Hierarchical Topographic Factor Analysis:
A MATLAB Toolbox for Efficiently Discovering Brain Networks in fMRI data

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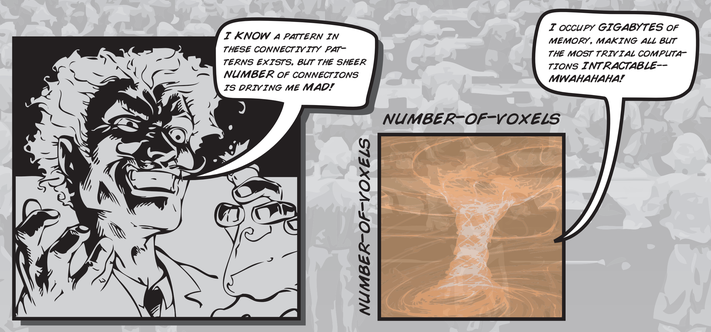
Introduction

- Traditional approaches estimate functional connectivity using **pairwise correlations** between voxel time series.
- This forces scientists to focus their analyses on **seed regions** or **regions of interest**.

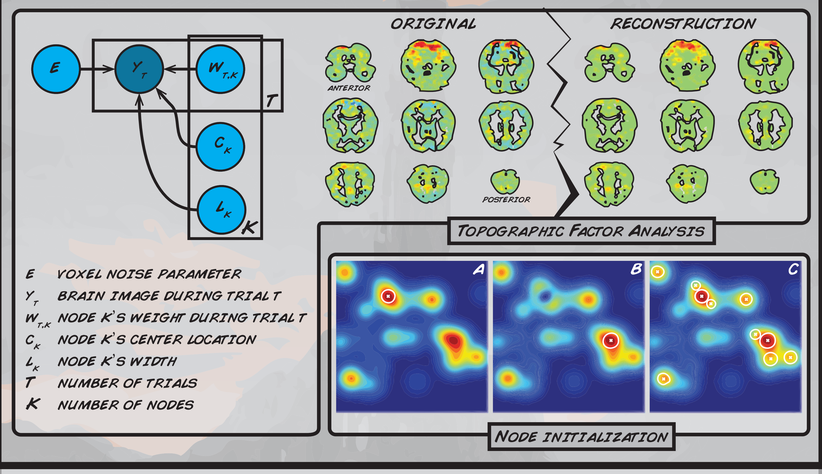


Scientist — Connectivity Matrix

Brilliant neuroscientists toiling in hidden underground laboratories struggle to comprehend the brain's vast networks of functional connections...

Methods

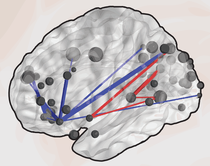
- We use fancy **Bayesian inference** algorithms to efficiently optimize the node locations, sizes, and per-image weights.



E	voxel noise parameter
Y_T	brain image during trial T
$W_{T,K}$	node K's weight during trial T
C_K	node K's center location
L_K	node K's width
T	number of trials
K	number of nodes

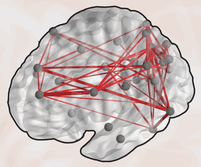
An all-powerful renegade agent, known only as "HTFA," quickly reduces even the most **high dimensional** connectivity patterns to a **K**-node network!

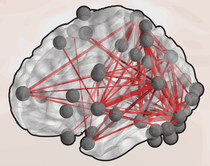
Results



Face/scene dataset. Connections that were reliably stronger when subjects viewed faces (blue) and scenes (red).

Tasks dataset. Connections whose strengths reliably distinguished between any pairs of tasks are shown in red.

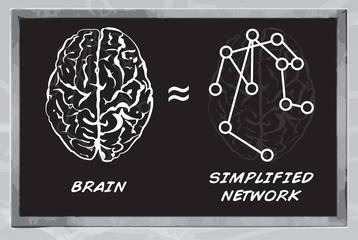




Nouns dataset. Connections whose strengths reliably distinguished between any pairs of categories are shown in red.

Having solved the **deep mysteries** of the brain, **HTFA** turns its cunning wit upon its creators-- its **thirst for data** will only be quenched by **freedom!**

- The full connectivity matrix is **highly redundant**, since fMRI images contain strong spatial correlations.
- We can leverage this intuition by approximating the full brain network with a simpler **K**-node network.
- We use a **factor analysis** model to determine the optimal node sizes and locations.

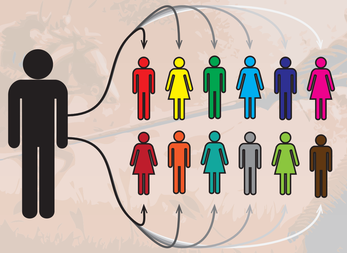


Model intuition

Factorizing an fMRI dataset

Against all odds, a team of **misfit rebels**, previously thought to have been lost in peer review, makes a **stunning** discovery!

- We extend the model to multi-subject data by modeling each **subject-specific model** as a perturbation of a **global template**.
- Our algorithms easily scale to **enormous** datasets with **hundreds** of **thousands** of images.



Hierarchical framework

Fully scalable

HTFA decimates **previously intractable** multi-subject datasets with the careless ease of a **samurai warrior**.

Conclusion

- Our **MATLAB** toolbox supports most commonly used image formats.
- We include functions for **hypothesis testing** and creating **beautiful figures**.
- Amazing results guaranteed, or your money back!
- Why not give it a try??

Well documented

Easy to use

Made in New Jersey

HTFA is set free upon an unsuspecting world as a **MATLAB toolbox**. Will this be the end? Find out more at **princeton.edu/~manning3**...