

Forecasting Alzheimer’s Disease conversion using time-aware deep-learning-based brain morphometry

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Introduction

- The growing burden of Alzheimer’s disease (AD) and the need for **early intervention** highlight the importance of reliable tools to **predict patients’ future conversion**.
- While PET imaging and cognitive testing are most used, their **limited accessibility** and **lack of standardization** across sites reduce clinical applicability and generalizability.
- Structural MRI is a **non-invasive** and **accessible** alternative.
- Our work highlights the **potential of volumetric Z-scores** as standardized biomarkers to reliably **predict AD conversion** across **different follow-up periods** that reflect real-world clinical practice.

Methods

- We extracted **age-and-sex-adjusted** cross-sectional **volumetric Z-scores** for 55 brain regions from each T1w scan¹.
- Z-scores at single tps were treated as **static features**, while **dynamic features** included average z-scores and their corresponding rates of change between tp1 and tp2.

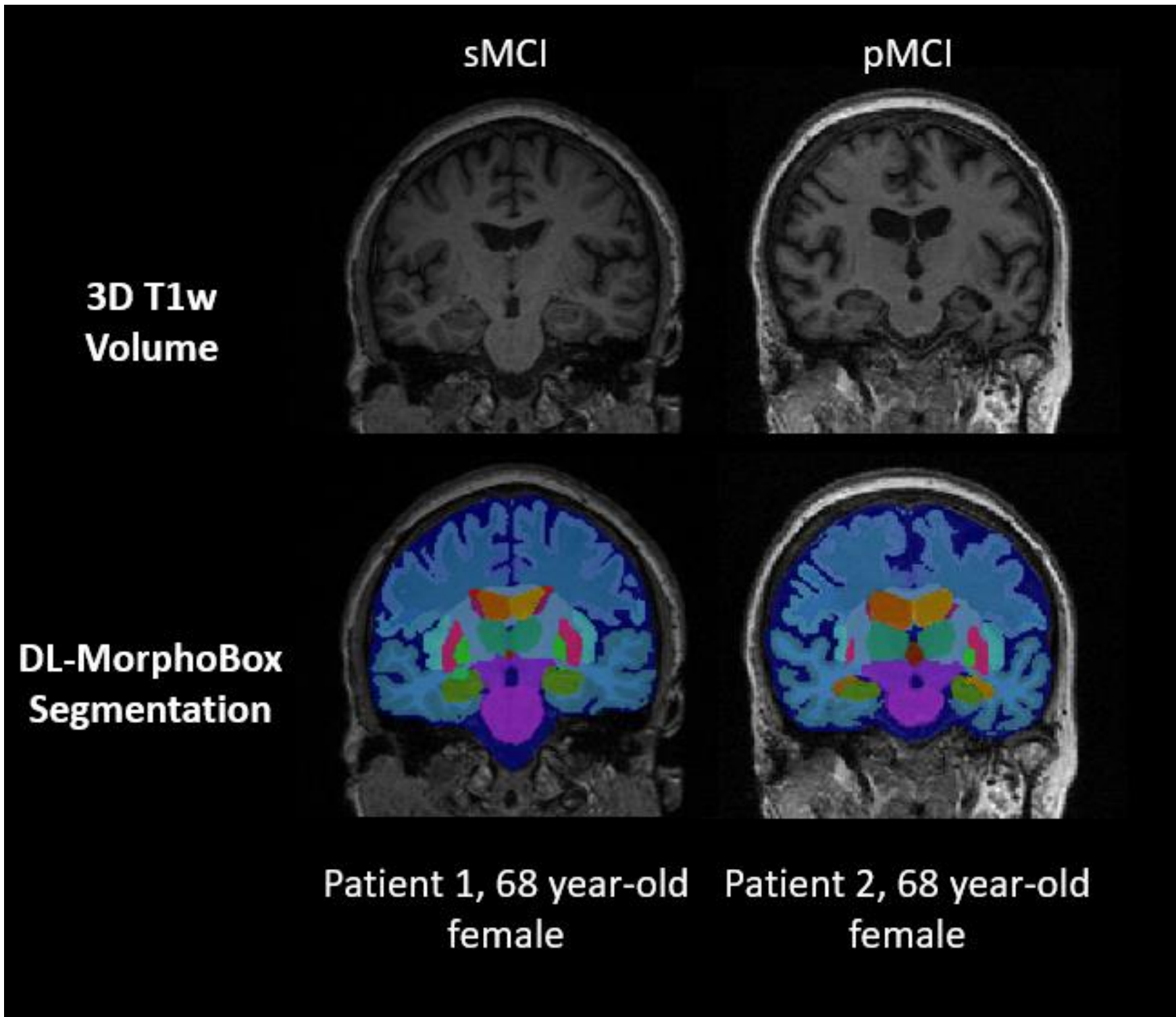


Figure 1. Multilabel brain segmentation examples.

- **Time intervals** (tp1-to-tp3 and tp2-to-tp3) were also added as **features**.
- The public transformer-based “**TabPFN**”² model was used in **nested cross-validation**.

Conclusion

- **Volumetric Z-scores** coupled with **time-dependent information** offer a practical measure for predicting dementia conversion, in this work, particularly AD.
- **Future work** will **expand the training cohort** to **other dementia types** and include **feature selection** to ensure pipeline efficiency and potentially improve performance.

Dataset

- **N=202** participants from the Alzheimer’s Disease Neuroimaging Initiative (**ADNI**) had 3D T1-weighted (T1w) MRI scans at baseline (time point [tp]1) and follow-up (tp2).
- Patients were labeled as progressive mild cognitive impairment (**pMCI**) if they clinically **converted to AD at a given tp3**, or as stable MCI (**sMCI**).
- For **validation**, we included an independent memory-clinic test set (**N=21**) with **varied dementia types**.

ADNI Patients	
Number of Patients	76 pMCI – 167 sMCI
Number of sessions	530 pMCI – 1076 sMCI
Age (baseline)	72.6 ± 8.6 years
Sex Distribution	42.57% F
Magnetic Field Strength	1.5T, 3T
Manufacturer	Siemens Healthineers, Philips Medical Systems, GE Medical Systems

Patients from Independent Memory Clinic	
Number of Patients	21 (13 AD – 4 VD – 2 FTD – 2LBD)
Age (baseline)	71.5 ± 7.9 years
Sex Distribution	33.33% F
Magnetic Field Strength	3T
Manufacturer	Siemens Healthineers

Results

- Most samples, primarily sMCI patients, were correctly classified.
- Progressions of **8/13 AD** patients and **2/8** of patients with **other dementia types** were **correctly predicted**.

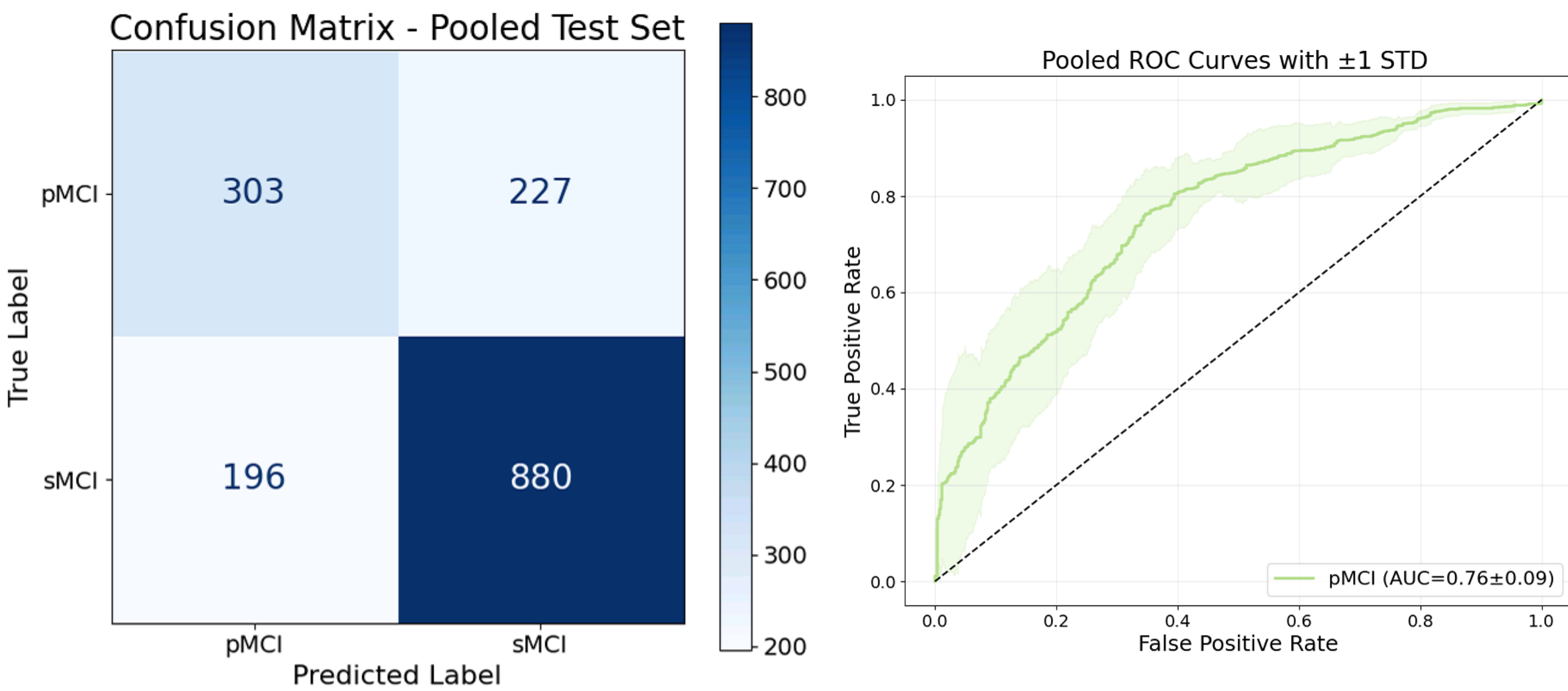


Figure 2. Prediction results and performance metrics.

Accuracy	F1-score	Sensitivity	Specificity
74.0 ± 9.7 %	73.0 ± 9.1 %	82.2 ± 18.2 %	55.4 ± 13.2 %

References

- 1- P. Venkatesgowda et al. , Proceedings of ISMRM 2025
- 2- Hollmann, N. et al. (2025) <https://doi.org/10.1038/s41586-024-08328-6>

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