# Automatic Detection of Cerebral Microbleeds: A Clinically Robust Deep Learning Framework


jl@cerebriu.com

**Jorge del Pozo Lérida**, Mathias Perslev, Veronika Cheplygina, Silvia Ingala, Akshay Pai


## Cerebral Microbleeds (CMBs)

***CMBs are small, round hypointensities detected on GRE T2* and SWI MRI sequences, under 10 mm in diameter, with associated blooming artefact***

- CMBs are associated with over 30 medical conditions
- Crucial diagnostic and prognostic imaging biomarkers
- Radiological assessment is time-consuming and error-prone

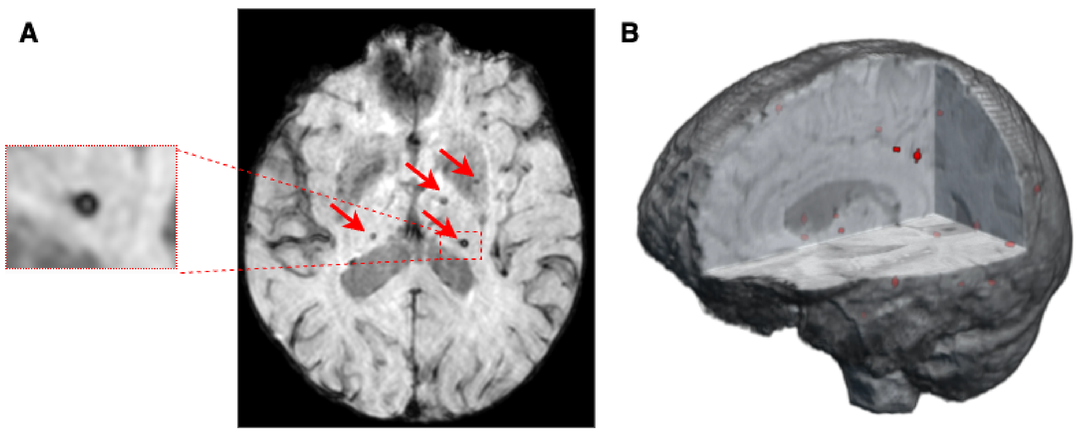


*Figure 1: (A) Axial SWI with four CMBs; (B) 3D reconstruction with CMBs.*

## Challenges in Automatic CMB Detection

- Presence of several mimics that closely resemble CMBs
- Small size (*i.e.*, huge class imbalance)
- Scarcity of publicly available data with annotated CMBs
- Lack of benchmark dataset and standardized evaluation

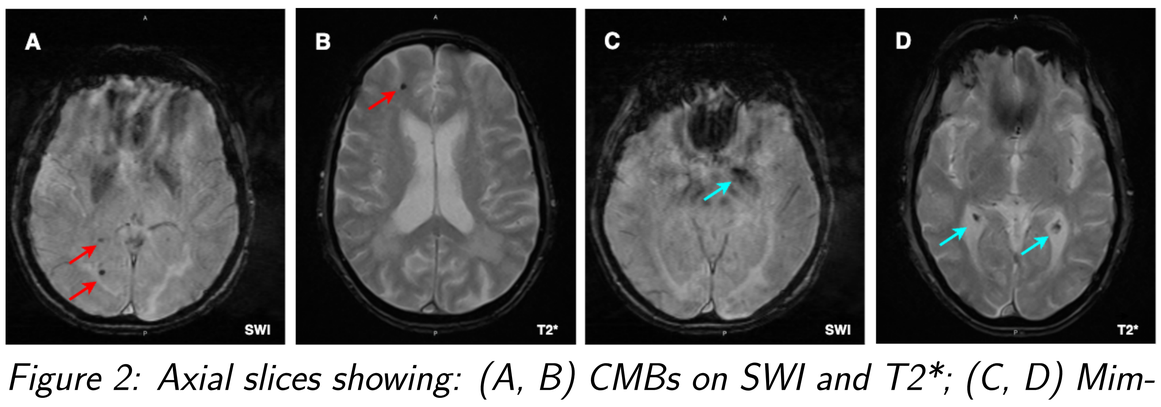


*Figure 2: Axial slices showing: (A, B) CMBs on SWI and T2*; (C, D) Mimics: basal ganglia calcification on SWI and calcified choroid plexus on T2*.*

## Our Approach

- 3D U-Net based segmentation network
- MRI sequence agnostic (GRE T2* or SWI)
- Standardization of 7 different datasets (public & private)
- Transfer Learning from thousands of clinical studies
- Intense and diverse data augmentation
- Pretrain on a large dataset of synthetic CMBs and negative scans with wide range of acquisition parameters
- Location-based post-processing (SynthSeg)
- Comprehensive evaluation on 2 unbiased datasets (Table 2) and 3 tasks: segmentation, detection & classification
- Performance analysis by CMB features and MRI acquisition parameters

## Results

*Table 1: **Detection** performance computed per scan and averaged. **DOU** is a public dataset with 20 scans and 74 CMBs. **CRB** is an internally curated dataset with 18 scans and 127 CMBs, representing high clinical variability.*

| Dataset | Precision | Recall | F1 | FPcmb |
|---|---|---|---|---|
| CRB Test Set | $0.78 \pm 0.25$ | $0.34 \pm 0.32$ | $0.43 \pm 0.19$ | $0.35 \pm 0.95$ |
| DOU Test Set | $0.91 \pm 0.18$ | $0.79 \pm 0.34$ | $0.87 \pm 0.18$ | $0.15 \pm 0.46$ |
| Valid Set | $0.50 \pm 0.45$ | $0.81 \pm 0.30$ | $0.80 \pm 0.20$ | $0.43 \pm 0.75$ |

*Table 2: Detection performance on DOU test compared to other methods. Metrics are computed globally for all CMB detections. FPscan is $n_{FP}/n_{scans}$.*

| Method | Precision | Recall | F1 | FPscan |
|---|---|---|---|---|
| Sundaresan et al. | 0.89 | 0.87 | 0.88 | 0.5 |
| Ferrer et al. | 1.00 | 0.50 | 0.67 | 0.0 |
| Dou et al. | 0.49 | 0.80 | 0.61 | 7.7 |
| **Our Approach** | 0.84 | 0.69 | 0.76 | 0.13 |

## Discussion

- Higher slice thickness and elongated CMBs shape are associated with lower model performance
- Detection of lobar CMBs is hindered by the presence of adjacent blood vessels
- False Negative detections are more prevalent than False Positives, not in line with literature
- Comparing performance across CMB detection studies is challenging without a standardized evaluation framework

***We developed a sequence-agnostic 3D segmentation model capable of accurately detecting cerebral microbleeds on both GRE T2* and SWI MRI sequences, robust to clinical data variability***