Deep Learning for Ischaemic Stroke Lesion Segmentation on Acute Non-Contrast CT

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NHS

What is ischaemic stroke?

- Stroke is a life-threatening condition in which blood supply to part of the brain is cut off, causing cells to become damaged and die.
- In ischaemic stroke, a clot forms or becomes lodged in a blood vessel in the brain, cutting off the flow of blood – and therefore oxygen – to the area that vessel usually supplies.
- The sooner a stroke patient is treated, the better their chances of recovery.

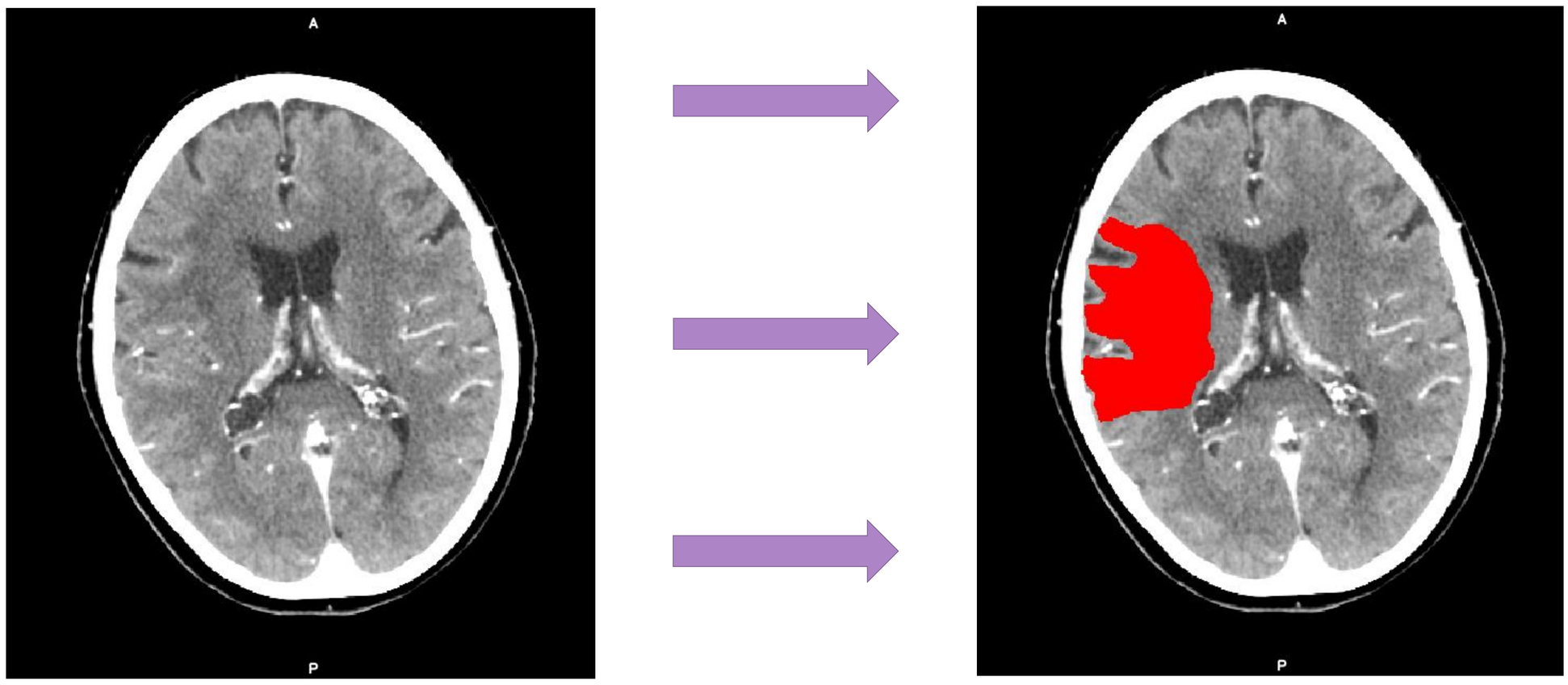
What is acute NCCT?

- A computed tomography (CT) scan uses x-rays to take a series of pictures of the body from different angles, which are then combined together into a 3D volume by a computer.
- In certain cases, a contrast material is injected or drunk which will stand out on the CT scan. In a non-contrast CT (NCCT), this is not done.
- An acute scan is taken shortly after symptom onset, when the stroke is in its 'acute' phase.

What are CNNs?

- A convolutional neural network (CNN) is a biologically-inspired learning algorithm which works particularly well with image data.
- The core building block of a CNN is the convolution operation, in which a matrix called a kernel slides over the input image.
- At each position, the sum is calculated of the dot products of each of the kernel values with the pixel value underneath it.

Can we train a classifier to detect the dead region of brain in CT scans of stroke patients?



<u>Hypothesis:</u> These scans contains subtle biomarkers which can be used for segmentation – too subtle to segment by eye, but enough for a CNN?

Challenges

- **Lack of Labeled Data:** Deep learning typically requires a significant amount of labeled data. With fewer than thirty labeled CT volumes, we must take steps to avoid overfitting.
- **Computational Demands of 3D Data:** Moving from 2D kernels to 3D exponentially increases the number of trainable weight parameters.
- **Subtlety of Early Ischaemic Changes:** This task has mostly been attempted on MRI images, which are more sensitive than CT to the changes in the brain caused by a stroke.

Objectives

1. Acquire and annotate a dataset of acute NCCT scans of ischaemic stroke patients, labeled voxel-wise into core and background.
2. Evaluate the performance of various existing state-of-the-art CNN models on our dataset so as to better understand how a CNN learns the defining features of ischaemic core.
3. Design an improved network model which optimises segmentation on our data, inspired by the strengths and weaknesses of existing models, and other background research.

Progress so far

- **Data Acquired:** We have an unannotated dataset of NCCT scans with ethics approval for its use in this project. I am now working with Dr Clatworthy to label the scans.
- **Framework Prepared:** The NiftyNet deep learning framework for medical image analysis has been installed and configured on BC4, ready to train models on labeled data.
- **Writing Dissertation:** I have made significant progress on my dissertation, including drafts of introduction and background chapters.

Next steps for this project

1. **Continue to Annotate Data:** With the help of Dr Clatworthy, a stroke neurologist at Southmead Hospital, I will continue the time-intensive task of labeling our dataset voxel-wise into core and background. I hope to label at least fifteen suitable NCCT volumes.
2. **Train Classifier with DeepMedic Model:** Using the modular NiftyNet framework, I will first train a classifier which uses the DeepMedic model by Kamnitsas et al, aiming to achieve relatively accurate segmentation results resembling theirs.
3. **Train More Classifiers with Different Models:** Once I have one trained classifier, I will train two or three more using alternative state-of-the-art network models. I will then evaluate how well each of these models performs on our data.

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