CRUK Cambridge Centre MRes rotation project

Rotation Project Title	Artificial Intelligence directed integration of imaging, pathology and genomics data to identify prognostic features and improve prostate cancer diagnosis
Head of Laboratory (PI) Name	Charlie Massie (Oncology)
Second supervisor if applicable	Shamith Samarajiwa (MRC Cancer Unit)
Programme	Early Detection Programme
Supervisor's Email	cem45@hutchison-mrc.cam.ac.uk ss861@mrc-cu.cam.ac.uk
Laboratory Location	Hutchison/MRC Research Centre

Project Outline	**Aims and objectives** Multi-parametric magnetic resonance imaging (mpMRI) is the emerging gold standard for prostate cancer diagnosis [1-2]. Men with suspected prostate cancer are classified using mpMRI, blood tests (PSA) and clinical features to determine who should receive trans-rectal diagnostic biopsies. However, 1-in-5 patients with highly suspicious lesions on mpMRI have benign disease and there is a similar risk of missing significant cancers. These data highlight limitations in the current diagnostic pathway and the need for more accurate tools to support clinical decision making. The long-term aim of the project is to spare tens of thousands of men each year from unnecessary invasive diagnostic procedures, while minimising the risk of missing significant cancers. Specifically, this project will develop AI based data science approaches to achieve the following aims: • Combining genomic data sets together with rich clinical and pathology data to mechanistically classify tumour samples [3] • Develop pixel level image analysis methods [4], training on 100 MRI scans with paired pathology and genomics data [5] • Apply these methods to validation cohorts in the diagnostic pathway to test the impact of AI approaches on diagnostic accuracy • Explore the added value of AI approaches to existing patient prognostication models [6]
Experimental plan	This project will apply deep neural network (DNN) approaches coupled with cross-modal machine learning (ML) methods and computational genomics, using imaging, pathology and genomic data collected from patients in the prostate cancer diagnostic pathway. Convolutional Neural Network analysis [4] of multi-parametric magnetic resonance imaging (mpMRI) data at the pixel level will be used to segment and classify diagnostic/prognostic features and these will be integrated with paired pathology diagnostics (ground truth) and genomics [3] data with the aim of improving diagnostic accuracy and informing the design of new imaging sequences and companion diagnostic tests. This exciting cross-disciplinary project will enable the selected student interact with and active clinical research team and two laboratories; the Massie lab, which will provide data sets and expertise in prostate cancer biology/bioinformatics and the Samarajiwa lab, contributing expertise in Data Science (including AI and ML approaches) and Computational Genomics.

Main Techniques	• Deep Neural Networks, Machine Learning (CNNs, Cross-modal representation learning & Transfer learning methods) • Computational Genomics • Data Science: Data Integration and Visualization, Statistical Modelling
Key References	1. Kasivisvanathan V et al. MRI-Targeted or Standard Biopsy for Prostate-Cancer Diagnosis. N Engl J Med. 2018; 378(19):1767-1777. 2. Kasivisvanathan V et al. "Don't Let the Perfect Be the Enemy of the Good": Time to Embrace Magnetic Resonance Imaging Before First Prostate Biopsy. Eur Urol. 2018; S0302-2838(18)30437-8. 2. Park Y, Kellis M. Deep learning for regulatory genomics. Nat Biotechnol. 2015; 33(8):825-6. 3. Tian Z, Liu L, Zhang Z, Fei B. PSNet: prostate segmentation on MRI based on a convolutional neural network. J Med Imaging (Bellingham). 2018; 5 (2):021208. 4. Wedge DC et al. Sequencing of prostate cancers identifies new cancer genes, routes of progression and drug targets. Nat Genet. 2018; 50(5):682-692. 5. Gnanapragasam VJ et al. The Cambridge Prognostic Groups for improved prediction of disease mortality at diagnosis in primary non-metastatic prostate cancer: a validation study. BMC Med. 2018; 16(1):31.