MSc in Computational Cognitive Neuroscience

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Investigating the use of convolutional networks for automatic segmentation of pediatric brain tumours.

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The importance of brain tumour segmentation.

Brain tumour segmentation is essential in the assessment of tumour growth, treatment and prognosis. Currently, segmentation is carried out manually by radiologists on patient MRI / CT scans. However, this manual process is extremely complex and time consuming.

The challenge in segmentation is the vast number of brain tumour classes and the variety of shapes and sizes within and between those classes. The main difficulty, but most important goal, is distinguishing the boundary between healthy tissue and tumour tissue, essential information for surgical intervention.

Currently, research has focused on models developed for adult brain tumour segmentation. A yearly brain tumour segmentation competition (BRaTs) encourages development in this area. Currently, less work has been done on the automation of pediatric brain tumour segmentation using convolutional networks. This presents a gap in vital research to aid the delivery of rapid and precise treatment plans to pediatric patients.

Example of brain tumour segmentation.

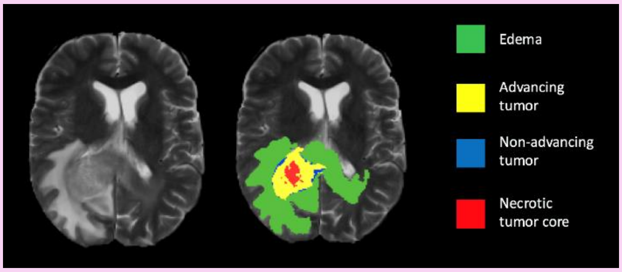
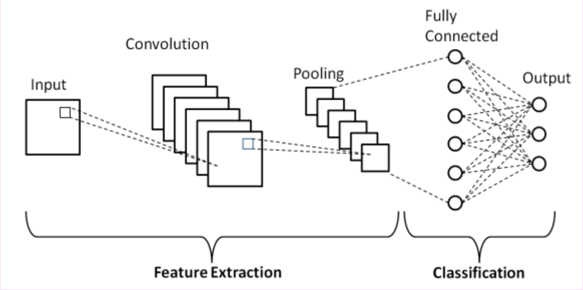


Image taken from Havaei et al.(2015)

Research goals.

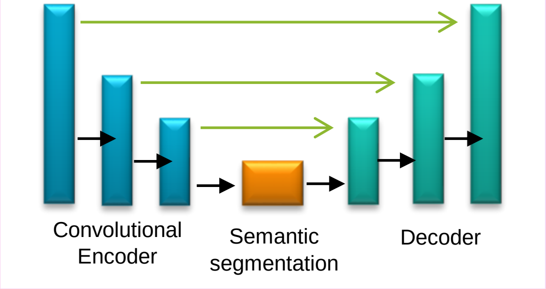
- To compare the performance of two structurally different pre-trained convolutional networks successful in adult segmentation on pediatric data.
- To tune and improve the models for pediatric segmentation.
- To begin research into the use of convolutional networks in medical diagnosis and treatment planning for pediatric brain tumours.

Model one: convolutional network architecture.



The structure of convolutional networks – convolution and pooling layers are stacked, and the output is fed into a fully connected classifier which classifies patches of the image into different segmentation classes (Pereira et al. 2016)

Model two: U-Net architecture.



U-Net has a convolutional network encoder and decoder structure. The U-net encoder never feeds into a fully connected layer, instead the compressed representation of the image is decoded back onto higher resolution image representations (Isensee et al. 2019).

Methodology.

- The data consists of retrospective clinical MRI scans of 34 pediatric brain tumour patients acquired at Great Ormond Street Children's Hospital.
- Each patient has axial T2-weighted, T1-weighted with contrast agent and ADC maps. Each scan has 25 slices amounting to 850 images for each modality.
- Data augmentation techniques will be trialed to increase the number of inputs to the network for optimal training.
- Two consultant radiologists have manually defined the tumour segmentation labels for each patient which will be used to assess segmentation performance of the models.
- Comparative evaluation of the models will be analysed via dice similarity coefficient, positive predictive value and sensitivity scores.
- Models to be run and analysed with Python 3.7, Tensorflow:Keras using a high-performance computer cluster GPU.

Hypotheses and expected results.

- Pediatric and adult brain tumours differ biologicaly, therefore models pretrained on adult data will not be optimized for pediatric data.
- The U-Net model will outperform the convolutional network model in segmentation as the structure of the U-net allows for more detailed segmentation maps.
- **Future work.**
- This research presents a starting point for further work to improve the performance of convolutional networks in pediatric tumour segmentation.
- This research should act as a benchmark for future convolutional models to be optimized for eventual use in the medical field.

Ronneberger, O., Fischer, P. and Brox, T., 2015, October. U-net: Convolutional networks for biomedical image segmentation. In *International Conference on Medical image computing and computer-assisted intervention* (pp. 234-241). Springer, Cham.

Pereira, S., Pinto, A., Alves, V. and Silva, C.A., 2016. Brain tumor segmentation using convolutional neural networks in MRI images. *IEEE transactions on medical imaging*, *35*(5), pp.1240-1251.

Isensee, F., Kickingereder, P., Wick, W., Bendszus, M. and Maier-Hein, K.H., 2018, September. No new-net. In *International MICCAI Brainlesion Workshop* (pp. 234-244). Springer, Cham.