EfficientNet Sequence Model for DICOM-Based Intracranial Hemorrhage Detection

CHALMERS

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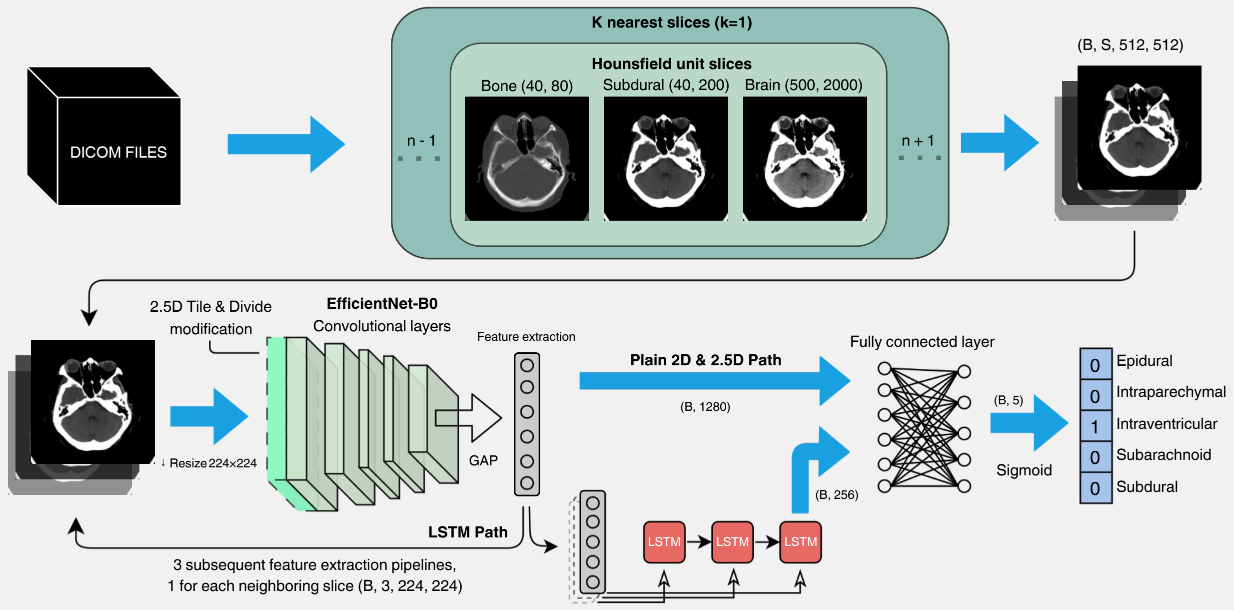
INTRODUCTION

Intracranial hemorrhage (ICH) refers to bleeding within the skull, either confined to the brain parenchyma or occurring in the spaces between the brain and its protective membranes [1]. This life-threatening condition demands prompt medical intervention to minimize the risk of permanent neurological deficits or fatality. A recent global burden study estimated that approximately 3.4 million individuals experienced ICH in 2019, leading to an estimated 2.8 million deaths worldwide [2].

PROJECT AIM

The proposed frameworks aims to achieve robust hemorrhage with detection at a low computational cost, while also providing clear visual explanations that increase the interpretability of the models and add additional support to clinical decision-making.

METHODOLOGY

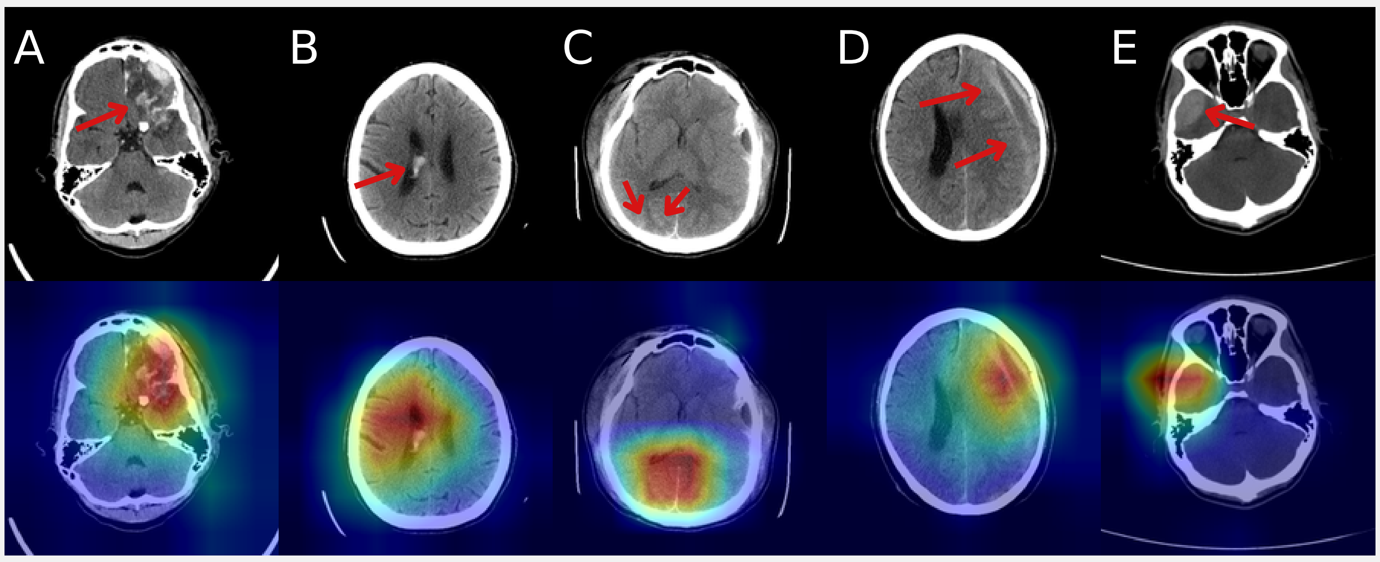


Plain 2D Path: Single-slice RGB – We convert its Bone, Sub-dural, and Brain windows into the three colour channels (B, 3, 224, 224), and feed that tensor directly to an unmodified EfficientNet-B0. After global-average pooling the 1280-dimensional feature vector drives a 5-logit classifier. Fastest to train and deploy, but blind to axial context.

2.5D Path: Neighbourhood as extra channels – Each slice plus its two neighbours are windowed and concatenated, giving a 9-channel input. We "Tile & Divide" the pretrained stem filters to accept nine channels; the rest of EfficientNet remains intact. One forward pass extracts a (B, 1280) embedding that a linear head converts to five haemorrhage logits. Captures local context with minimal extra cost.

LSTM Path: Ordered slice fusion – Each slice's 3-channel image runs through a shared EfficientNet-B0, producing three 1280-dim vectors that form a sequence. A single-layer LSTM aggregates the slice information and outputs a (B, 256) patch representation, which a final fully connected layer maps to the five logits. Highest modelling power—explicitly learns slice-to-slice dynamics—at the expense of ~3× compute and larger memory footprint.

RESULTS



CT images and corresponding Grad-CAM saliency maps for five intracranial hemorrhage types. Top row: Axial non–contrast CT slices demonstrating (from left to right) (A) intraparenchymal hemorrhage, (B) intraventricular hemorrhage, (C) subarachnoid hemorrhage, (D) subdural hemorrhage, and (E) epidural hemorrhage. Bottom row: Grad-CAM overlays computed from the sequence LSTM model, projected onto the same CT slices. Warmer colors indicate regions of greatest model attention when classifying each hemorrhage subtype.

Hemorrhage	2D	2.5D	LSTM
Epidural	0.75	0.75	0.77
Intraparenchymal	0.79	0.78	0.82
Intraventricular	0.77	0.76	0.75
Subarachnoid	0.75	0.73	0.78
Subdural	0.79	0.80	0.84

Per-class F1 scores for three architectures on the test set. Higher numbers mean better bleed detection. The LSTM model (right-hand column) comes out on top for 4 of 5 bleed types, especially subdural (+0.05, +0.04), showing that adding slice-to-slice context helps the network in general make more accurate calls than the 2-D or 2.5-D versions.

DATASET

- Subset (N=1000 patients) of the RSNA 2019 Intracranial Hemorrhage Detection dataset
- 50 863 individual CT images

Number of slices with each hemorrhage type:

Epidural:	240
Intraparenchymal:	2853
Intraventricular:	1962
Subarachnoid:	2627
Subdural:	3180

TAKE HOME MESSAGE

- Small models can achieve high diagnostic accuracy
- Adding ordered spatial context noticeably increases the performance
- Grad-CAM overlays increase the intepretability of the predictions

FUTURE WORK

Future work might examine supplying the LSTM with a wider window of neighboring slices or integrating slices from multiple imaging planes to better capture and differentiate three-dimensional features.

Bibliography

[1] J. A. Caceres and J. N. Goldstein, Intracranial hemorrhage, Emergency Medicine Clinics of North America 30, 771 (2012)
[2] T. Sun, Y. Yuan, K. Wu, Y. Zhou, C. You, and J. Guan, Trends and patterns in the global burden of intracerebral hemorrhage: a comprehensive analysis from 1990 to 2019,Frontiersin Neurology 14, 1241158 (2023)