Project suggestions from Dr Sarah Morgan

Project 1:

Supervisor: Dr Sarah Morgan sem91@cam.ac.uk

Magnetic Resonance Imaging (MRI) scans of the brain can be used to derive multiple high-resolution features that offer useful information about brain structure. For example, information about cortical thickness, myelination, and folding patterns can all be estimated from common brain scans. Each of these structural features is closely related to each other – for example, the cortex tends to be thinner in less myelinated areas and at the crowns of brain folds. However, due to nonlinear, spatially-varying relationships between each of these structural features, there currently lacks a fundamental understanding about how each of these structural features relate to each other in different parts of the brain, and the extent to which they capture redundant information.

In this MPhil project, the student will devise a probabilistic dimensionality-reduction model to understand whether there exists a limited number of latent variables that can explain the complex relationship between commonly-used brain structural features in different brain regions. Moreover, in a large-scale dataset, the student will study how these latent variables differ across individuals and probe how they develop over time and/or their implications for cognitive traits and psychiatric disorders. The project will be suitable for students interested in neuroscience and probabilistic modelling, and will hopefully lead to fundamental insight about the generation of the structural architecture of the human brain.

This project would suit a student interested in neuroimaging data, and applications of machine learning to neuroscience and mental health research. The student will also benefit from being part of the Accelerate Science programme, which brings together researchers using machine learning to accelerate progress in scientific research.

Project 2:

Supervisor: Dr Sarah Morgan sem91@cam.ac.uk

Functional Magnetic Resonance Imaging (fMRI) data offers an unparalleled, non-invasive window into the functional organisation of the brain. Substantial research has shown that fMRI scans can help understand and predict mental health conditions, from shedding light on differences in brain activity between patients with mental health conditions and healthy control subjects, to predicting disease trajectories for individual patients.

However, one key challenge in analysing fMRI data is site effects, or systematic differences in feature distributions across different sites or hospitals at which data can be acquired. These differences come from several sources, including the use of different scanners, head coils and scanning sequences. Common approaches to remove site effects include statistical approaches such as the ComBAT software (Fortin et al, Neuroimage 2017), but often also remove important biological variability. Recent work has employed Generative Adversarial Networks (GANs) to remove site effects from structural brain images, but so far few researchers have applied GANs to fMRI (Bayer et al., Front. Neurol., 2022). Here we propose to explore the use of GANs to remove site effects from fMRI data, whilst retaining information that can distinguish patients with psychotic disorders from healthy control subjects.

This project would suit a student interested in neuroimaging data, and applications of machine learning to neuroscience and mental health research. The student will also benefit from being part of the Accelerate Science programme, which brings together researchers using machine learning to accelerate progress in scientific research.