Fully-automatic AI segmentation of subcortical regions: comparison of ATLAS and deep-learning based approaches

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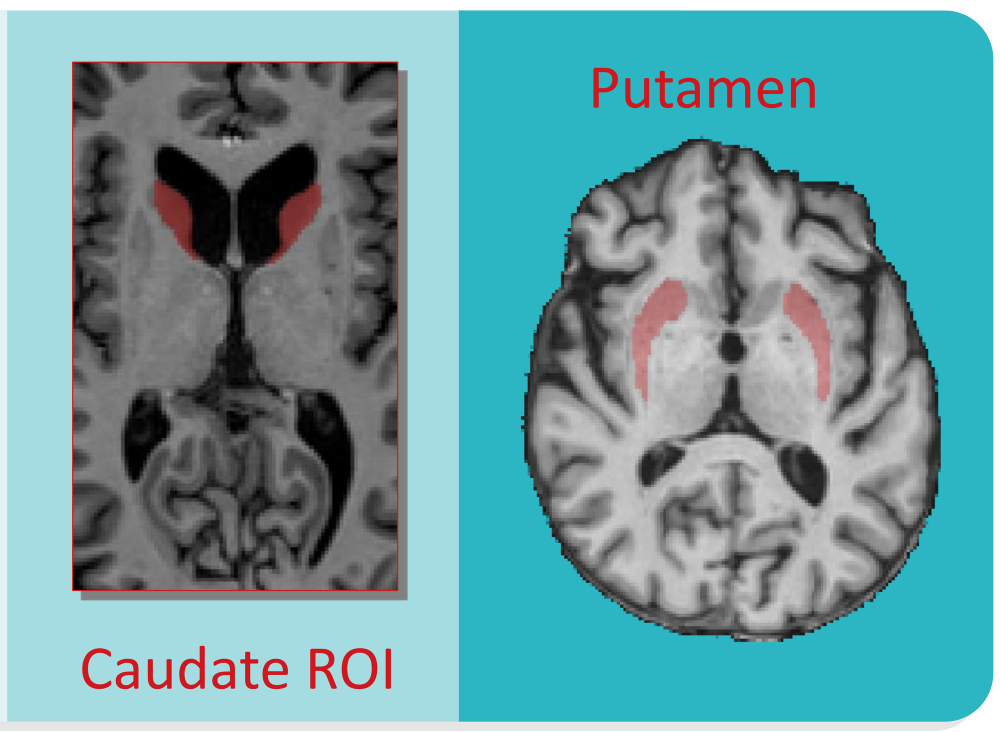
Changes in volume of the caudate and putamen are used as biomarkers to track the development of Huntington's disease and monitor the potential effect of interventional treatments. Accurate volume calculations, obtained via segmentations, are of utmost clinical importance.

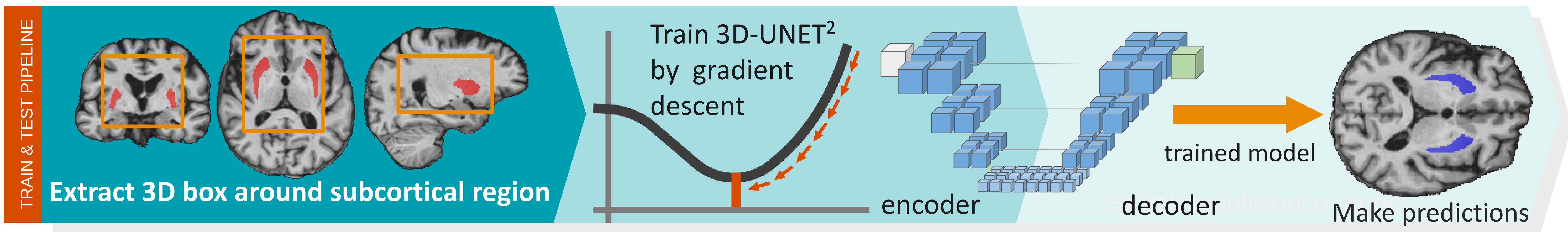
We compare two AI methodologies for anatomical segmentation, tuned for subcortical regions.

To test the models on the caudate, we used 100 manually labelled brains from an early manifest HD population. For the putamen, we used semi-automatic labels from 180 brains from ADNI[1].



Neural Network Method

A neural network is a set of operations, loosely modelled on the human brain, that by repeated exposure to 100s of examples of labelled data (caudate or putamen), learns how to predict anatomical regions at the pixel level.



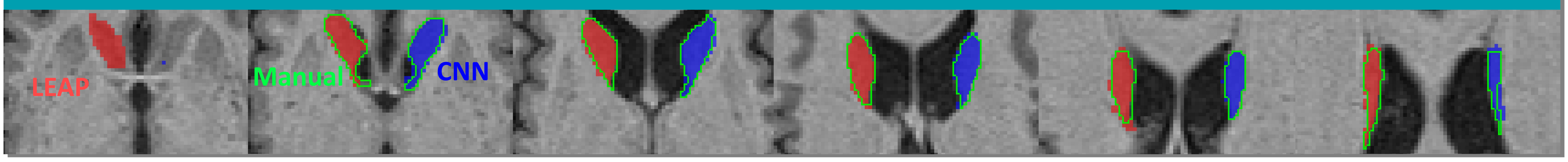
LEAP

LEAP is an atlas based approach that selects nearest neighbours in manifold space. A majority voting on these atlas's labels fuses into one prediction. Graph cut segmentation is performed on the output to refine the final prediction.

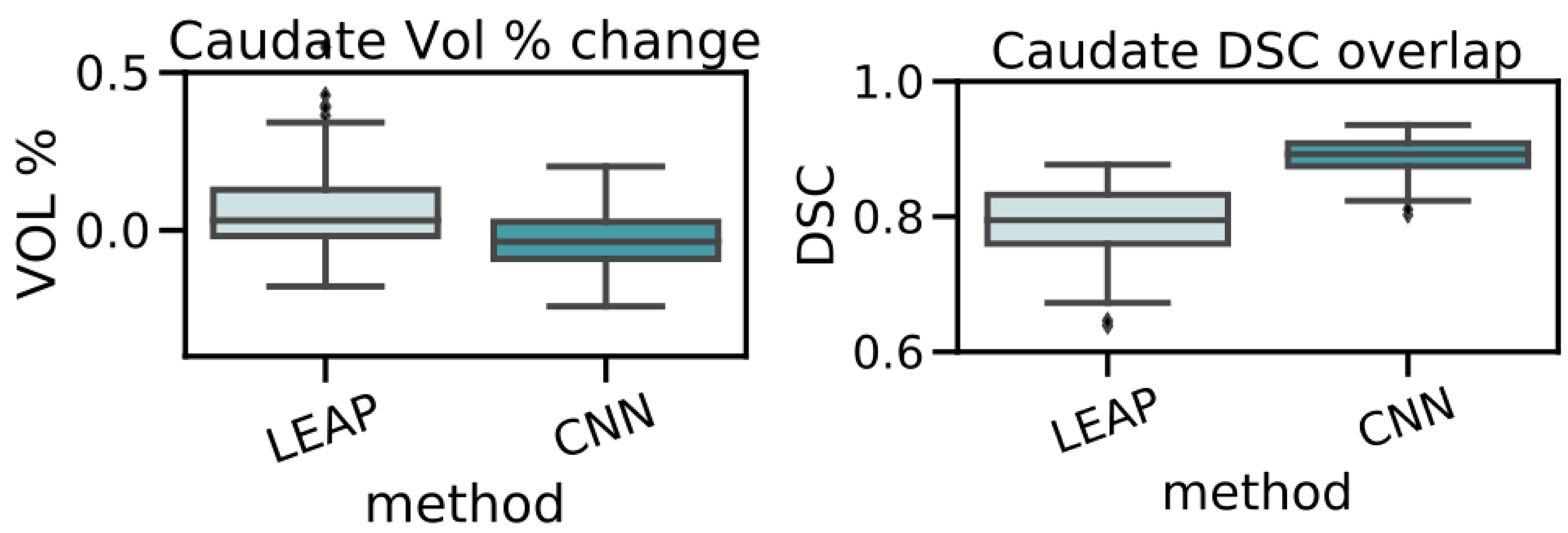
Results

For both the caudate and putamen, the neural network outperforms LEAP. Despite the hard boundary with the ventricles, the caudate is a more challenging region than the putamen for LEAP – where as the neural network is comparable for both regions.

Example caudate prediction: LEAP v CNN against manual label ground truth. L-R: moving axially through brain



To test the models' efficacy, statistics are computed across the validation set. For the caudate dataset, the two methods perform:



Putamen statistics	DICE	Execution Time
LEAP	0.8988 (0.0281)	15m 24s
CNN	0.9017 (0.00983)	1m*

*multiple brains can be run simultaneously at no extra cost, time excludes any pre-registration required

Both methodologies perform well for both regions, in terms of volume and dice metrics.

The CNN outperforms LEAP for the caudate, but for the putamen, both are statistically equivalent in terms of performance.

1. Jack Jr, Clifford R., et al. "The Alzheimer's disease neuroimaging initiative (ADNI): MRI methods." Journal of Magnetic Resonance Imaging: An Official Journal of the International Society for Magnetic Resonance in Medicine 27.4 (2008): 685-691.
2. Ronneberger, Olaf, et al. "U-net: Convolutional networks for biomedical image segmentation." International Conference on Medical image computing and computer-assisted intervention. Springer, Cham, 2015.
3. Wolz, Robin, et al. "LEAP: learning embeddings for atlas propagation." NeuroImage 49.2 (2010): 1316-1325.