DeepStroke

ASPECTS Region Localization and Tissue-Aware Signal Analysis in Brain CT Scans of Stroke Patients

Graduate

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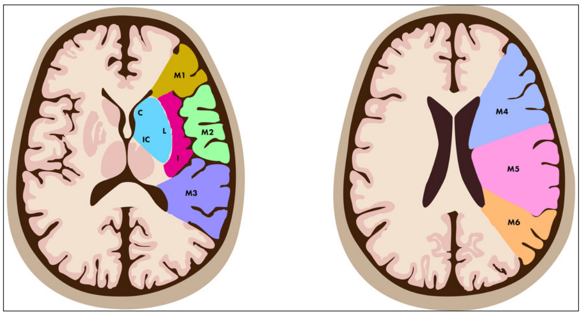
Introduction: Stroke is a major cause of death and persistent disability, making rapid and reliable imaging essential in acute care. Non-contrast computed tomography (NCCT) is routinely acquired to exclude intracranial hemorrhage and assess early ischemic change, although relevant findings can be subtle. The Alberta Stroke Program Early CT Score (ASPECTS) structures this assessment across ten regions of the middle cerebral artery territory. Automated analysis must therefore first localize these regions despite variation in anatomy and acquisition before evaluating regional image appearance. This thesis treats anatomical localization and regional signal analysis as connected but distinct problems; neither alone constitutes or validates a clinical ASPECTS score.

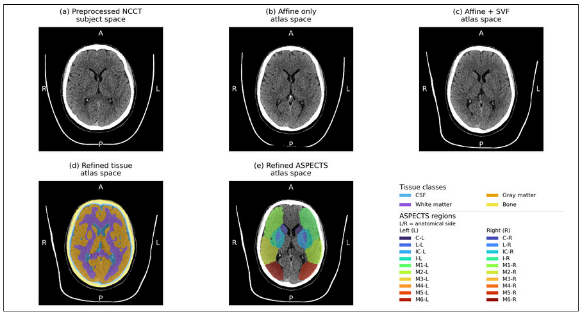
Problem: Three limitations motivate the proposed anatomy-first approach: dense anatomical labels are scarce relative to the variability of clinical NCCT; offline registration used to generate labels is costly and can turn registration errors into hidden label errors; and treating registration and segmentation independently discards spatial structure already encoded by an atlas. The proposed pipeline instead combines synthetic generation with known labels and transformations, learned atlas-to-subject registration, and propagated anatomical priors. The ASPECTS head learns corrections to its registered prior, while the tissue head uses its registered prior as features and predicts tissue logits directly, keeping atlas transport and learned prediction distinguishable.

Conclusion: DeepStroke establishes a transparent research pipeline connecting synthetic training, anatomical localization and regional analysis of non-contrast CT. Geometry-preserving data conversion, a fixed bilateral ASPECTS atlas and a population tissue prior built from 212 subjects provide a reproducible spatial foundation. Synthetic generation varies anatomy, image appearance and acquisition characteristics while retaining known labels and transformations. Each sample supplies direct supervision for registration and segmentation, addressing the scarcity of dense manual annotations. A coupled 3D model and progressive training curriculum integrate learned affine and deformable registration with atlas guidance and anatomical prediction. Complementary input channels retain intracranial contrast and skull information. The neural model refines propagated ASPECTS regions and uses the tissue prior as context for direct tissue prediction, while keeping alignment, deformation, priors and learned outputs separately inspectable. Applied to 895 scans from 772 patients, six regional measurements connected anatomical maps to tissue attenuation, tissue composition, contralateral and reference comparisons, loss of gray-white differentiation and a net-water-uptake proxy. Plausible attenuation patterns support the feasibility of this analysis chain. Agreement between measurements can guide closer review, while disagreement exposes uncertainty. These contributions provide a practical foundation for developing automated ASPECTS assessment with visible anatomical and image evidence. However, quantitative model validation was synthetic, the highest-resolution results remained provisional, and independent regional annotations were unavailable. Expert validation of anatomical localization and regional findings on acquired scans is essential before diagnostic accuracy or clinical ASPECTS scoring can be established.

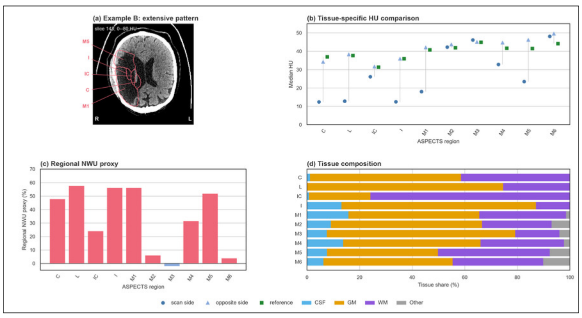
Schematic illustration of the ten anatomical regions evaluated by ASPECTS.
Own presentment



NCCT registration, tissue segmentation and ASPECTS regions from model inference.
Own presentment



Extensive attenuation loss, regional HU comparisons, net water uptake (NWU) proxies and tissue composition.
Own presentment



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Subject Area
Data Science, Medical Engineering