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RH-BrainFS: Regional Heterogeneous Multimodal Brain Networks Fusion Strategy

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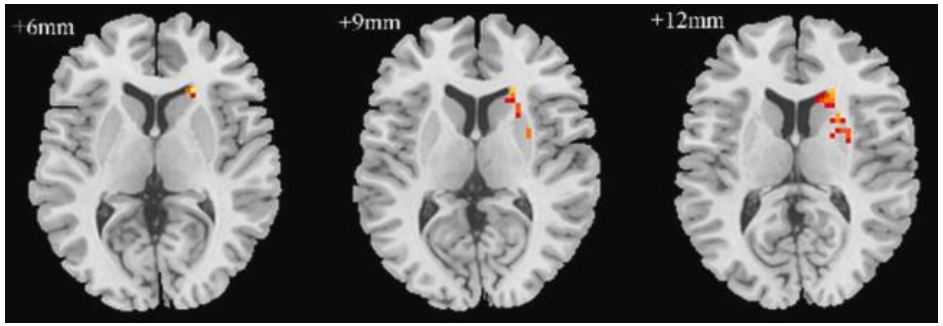
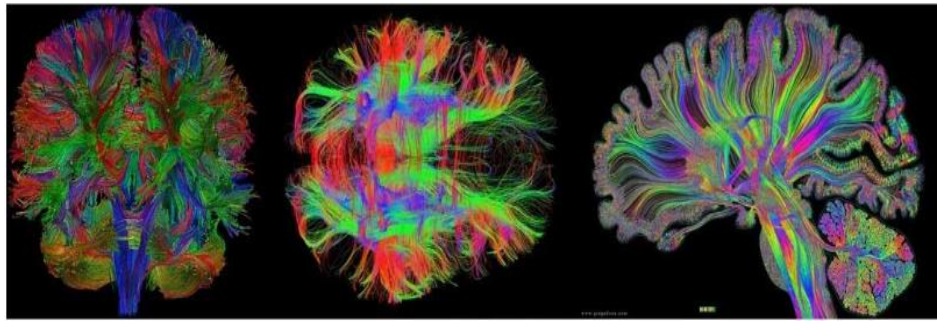
Background

- Multimodal fusion has become an important research technique in neuroscience that completes downstream tasks by extracting complementary information from multiple modalities.
- Existing multimodal research on brain networks mainly focuses on fusing structural and functional modalities, where **structural modality** is constructed from diffusion magnetic resonance imaging (dMRI) and **functional modality** is constructed from functional magnetic resonance imaging (fMRI).



fMRI



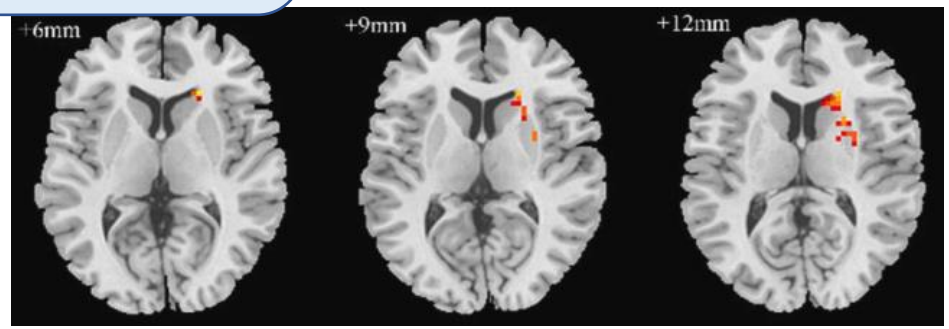
dMRI

Motivation

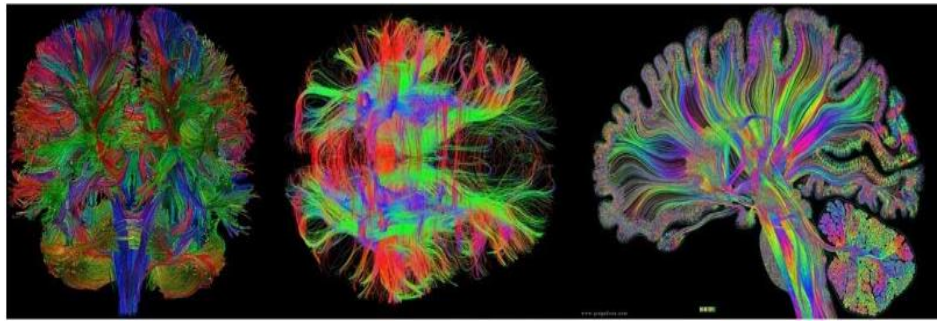
Direct interaction, where two modal features/embeddings are directly combined to perform some computation, e.g. concatenation, weighted summation, or self-attention techniques.

- Most previous methods directly fuse the two modal representations via "simple patterns“, without considering the issue of **regional heterogeneity** between this two modalities.
- However, extensive literature has shown that the relationship between structural connectivity (SC) and functional connectivity (FC) is complex and not a simple one-to-one mapping.

The coupling of structure and function at the **regional level is heterogeneous** and follows the molecular, cellular and functional hierarchical structure.
In other words, structure may be more tightly coupled to function in some regions than in others.



fMRI



dMRI

Method

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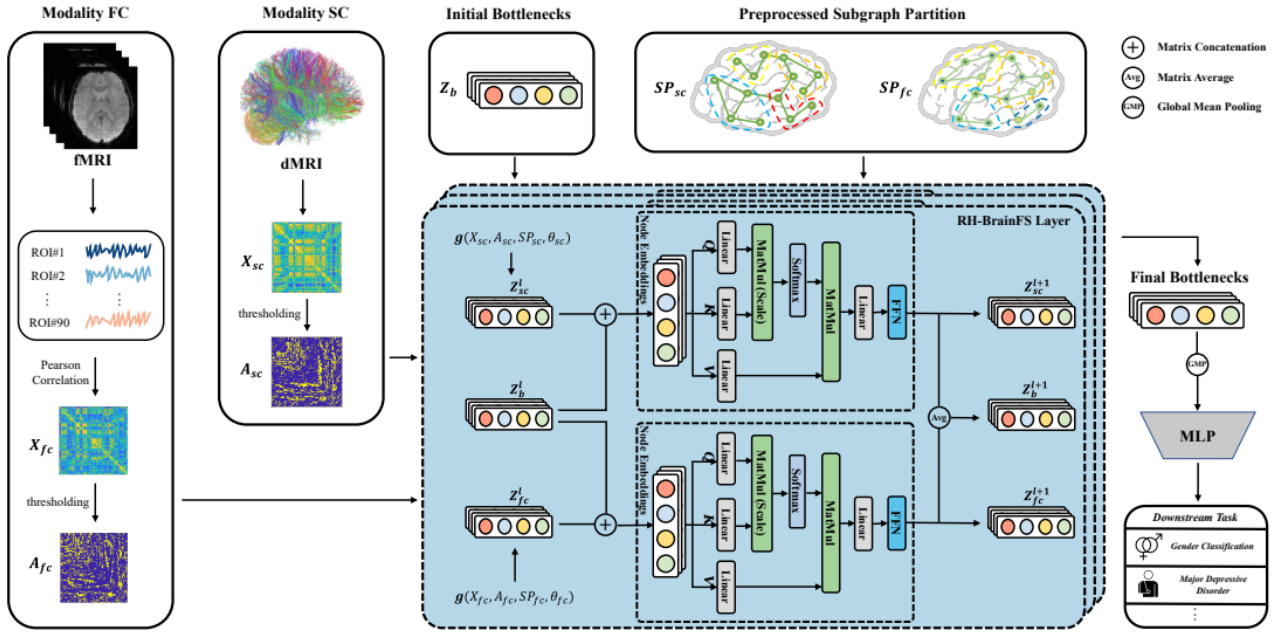
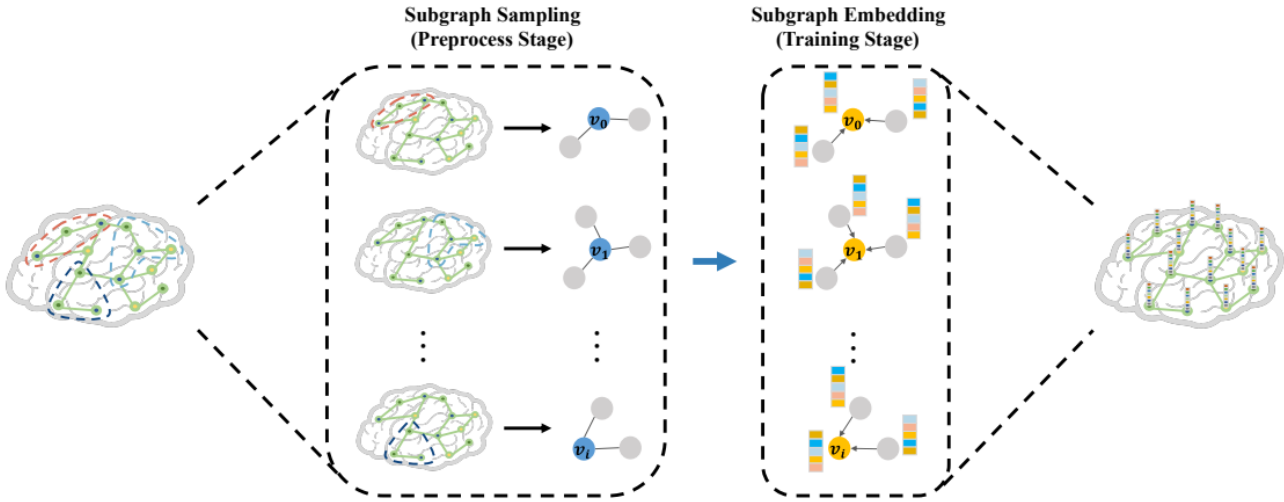
- To alleviate the issue of regional heterogeneity of multimodal brain networks, we propose a novel **R**egional **H**eterogeneous multimodal **Brain** networks **F**usion **S**trategy (**RH-BrainFS**), using BrainSubGNN module and Trans-Bottleneck module to fuse regional heterogeneous multimodal brain networks for neuroscience tasks.



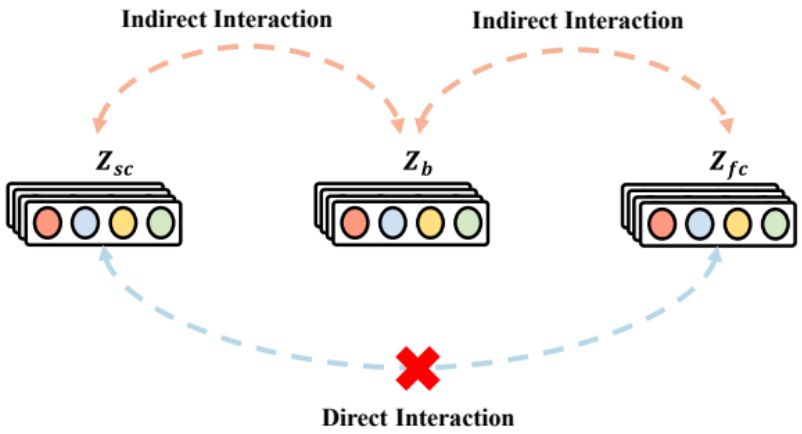
Method

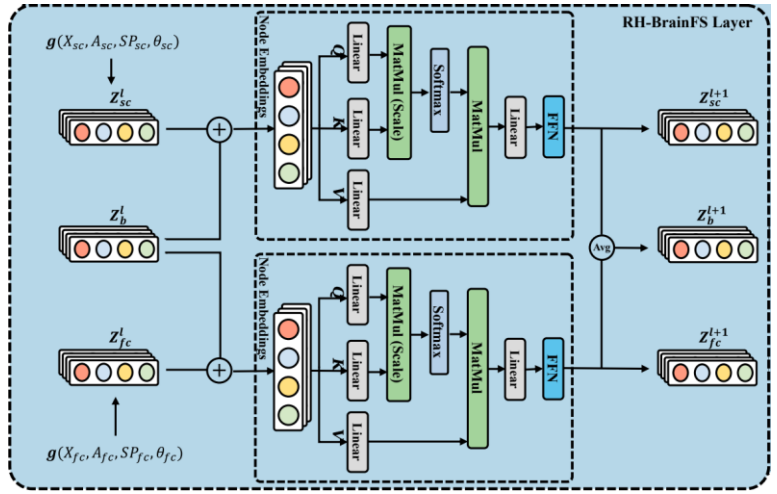
- **BrainSubGNN**: captures the regional characteristics of brain networks. The BrainSubGNN contains subgraph sampling step and subgraph embedding step.
  - Subgraph sampling: construct a receptive field for each brain region.
  - Subgraph embedding: integrates the characteristics of all the brain regions in a subgraph and extract an embedding to represent the entire subgraph.



Method

- **Trans-Bottleneck**: alleviate the issue of regional heterogeneity in multimodal brain networks.
- **Fusion Bottlenecks**: we are committed to avoiding the **direct interaction** of two modalities, and we prefer to find an intermediate element as a bridge for the interaction between two modalities (means **indirect interaction**).
- **Transformer-Based Fusion**: individual regional characteristics of brain networks have different influence values for neuroscience tasks. Based on these, our RH-BrainFS method utilizes the Transformer as a baseline for the fusion strategy to capture key subgraph characteristics in brain networks.





Summary

- To alleviate the issue of regional heterogeneity of multimodal brain networks, we propose a novel Regional Heterogeneous multimodal Brain networks Fusion Strategy (RH-BrainFS), using BrainSubGNN module and Trans-Bottleneck module to fuse regional heterogeneous multimodal brain networks for neuroscience tasks.
- To the best of our knowledge, this is the first paper to explicitly state the issue of structural-functional modal regional heterogeneity and to propose a solution.

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The Ends, Thanks!

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