Brain Connectivity Visualization

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1 Overview

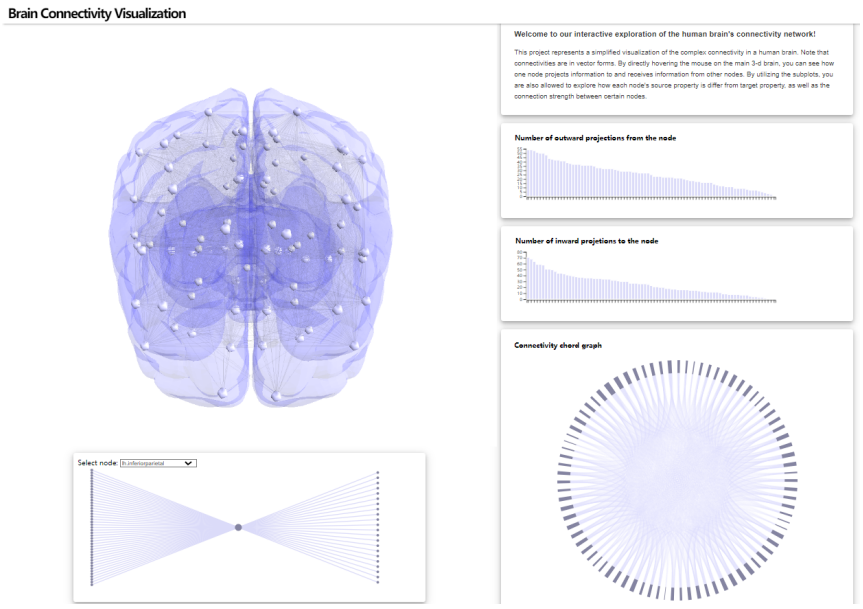

Figure 1: Screenshot of our Visualization

Our visualization aims to visualize the human brain connectivity for different cortical areas. We included multiple views, including a brain 3D brain node-link map, simplified network diagram, bar charts, and chord graphs to gain insight from multiple perspectives of connectivity.

2 Data

2.1 Neuroanatomy Data

We use data generated by previous studies [1] to visualize the MNI standard brain on a webpage using three.js. The data consists of over 58,000 points to model a 3D MNI standard brain on a

webpage.

2.2 Connectivity Data

This visualization would fit any brain connectivity data, as long as it has been formatted JSON like our presented data. We use data generated by previous studies[1] that has already been formatted as JSON file; this dataset consists of 2103 entries, representing 83 nodes and 2103 links of connectivity between cortical areas. Each entry contains the MNI standard 3D coordinates of the cortical areas that this projection is projecting to and from, fiber density, and the direction of this projection.

3 Goals and tasks

3.1 Data Processing

To cooperate with all the views we have built, we have to do some processing of our data. To plot nodes on brain visualization, we select all the MNI standard 3D coordinates from all entries and stack them according to the ID of the nodes; in this process, we can count the links that are projected from/to this node. For the visualization of the links, we need no 3D coordinates anymore; we strip all the unnecessary information and only keep the node ID information for the projection. To use the built-in chrode function in D3.js, we reconstruct the link information into a matrix; each row/column represents one node, and the data in each cell represents the fiber density for the specific connection.

3.2 Visualization Plan

We aim to build 5 different views, one brain node-link diagram, one 3D brain node-link map, one simplified network diagram, two bar charts, and one chords graph. All of the views will be connected through interaction if the user selects a specific node/link; all views should have some way to highlight the node/link.

3.3 DOM Arrangement and Webpage Beautification

To ensure the views are presented on the webpage in the way we want, we set the position attribute of all the elements to be relative and construct additional layers of div structure to ensure the specific arrangement. For the beautification, we defined a class of card-like components in CSS and used the effect for the specific web elements we wanted.

4 Visualization

Our visualization has five interrelated views: a 3D brain node-link map, two bar charts, one chord graph, and one simple network. In this section, we will first introduce each view and then show how the five views are interrelated.

4.1 Views Introduction

- 3D brain node-link map - The 3D brain node-link map is acquired from the previous[1] research. The map is built using 58k 3D coordinates, and the brain regions are classified into 83 nodes. Each of the 83 nodes has a relative position to the map, and 2103 projections connect these nodes. This brain map is the key view in our visualization project; it gives users a general concept of the structure of the brain, the position of nodes, and the connection between nodes. Any interactions later in other views will be linked to the brain map.
- Bar Charts - Two bar charts have the same implementation procedure but express different information. The first bar calculates the number of projections sent from a node, and the second bar calculates the number of projections received by a node. Both of the bars are sorted in a descending manner. These two bar charts give users a sense of which part of the region receives more information and which projects more information.
- Chord Graph - The chord graph shows all the connections (both inward projections and outward projections) between the nodes. Each arc at the edge of the circle represents one of the 83 nodes and its width is positively correlated with the number of connections. This graph visualizes the distribution of connectivity strength among nodes.
- Simple Network - A 3-layer simple network is used to view the detailed connectivity of a single node. A selection box is provided for users to select the node they are interested in. The first layer contains nodes projected to the selected, the second layer is the selected node, and the third layer contains nodes projected by the selected node. This view allows users to zoom in on the details of the node of interests

4.2 Interractions

4.2.1 Free position of the 3D brain node-link map

Users can freely rotate, move, zoom in, and zoom out the 3D brain node-link map to get the best view for certain regions; this is helpful when users want to check some links or nodes being blocked by other nodes.

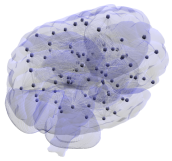

Figure 2: The 3D brain node-link map after rotating, moving, and zooming out

4.2.2 Mouse hovering on views

Hovering the mouse on a node on a 3D brain node-link map will highlight all connections related to that node and dim unrelated connections. At the same time, the bar related to that node on two bar charts will be highlighted and a text will pop up to tell the name of the node.

Similarly, by hovering the mouse on two bar charts, the corresponding connections as well as name text on the brain map, will be highlighted. The inward projection bar chart and outward projection bar chart will trigger different connections based on projection directions. In addition, the simple network will be updated to the latest hoverd bar, the chord diagram will also be updated, highlighting the connection of the selected node.

Hovering on the simple network can trigger multiple events: if hovering over nodes, the brain map will highlight that node, and bar charts will change accordingly; if hovering over links, the brain map will highlight that link and the nodes at both ends. Text information about connection strength and number of fibers as well as names will be displayed.

Hovering on the arc of the chord graph will highlight the corresponding connections with that arc (node), and dim the unrelated connections. Invisible arcs are used to improve the mouse hovering experience when users are trying to hover on some very thin arcs. Similar changes in bar charts, the simple network, and the 3D brain node-link map will also be triggered.

4.2.3 Selection box

A selection box for a simple network provides users a way to manually select the node of interest. The simple network will be updated after the selection.

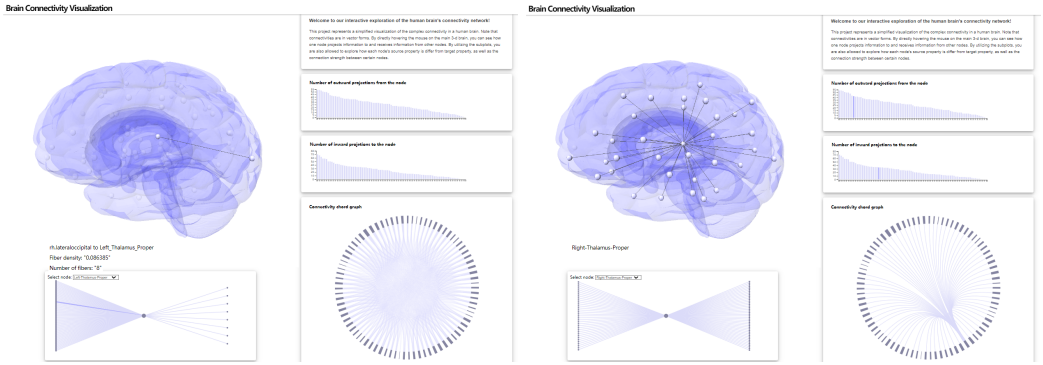

Figure 3: Demo of triggering events. Left: hovering the mouse on one of the links in the simple network. Right: hovering mouse on one of the arcs on chord diagram

5 Reflection

We only kept two views mentioned in the proposal: the 3D brain node-link map and two bar charts. The reason for us to abandon the matrix view is that the matrix view can be hard to interact with, and users can not easily extract information from a big matrix like 83-by-83; a simple network could be more straightforward. The reason for not including the abstract 2D brain map is that all of the information can be informed from the 3D one by rotating the 3D structure. To show the fiber density, we also include a chord graph. In terms of technique perspective, we did not change much compared to the plan we proposed; the only difference is that we introduce a 3D brain node-link map using three.js because it can provide an additional layer of interaction by rotating the brain; we believe the users can be more informed through exploring the 3D structure.

References

[1] Renaudmarquis, "Renaudmarquis/conn-viz: Og 2019 - project 09: Visualizing brain connectomics using d3.js," 2019.