STARDUST - Deep segmentation of brain perivascular spaces in Parkinson's disease: informing decision support from clinical low-field MRI

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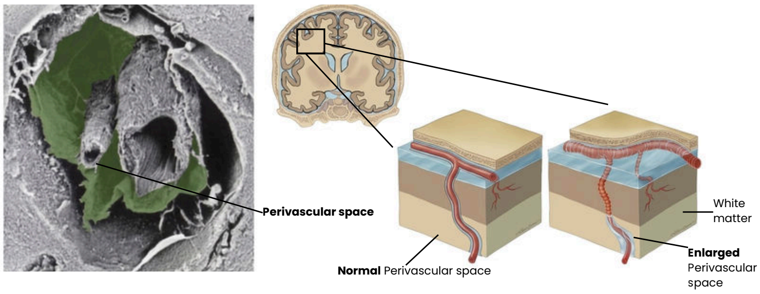
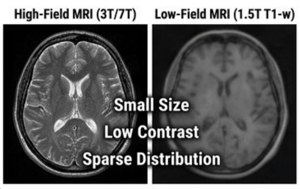
INTRODUCTION



- **Perivascular spaces (PVS)** play a critical role in the brain's glymphatic clearance system
- The **enlargement of PVS** is recognized as a **biomarker** in neurodegenerative diseases such as **Parkinson's disease** (PD).

CHALLENGES

- **PVS detectio**n is strongly **limited by MRI spatial resolution**.
- PVS are extremely small, sparsely distributed structures.
- **Low contrast** in 1.5T T1-weighted MRI makes PVS difficult to distinguish from surrounding tissue.



AIM

Support **PD biomarker analysis** through **STARDUST**: an automated framework for fine-grained **PVS segmentation** in clinical **1.5T T1-weighted MRI**, enabling an objective proxy for glymphatic function and disease progression.

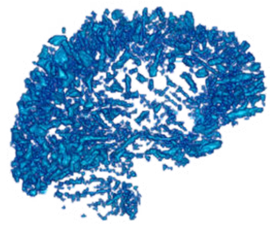
OBJECTIVES

- Handle anatomical sparsity and label uncertainty.
- Validate reliability in real-world 1.5T protocols, **shifting from subjective visual rating scales to objective, topology-informed quantification.**

RESULTS

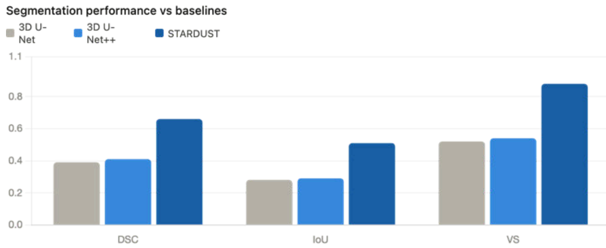
QUALITATIVE RESULTS

WHITE MATTER 3D RECONSTRUCTION

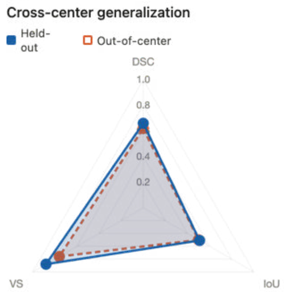


PVS 3D RECONSTRUCTION

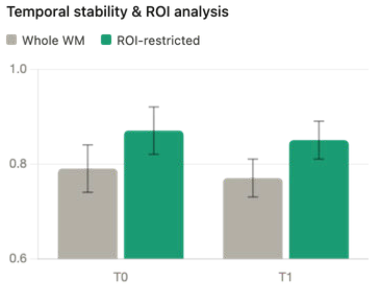
QUANTITATIVE RESULTS



STARDUST outperforms baseline variants.



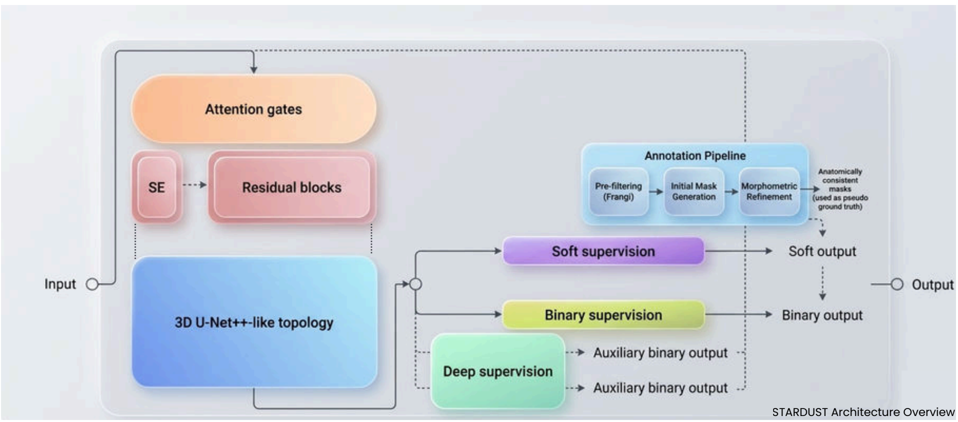
STARDUST demonstrates **robust** performance on the held-out test set, both at global and subject level.



Region-restricted evaluation **improves** anatomical precision and enhances clinical interpretability.

Ablation studies demonstrate that the integration of SE modules, attention gates and dual supervision strategies results in a cumulative **+61% DSC improvement** over the standard 3D U-Net++ backbone.

METHODS



STARDUST Architecture Overview

STARDUST Architecture

- **3D U-Net++ backbone** with **SE-residual blocks** and **attention gates**.
- **Multi-output training** leveraging soft supervision and asymmetric losses.
- Specifically **designed** for **sparse anatomical structures** and **uncertain**
- **labels**.
- **Semi-automatic annotation** via multiscale Frangi filtering and morphometric refinement for high-fidelity pseudo-ground truth.

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