methods.

Project specific entry requirements:

- R coding
- Background in data science, computer science or bioinformatics
- An understanding of mental health, desirably neurodevelopmental conditions
- Python coding (desired)

Potential PhD programme of study: PhD in Psychology

Department: Psychology

Location: Washington Singer

Please direct project specific enquiries to: Dr Doretta Caramaschi

Please ensure you read the entry requirements for the potential programme you are applying for.

To Apply for this project please click on the following link - **APPLY HERE**