NeuroSTORM: Towards a general-purpose foundation model for fMRI analysis

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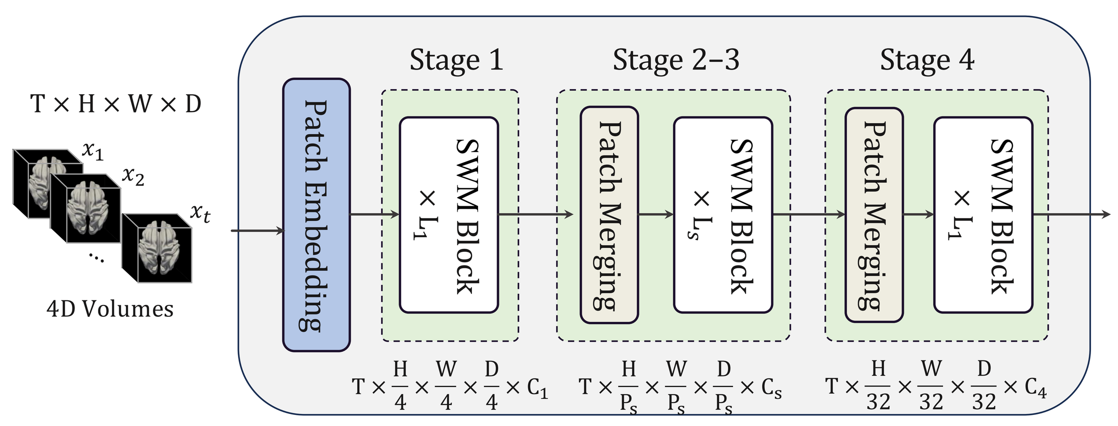
Introduction

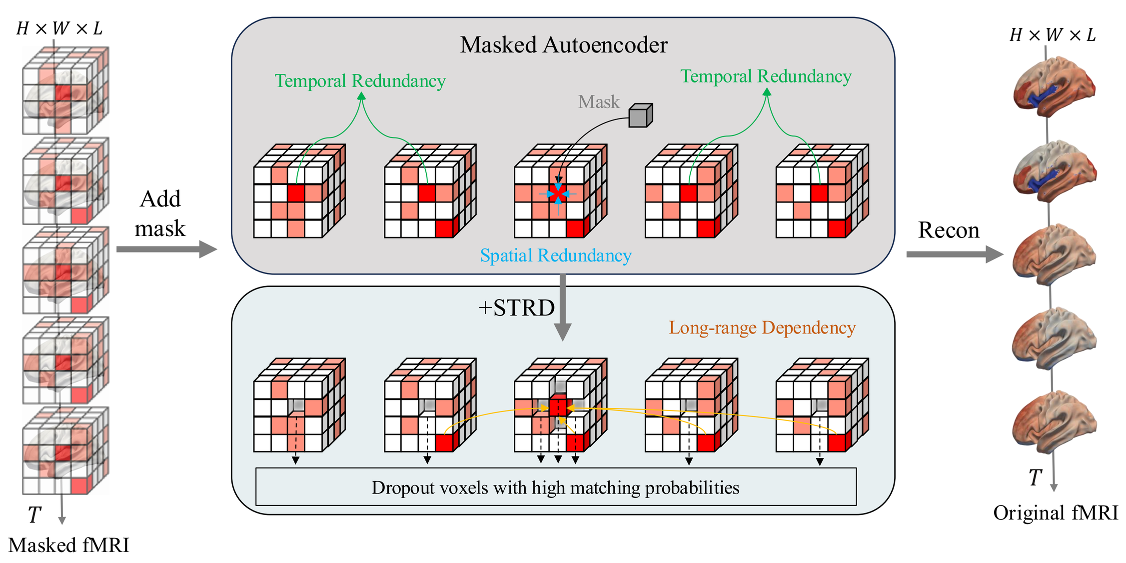
- The broader impact of functional MRI (fMRI) remains limited by challenges in **reproducibility** and **transferability**.
- Medical **foundation models** show promise for addressing these challenges through scalable pretraining and cross-task generalization.
- We propose a **fMRI foundation model "NeuroSTORM"** pretrained on >65k scans, featuring 1) Shifted-Window Mamba backbone for efficient 4D processing, 2) Spatiotemporal Redundancy Dropout to mitigate redundancy in voxel-wise signals, and 3) Task-specific Prompt Tuning for parameter-efficient adaptation.
- We constructed a comprehensive, independent **benchmark of five tasks** to evaluate the performance of NeuroSTORM.

Methods

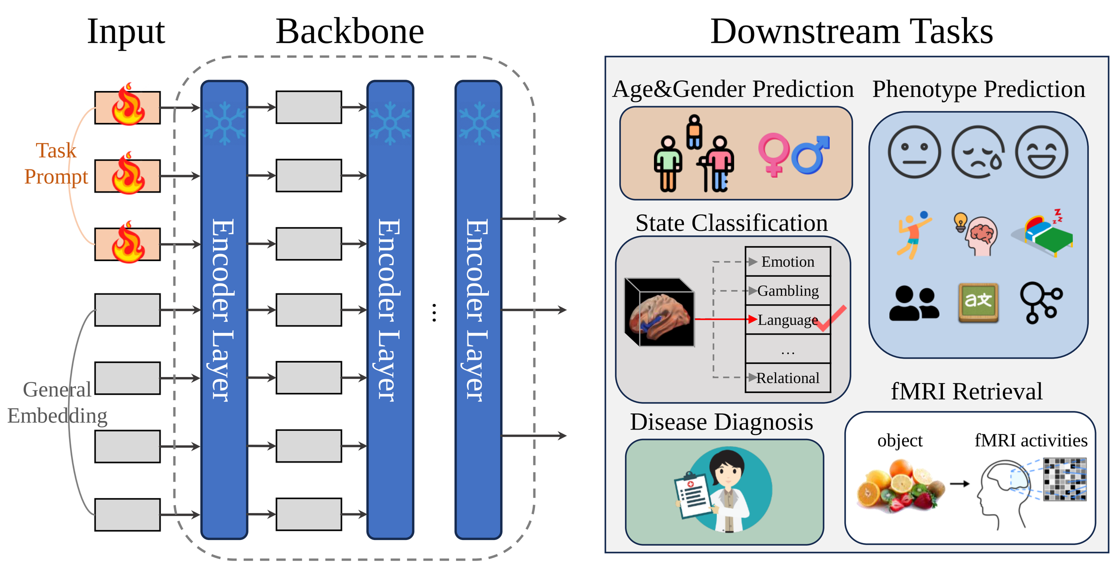
NeuroSTORM is built on a **Shifted-Window Mamba backbone**, which efficiently processes 4D fMRI volumes



The **Spatiotemporal Redundancy Dropout module** encourages the model to focus on capturing complex long-range relationships within 4D fMRI sequences

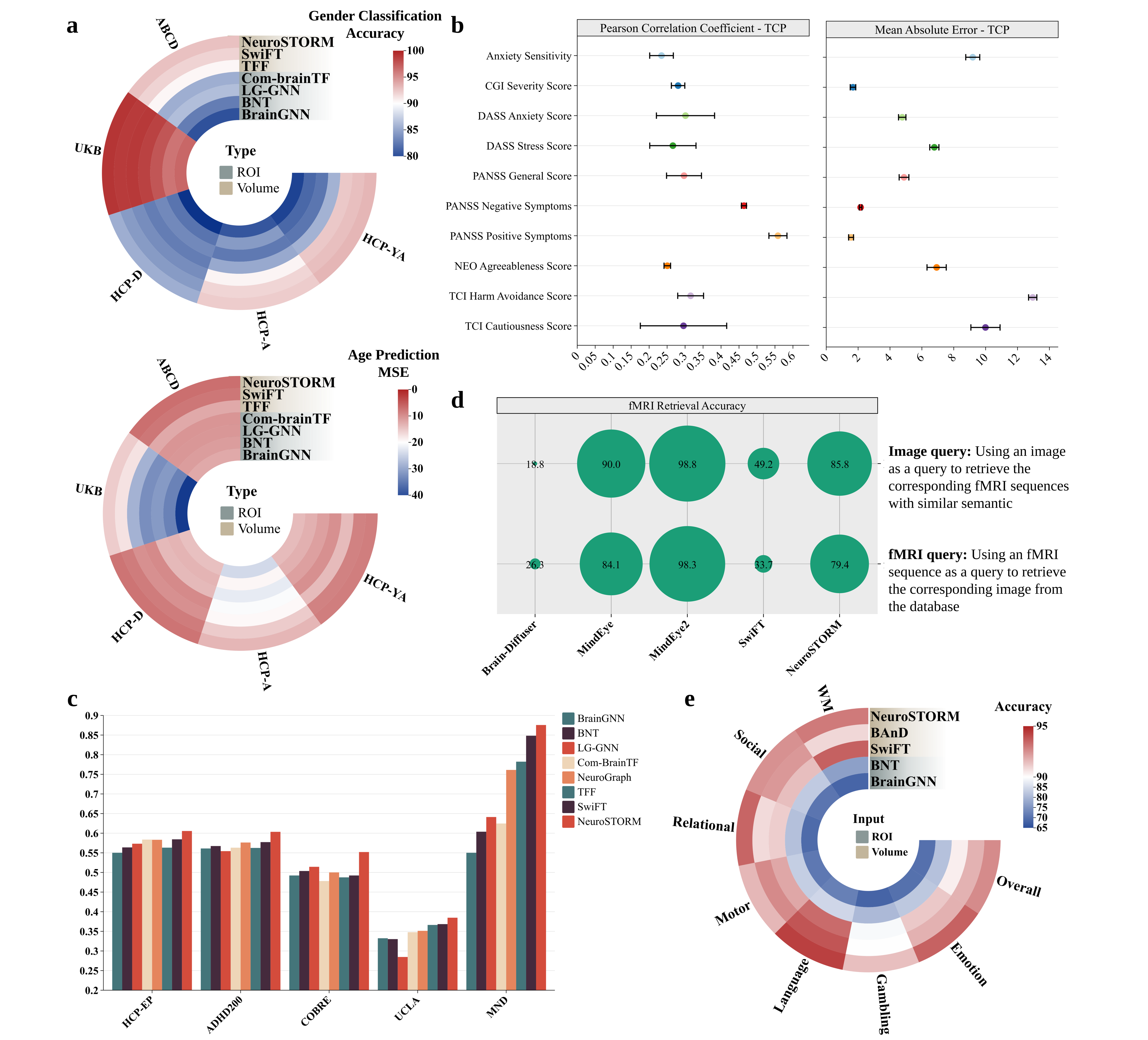


Task-specific Prompt Tuning introduces learnable prompt parameters for each downstream task while keeping the backbone parameters fixed



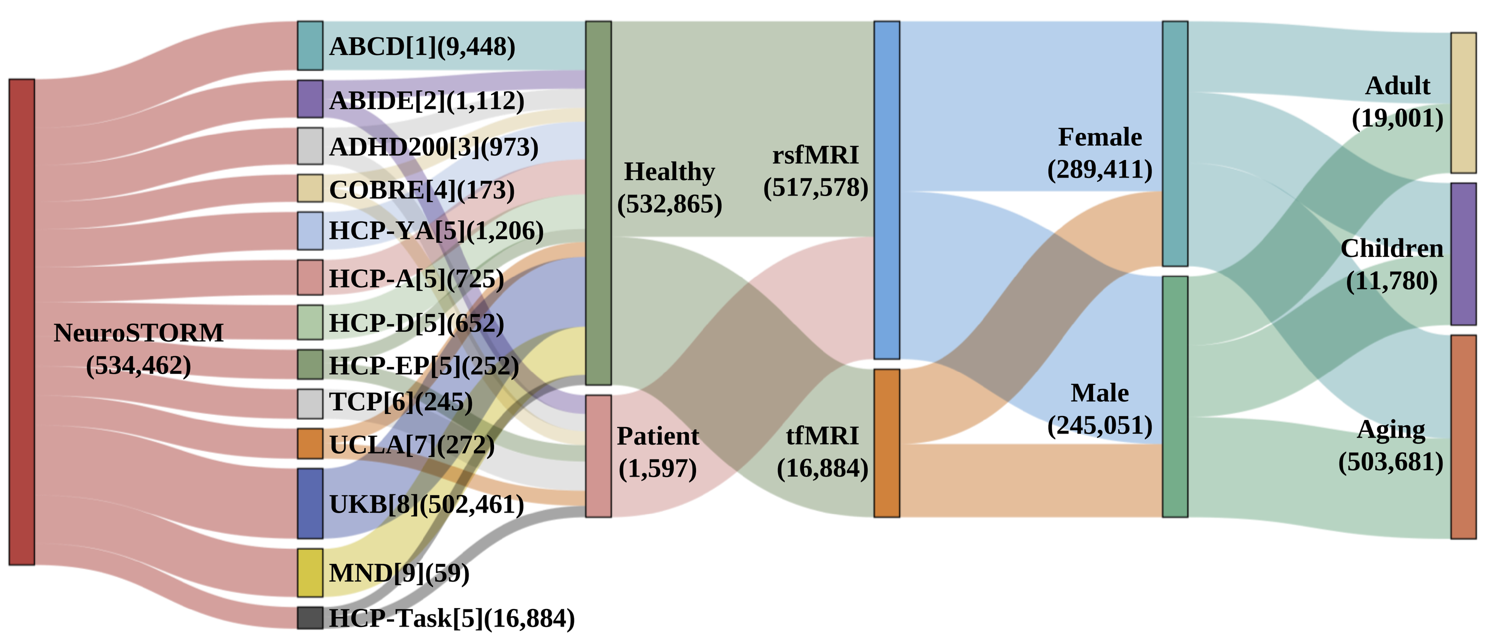
Results

To validate the performance and applicability of NeuroSTORM, we established five benchmark datasets, each representing a distinct downstream task: a) Age/Gender prediction, b) Phenotype prediction, c) Disease diagnosis, d) fMRI retrieval, and e) task fMRI state classification.



Dataset Corpus

The model is pre-trained on a collection of publicly available datasets, including over 500,000 rsfMRI and 16,000 tfMRI sequences. All data are aligned to 2mm MNI152 space to create standardized 4D volumes



Conclusion

- Our study addresses two fundamental challenges in fMRI research through systematic innovations in data curation, architecture design, and benchmarking;
- NeuroSTORM exhibits satisfied performance across all tasks, highlighting the potential of the fMRI foundation model;
- NeuroSTORM creates new opportunities for integrating fundamental brain theories

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