Visualization of time-series biological data with spatial and non-spatial features embedded

Chihua Ma

July 22, 2015

- Why time series data?

  Most real world problems are dynamic in nature.

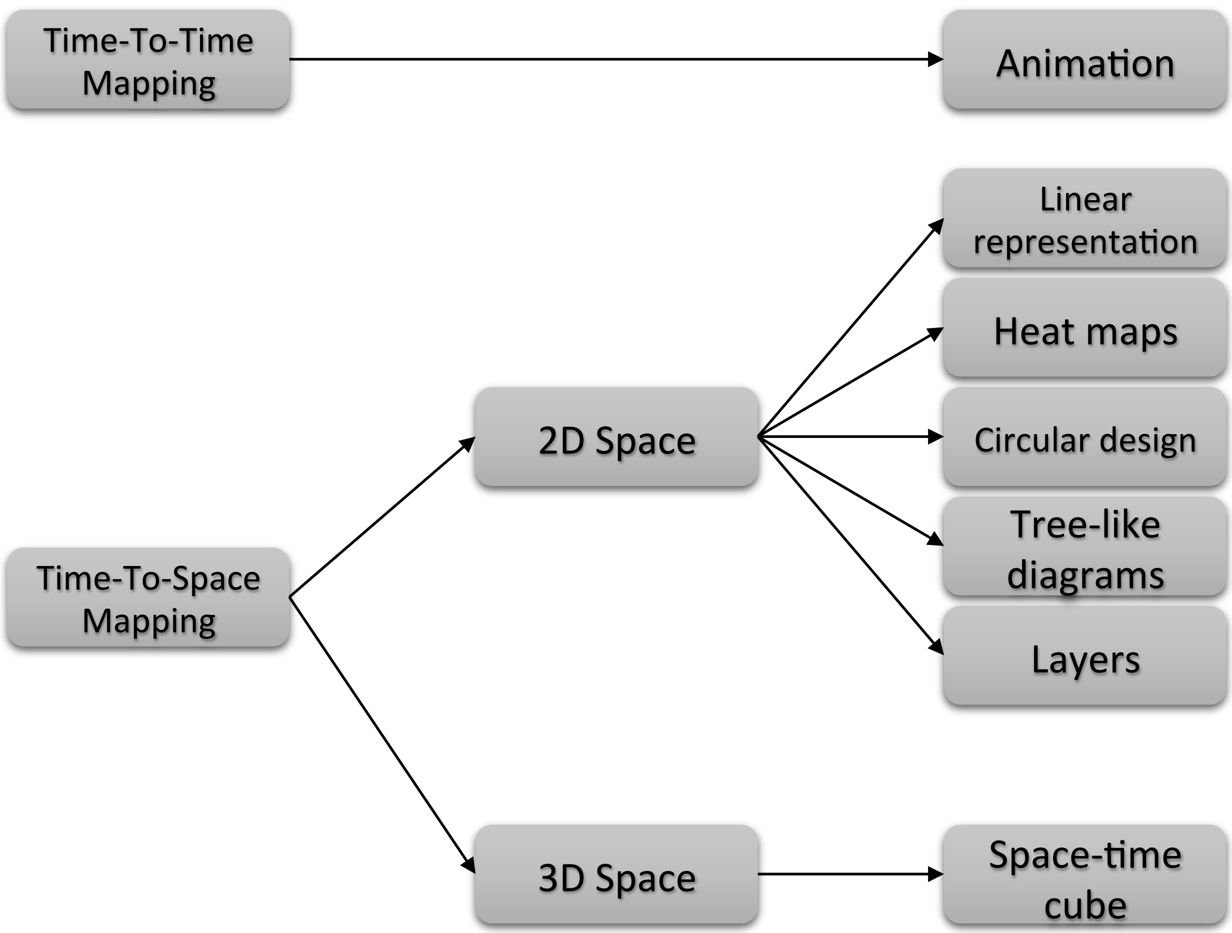
- Why spatial data?

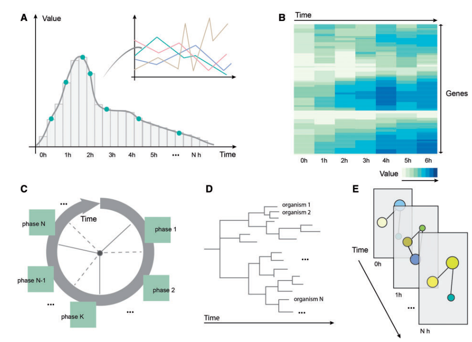
  Those are the properties of biological systems. Such as the physical locations (coordinates) of neurons in networks.

Time series data visualization

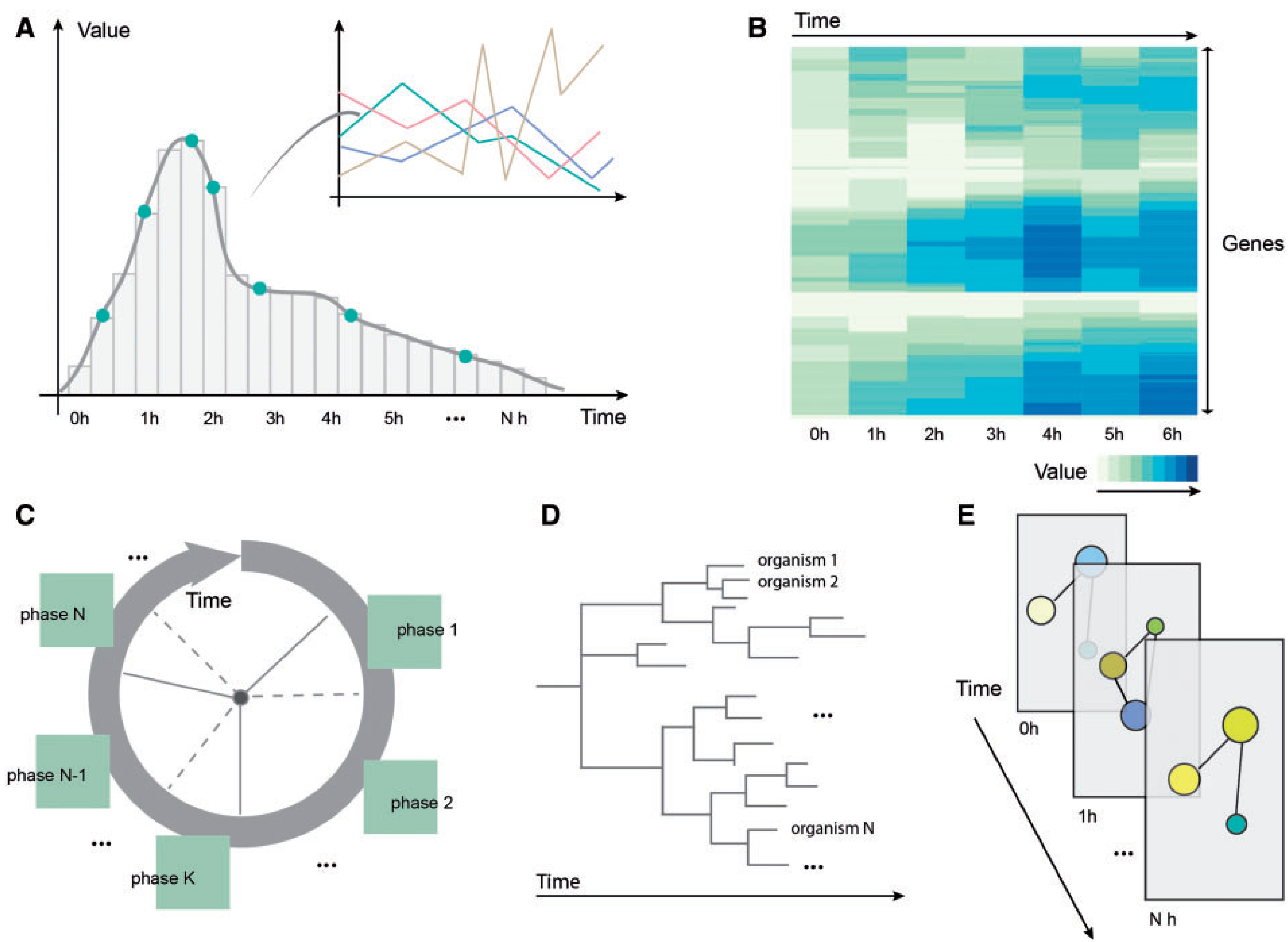
- Time-To-Time Mapping
- Animation
- Time-To-2D Space Mapping (Timeline)
- Line graph: ThemeRiver
- , radial-based layout: Spiral Graph
- , small multiples
- Time-To-3D Space Mapping
- Space-time cube

Time series data visualization





Secrier and Schneider. Visualizing time-related data in biology, a review. *Briefings in bioinformatics* (2013)

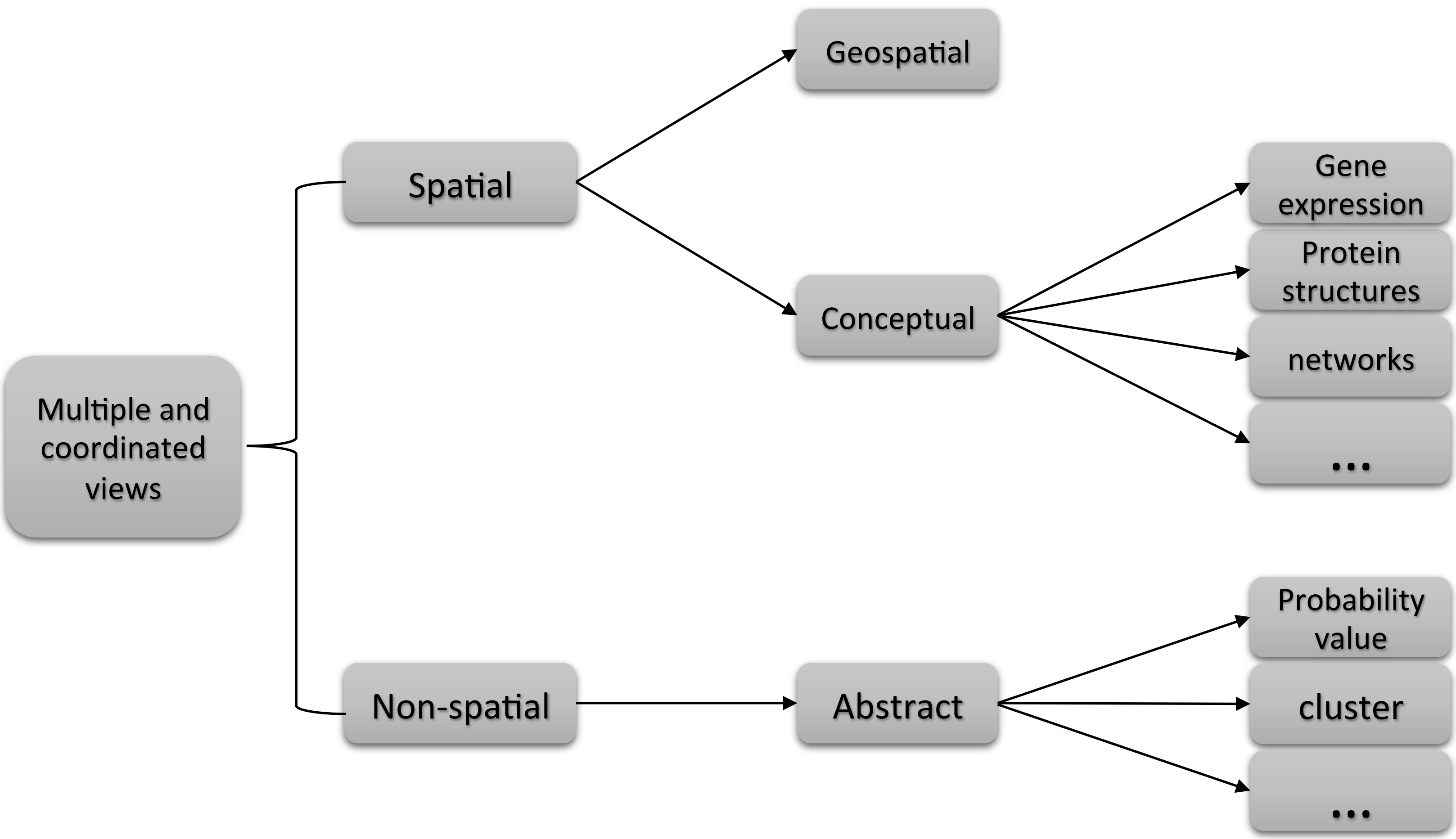


Secrier and Schneider. Visualizing time-related data in biology, a review. *Briefings in bioinformatics* (2013)

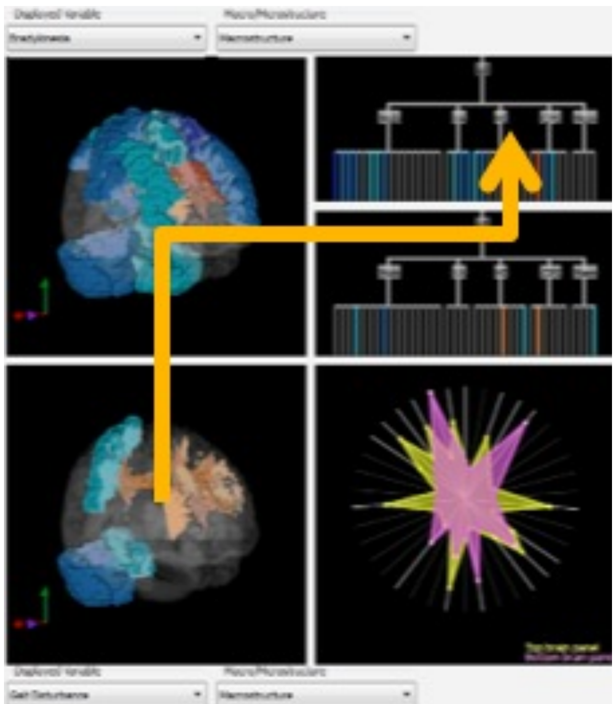
Representing time at different levels

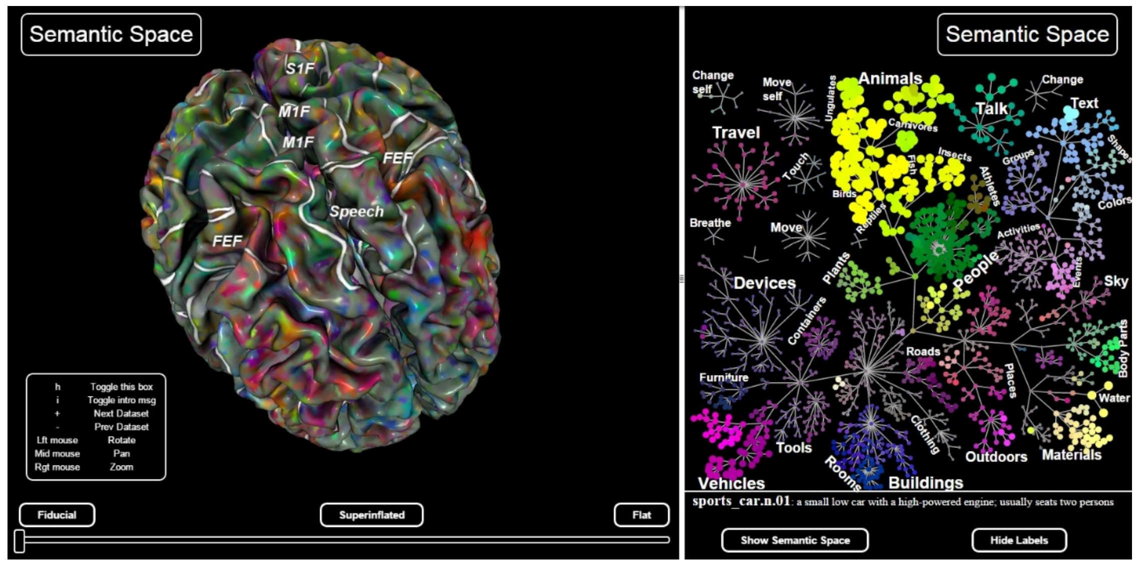
- At the molecular level
- **At the gene level: linear methods and heat maps**
- **At the network level: animation**
- At the cellular level
- At the organismal level
- At the population level
- At the evolutionary scales

Spatial and non-spatial data visualization



Multiple and coordinated views





Brain Viewer. http://gallantlab.org/brainviewer/huthetal2012/

Marai. Visual Scaffolding in Integrated Spatial and Nonspaial Analysis. *EuroVA* (2015)

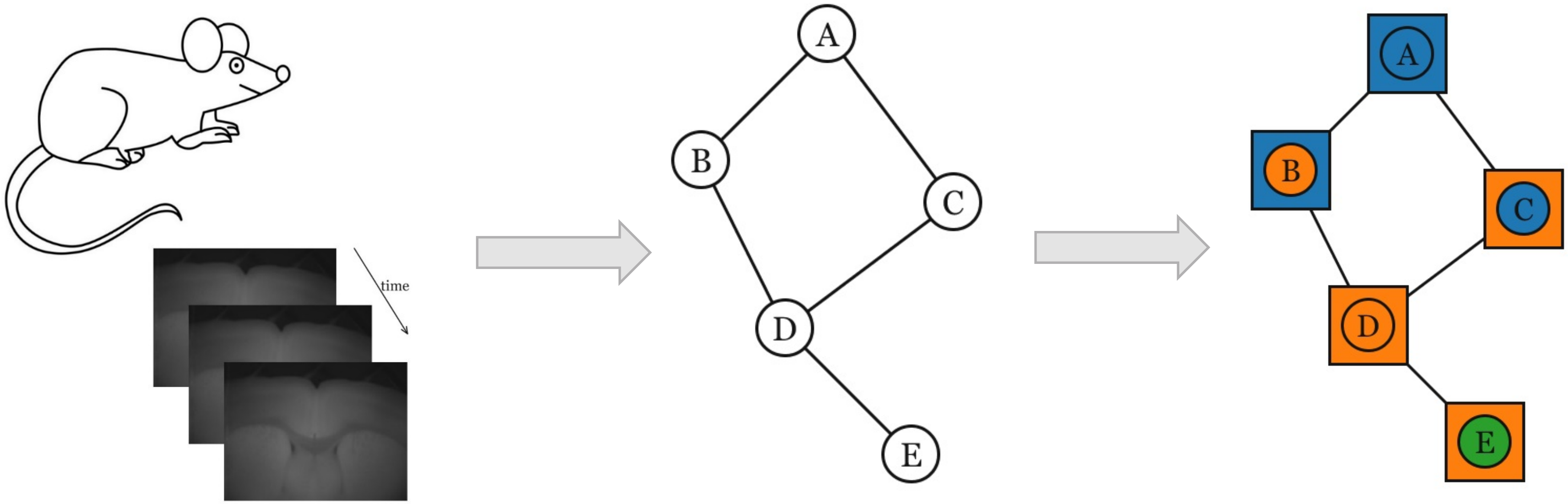
Case Study 1: Dynamic mouse brain networks

- Problem

We collaborate with domain scientists from neuroscience and computational biology who use the approach of dynamic network analysis to explore the change in **functional connections** and **community identities** over time within the mouse brain.

A dynamic community is defined as a time-series of sets of neurons that have similar functional behaviors.

Data Processing



A time series of neuron activity in the mouse brain

A time series of correlation networks

Dynamic communities

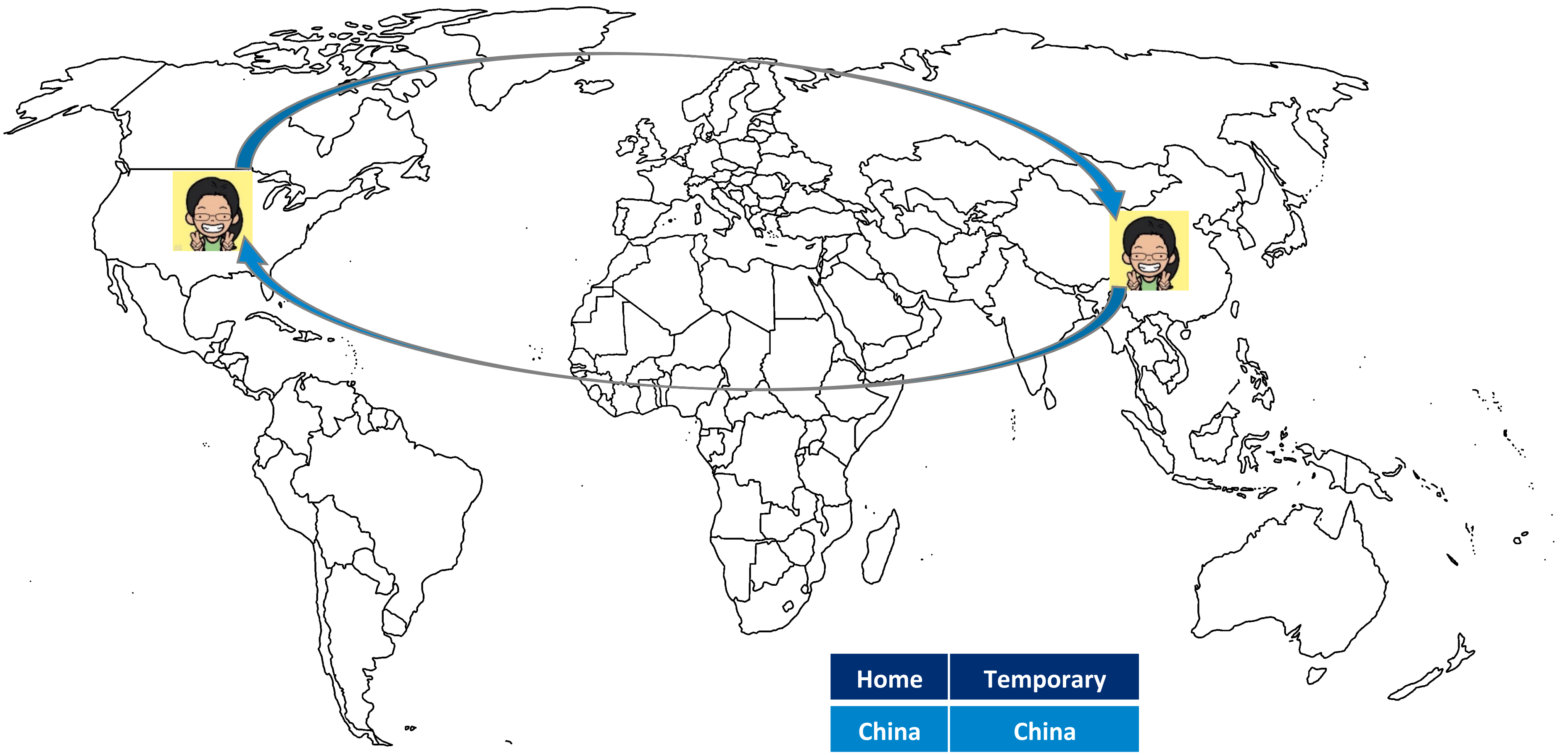
CommDy

CommDy is a method of detecting dynamic communities.

Two community identification codes:

- **Home Community** identifying the community that the neuron belongs to;
- **Temporary Community** identifying the community that the neuron currently visits.

Example for CommDy



Home	Temporary
China	China
China	USA
China	China

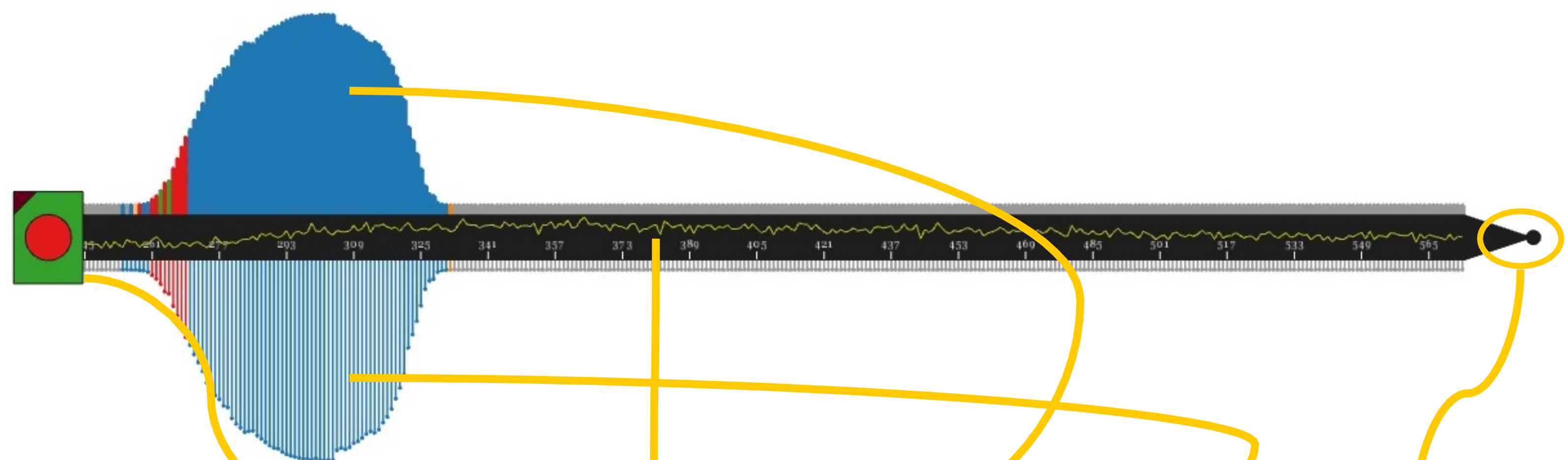
Data features

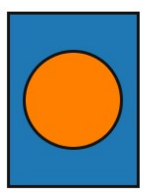
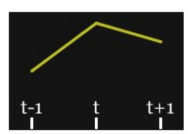
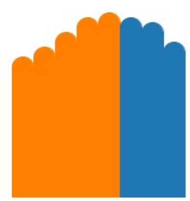
- Time: ~1,000 time steps
- Spatial data: the coordinates of nodes (a set of neurons)
- Non-spatial data: pixel intensity, node degree, community identifications, network size, etc.

Visual encodings

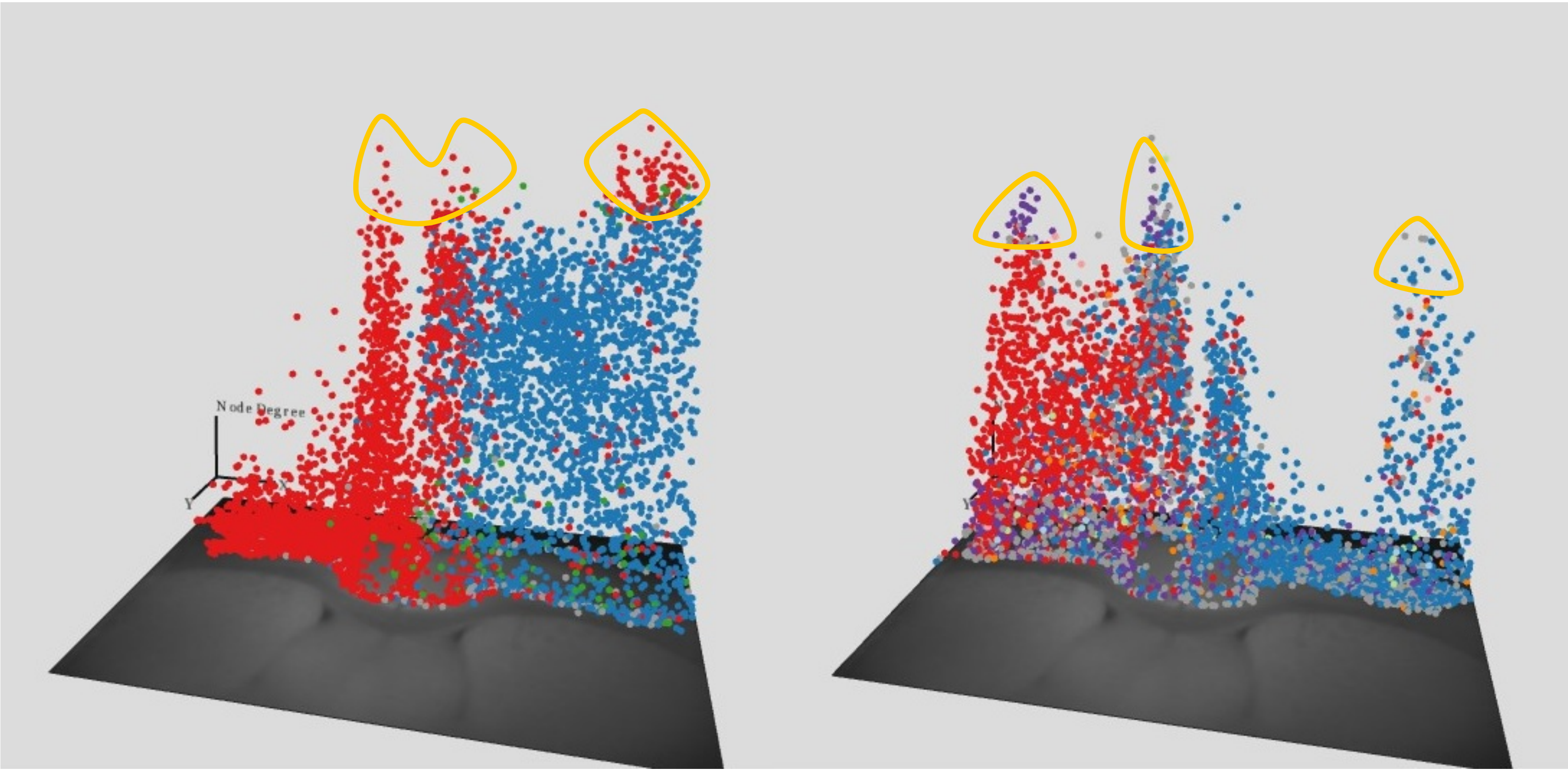
- Time: linear representations and animation
- Spatial data: 2D mapping (map the nodes onto the brain slice images)
- Linked views

SwordPlots



Sword Parts	Sword Pommel	Sword Body	Upper Cross-guard	Lower Cross-guard	Sword Point
Representation	Current Time Status	Raw pixel's value	Temoprary Community	Home Community	—
Visual Encoding					
Interaction	change location	—	—	display detail panel	change size

Space attribute cube



Case Study 2: Probability distributions at states in the FFL network motif

- Problem

Our domain scientists develop numerical methods for the simulation of biochemical networks. They need help with either journaling a set of simulations or exploring the simulation itself through visualizations.

# of Protein 0	…	# of Protein N	Copies of Gene 0	…	Copies of Gene M	Probability
2	…	30	0	…	0	0.000001
…	…	…	…	…	…	…
10	…	100	0	…	1	0.002
						$\sum P = 1$

Tasks

- Find the number of probability peaks
- Find the locations of peaks
- Describe the shapes of peaks
- Track how the peaks change over time
- Track how the peaks change over different system settings
- Comparison
- …

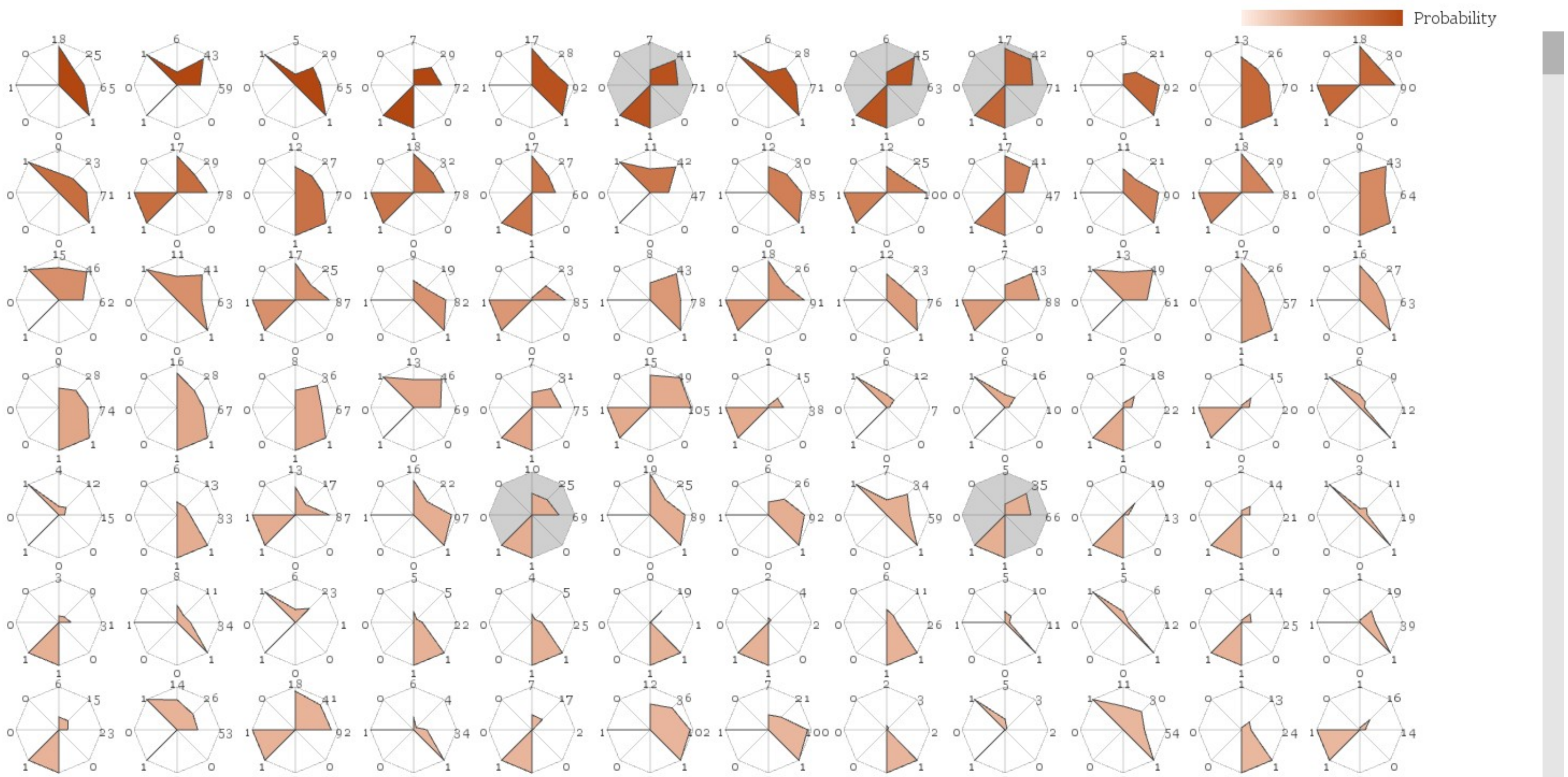
Data features

- Time: 2,000 ~ 20,000 time steps
- Spatial data: corresponding states
- Non-spatial data: probability values, copies of genes, etc.

Visual encodings

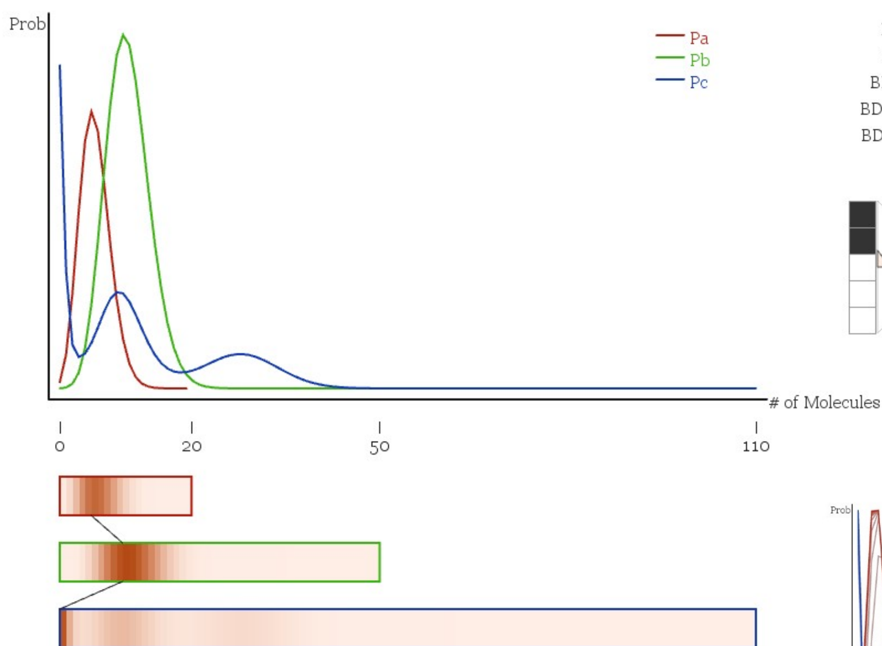
- Time: heat maps OR spaghetti plots (considered as ensembles)
- Spatial data: radar charts

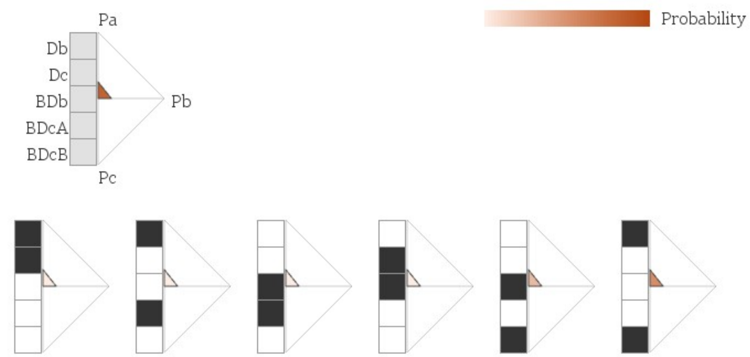
Multiple radar charts

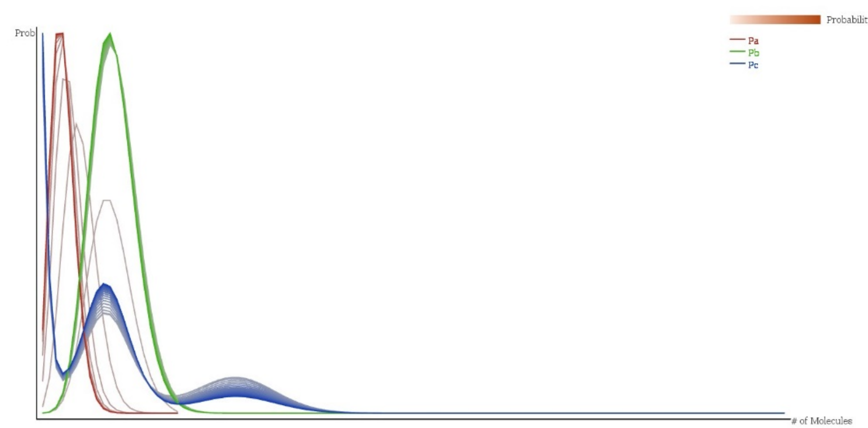


Selected radar charts with time

1D projection and half-radar charts







Spaghetti plots for time