A Topology-based Approach Towards Subject-specific fMRI Analysis

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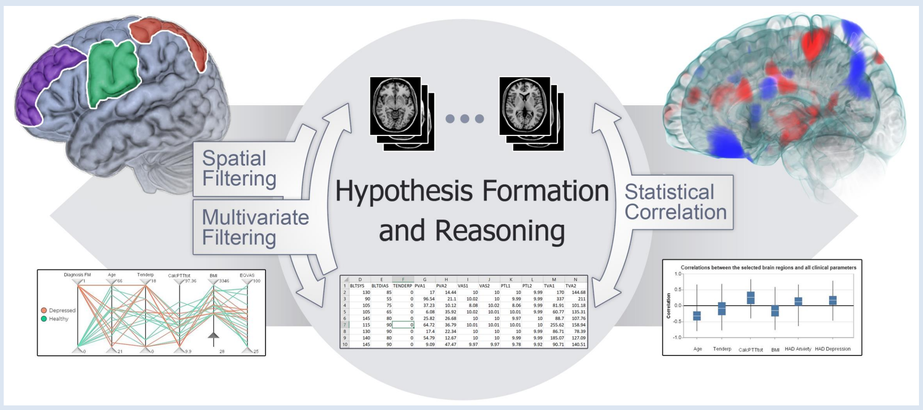
Motivation

Develop a Subject-Specific reference brain for time-varying fMRI data

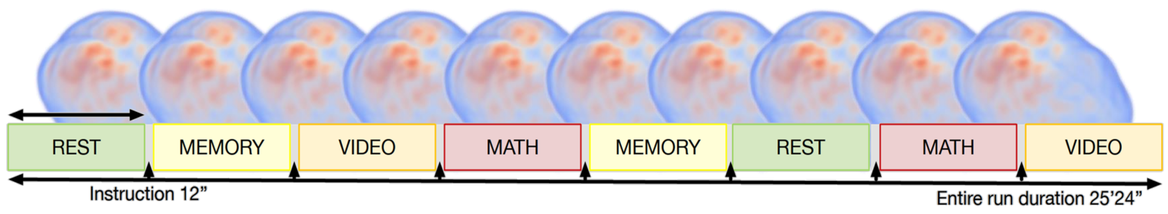


Jönsson, D et al,. (2020). VisualNeuro : A Hypothesis Formation and Reasoning Application for Multi-Variate Brain Cohort Study Data. Computer Graphics Forum

Highlights

- A merge tree-based feature vector obtained directly from raw dynamic fMRI data, which allows to find similar brain activity patterns.
- A subject-specific reference brain obtained by combining highly activating regions from all time points that establish correspondence across time.
- An approach for both temporal and connectivity analysis of active brain regions.
- Visualization components tailored to explore feature-based brain activity patterns with interactive capabilities.

Data & Challenges



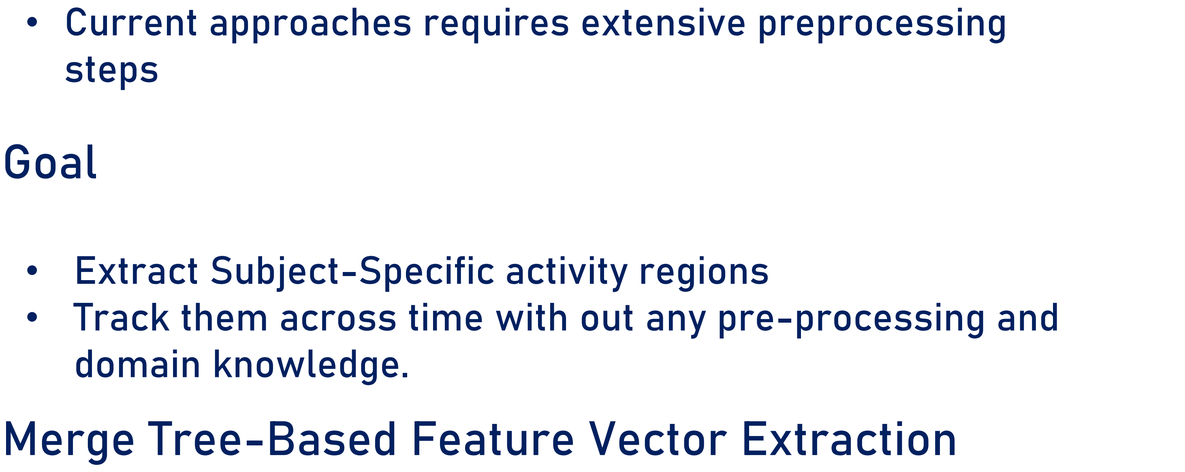
- Neural activity coupled with oxygenated blood flow
- Inherently noisy
  - Scanner noise
  - Psychological & Physiological noise
- Current approaches requires extensive preprocessing steps

Goal

- Extract Subject-Specific activity regions
- Track them across time with out any pre-processing and domain knowledge.

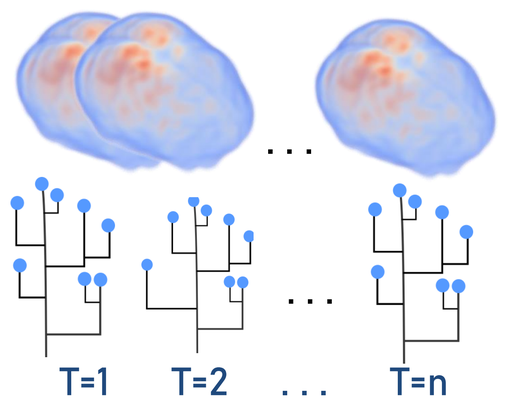
Merge Tree-Based Feature Vector Extraction

(A) Illustration of feature extraction method in 1 dimensional case.
(B) From left to right: First, a reference brain is constructed from raw temporal fMRI data, followed by extracting merge tree for the reference brain.



Comparison and Feature Matrix

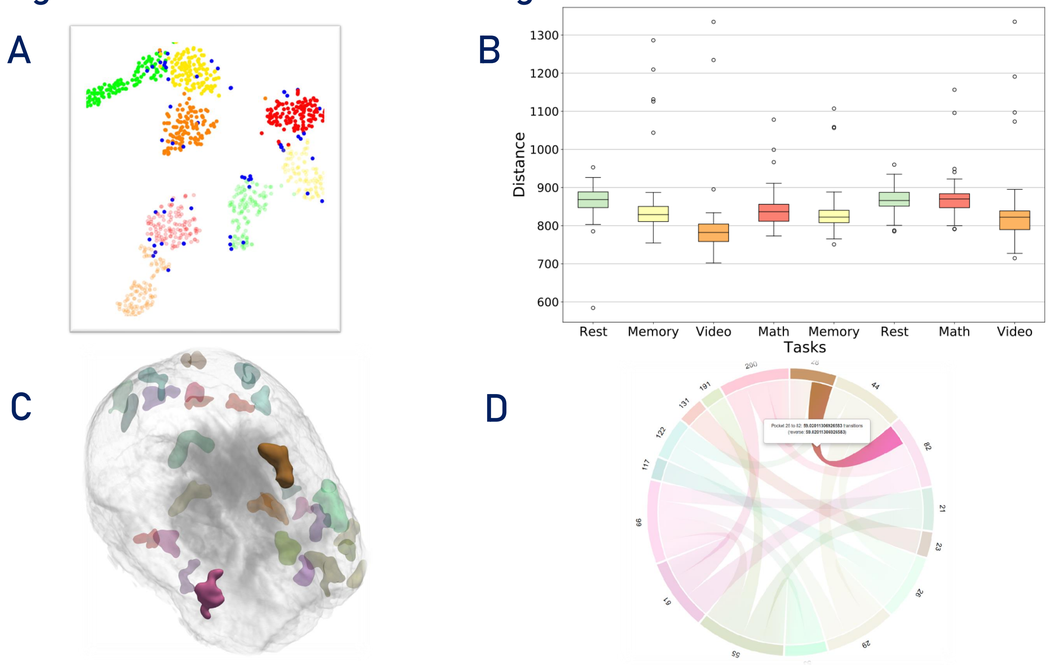
Then correspondence across time is established by matching merge trees with reference merge tree, which results in a feature matrix.



Index	1	2	3	...	m
T=1	x	x	x	...	x
T=2	x	x	x	...	x
T=3	x	x	x	...	x
T=n	x	x	x	...	x

Temporal Comparison & Connectivity Analysis

(A) Feature vectors mapping into two dimensions space reveals the different activity tasks and their transition. (B) Deviation of the activity level from reference brain. (C) Topological segmentation of fMRI data for single participant. (D) Brain connectivity between active regions is visualized through chord diagram. Linked with chord diagram.



References

1. Javier Gonzalez-Castillo et al, Tracking ongoing cognition in individuals using brief, whole-brain functional connectivity patterns, *Proceedings of the National Academy of Sciences (2015)*

2. Rasheed F, Jönsson D, Nilsson E, Masood T. B, Hotz I, Subject-specific activity pattern analysis in fmri data using merge trees, In 2022 IEEE Workshop on Topological Data Analysis and Visualization, to appear.