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Precision Imaging Beacon of Excellence
Studentship Form

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Start date	September 2018	**Duration**	3 years
Project	**Towards better and individualised characterisation of multiple sclerosis using deep learning**		
Project abstract	Despite advances in our understanding of the pathogenesis of Multiple Sclerosis (MS), diagnostic methods have changed little over the last 30 years. Incorrect and delayed diagnoses remain common problems, impeding the understanding of the disease mechanisms. Although magnetic resonance imaging (MRI) has greatly enhanced the diagnostic process, it has also contributed to the misdiagnosis of MS. The commonest diagnostic errors are from misinterpretation of non-specific brain "lesions" seen on MR images. To date we have been unable to tell whether these lesions are caused by MS or other conditions. Pathologically we have known that MS lesions have a central vein, whereas, in lesions arising from other conditions, no central vein is seen. Knowing the presence of this vein to be specific to Multiple Sclerosis we have first reported a novel MRI test that allows us to detect the presence/absence of a vein within white matter lesions. Using ultra high field (7T) MRI, this can accurately distinguish between MS and non-MS patients. Despite the potential, the detection of lesions with a central vein is currently done manually and heuristics are used to characterise disease status. Moreover, it is less obvious and more challenging to detect such lesions at 3T, which is the field strength typically found in clinical centres. The PhD project has three main **Aims**: 1) Develop *deep convolutional networks* that learn the difference MS/non-MS lesions and make the decision automatically using FLAIR and T2*sequence or FLAIR * images acquired by state-of-the-art, but non-clinical, 7T MRI scanners. 2) Learn a mapping between the features of MS lesions as they appear on 7T images and the way lesions are depicted on 3T (or even 1.5T data). We hypothesise that MS cases with 7T FLAIR* can be uniquely mapped to a multivariate combination of 3T images (e.g. FLAIR/T2*/diffusion FA), not visible to the naked eye. We will use *machine learning (e.g. random forests)* to explore these mappings and open new avenues for how to distinguish MS lesions using clinical scanners. 3) Explore the generalisability of the developed technology and perform *data mining* on images of multiple sclerosis patients from a population-level imaging study, such as the UK Biobank (currently 20,000 subjects available, with the aim to reach 100,000 subjects). **References** 1. Tallantyre EC, Dixon JE, Donaldson I, et al. Ultra-high-field imaging distinguishes MS lesions from asymptomatic white matter lesions. Neurology 2011; 766: 534–539. 2. Mistry N, Dixon J, Tallantyre E, et al. Central veins in brain lesions visualized with high-field magnetic resonance imaging: A pathologically specific diagnostic biomarker for inflammatory demyelination in the brain. JAMA Neurol 2013; 705: 623–628 3. K. Kamnitsas, C.Ledig,V Newcombe et al Efficient multi-scale 3D CNN with fully connected CRF for accurate brain lesion segmentation Medical Image Analysis 2016, Volume 36, Pages 61-78		
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