PhD Project
Deep Learning for Medical Imaging

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The project is aimed to perform the analysis of medical images to detect the structures and activities inside the human body. You will have opportunities to gain experience with the industry-demanding deep learning tools such as TensorFlow or Keras, and the commonly-used deep learning networks such as Convolutional Neural Network (CNN), U-Net and Generative Adversarial Network (GAN).

Project Description

Medical imaging seeks to reveal the structures and activities inside the human body that are normally invisible behind other body parts such as skin and bones. With a wide range of imaging technologies such as radiography, magnetic resonance imaging, ultrasound, echocardiography and tomography, it has long been of great importance in clinical practices for measurement, identification, location and structural analysis of targeted organs, tissues or areas of abnormality. In this project, we will address the following key problems of medical imaging using deep learning methods.

1. Segmentation and structural analysis. Within the commonly used architecture of U-Net, we propose to add the residual blocks to protect the low-level information transmission and recurrent blocks to capture the global spatial structure. However, the end-to-end architectures, even with the directly links from the down-sampling layers to the up-sampling layers, may still suffer from inaccurate segmentation at details. To address this problem, we will work on further refinement of the results using fast graph search methods. Also, to improve the segmentation accuracy at multiple scales, we will concatenate the output from various up-sampling layers to the output.

2. Image registration. The objective is to establish the pixel-to-pixel alignment between a pair of input images from the same patient at different time, from different patients, or images from different imaging modalities. We will work on the conventional feature-based image registration methods as a baseline for this problem. In addition, we propose to develop a deep regression neural network that explicitly use the structural information to guide the search of the deformation mappings. The mappings are modelled into the cost function therefore alignment by these structures is enforced in the learning process.

3. Image generation. Training a model for segmentation of structures or classification of diseases required labelled data, but labelling large set of images is a tedious and time-consuming process. We propose to use synthesised images with their corresponding labels to augment the training data set to improve the performance. We will investigate the potential performance gain from an augmented data set using the Generative Adversarial Network (GAN). Various types of image generation will be investigated, including from images to target structures, from structures to images, and between images of different imaging modalities

Project Impacts

We have an extensive research experience in the relevant areas of medical image analysis and machine learning. Over the past years, we have produced numerous publications and have won best paper prizes in international conferences including MVA 2019, Bioimaging 2018 and HIS 2012. The proposed project is a continuation of the ongoing research in these areas to strengthen our international standing.

The group have established collaborations with numerous leading hospitals in the world such as Moorfields Hospital (UK), Tongren Hospital (China) and National Centre for Cardiovascular Diseases (China). Our research outputs have been applied in the development of clinical protocol for

decease diagnosis, for example, the retinal layer profile for assessment of glaucoma progression at Tongren Hospital. The proposed project will strengthen these collaborations and make further contributions to the relevant healthcare applications.

Environment and Support

The Department of Computer Science enjoys a strong international standing for its research in both data science and artificial intelligence, as evidenced by numerous research performance metrics, e.g., 3rd in UK overall and 1st in UK for H-index from 2018-2020 (the NTU Performance Ranking of Scientific Papers, Subject: Computer Science, 2020). Data Science and artificial Intelligence has been a strategic focus of the Department for both research and teaching. The proposed research sits right in the centre of the above focus area, and covers promising topics of neural networks, deep learning, medical imaging, data fusion and generative models.

Eligibility

Applicants will be required to demonstrate that they have the following qualification, knowledge and skills:

- An Undergraduate First Class or Upper-Second Honours degree in computing, engineering, or other STEM subjects.
- A Postgraduate degree is not required but may be an advantage.
- Strong programming skills, ideally in Python, but other languages also acceptable.
- Good knowledge in machine learning, deep learning and artificial intelligence.
- Knowledge of deep learning models such as Convolutional Neural Networks, Recurrent Neural Networks and Generative Models may be an advantage.
- Highly motivated to learn.
- Able to work independently as well as collaborating with others in a team.