Deep Learning for ELVO Stroke Detection

Purpose

Emergent large vessel occlusions (ELVOs) — the most disabling acute ischemic strokes — are primarily diagnosed through CT angiography (CTA), but require trained radiologists for rapid interpretation [1]. Recent deep learning advancements, especially in the field of image classification, show great promise to automate ELVO detection, accelerate downstream care delivery, and improve patient outcomes. This study tested the fidelity of 2D convolutional neural networks (CNNs) to detect ELVOs.

Materials and Methods

The dataset consisted of 1,212 CTAs from Rhode Island Hospital and surrounding hospitals during a 35-month period (July 2015 to May 2018); 638 patients were ELVO negative and 574 were positive in the internal carotid, middle cerebral, and basilar arteries. This project utilized both custom and pre-trained 2D CNNs (*Figure 1*). Accuracy and area under the ROC curve (AUC) were the primary metrics used to evaluate model performance.

The thin CTA data were standardized and cropped to an anatomical volume extending from the circle of Willis to the brain apex. Each cropped three-dimensional CTA was then collapsed into a stack of three non-overlapping, axial Maximum Intensity Projection (MIP) images, which displayed only the densest (brightest) pixels along the z-axis [2]. Data were split into training (80%), validation (10%), and test (10%) sets, then fed into pre-trained architectures — including Inception v3, DenseNet 121, ResNet-50, and NASNet — and custom CNNs. Hyperparameters were iteratively adjusted to improve accuracy and sensitivity.

Results

Of the architectures tested, pre-trained models significantly outperformed custom CNNs; ResNet-50 pre-trained on ImageNet data was adapted to the task at hand by replacing the top layers with three fully connected layers, achieving a peak validation accuracy of 86.3% and AUC of 0.917.

Discussion

The high accuracy and AUC values achieved demonstrate the feasibility of using a fully automated deep learning–based ELVO detection system to streamline ELVO diagnosis and treatment. We aim to conduct a prospective study that involves integrating these models into the RIH Emergency Department, and hope to perform further analysis on multiphase CTA data. These results can potentially be integrated into a platform that helps physicians at RIH and other clinics to accelerate and improve ELVO diagnosis and treatment.

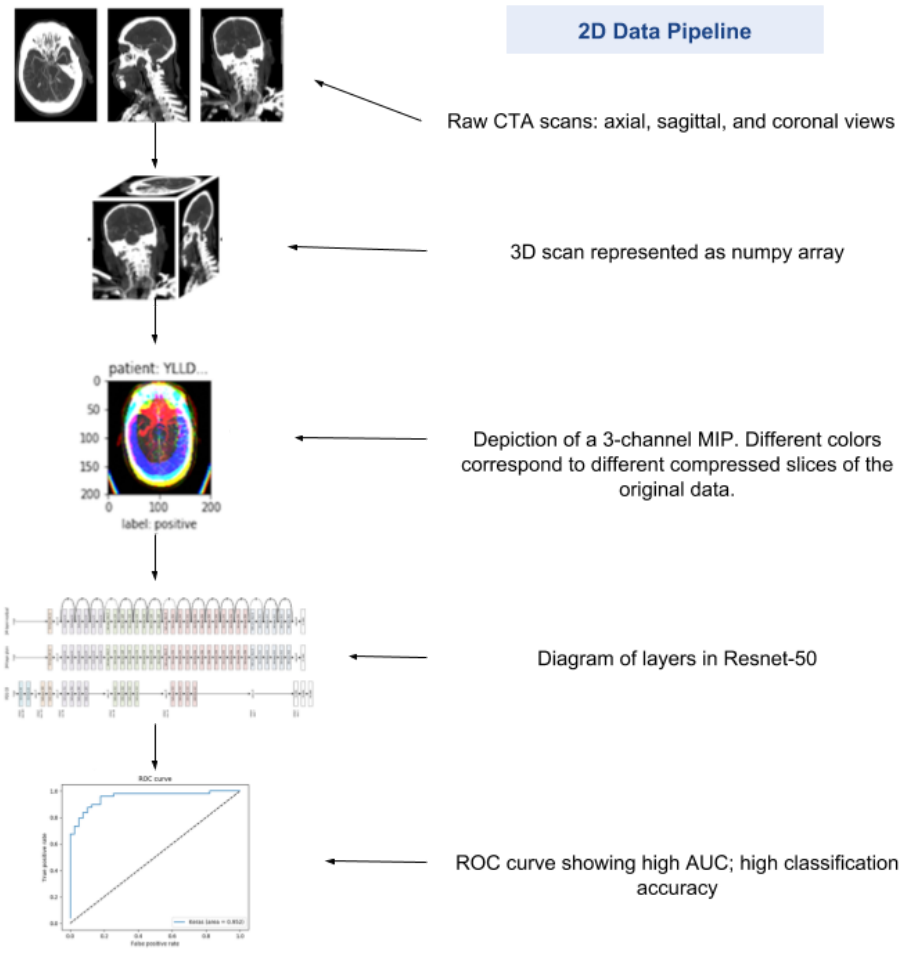

Figure 1: Flow chart showing methodology and best ROC curve.

References

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[3] Tran, D. et al. “Learning Spatiotemporal Features with 3D Convolutional Networks.” *ICCV '15 Proceedings of the 2015 IEEE International Conference on Computer Vision* (2015); 4489-4497