CSCI 55200 – Final Report on
Brain Network Visualization To Aid Research

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and

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Background

The brain is still a mystery despite mankind research since ancient times. However, in modem times, technology allows imaging of certain portion of the brain. Images of such information is usually vast and very difficult to read. In order to aid in understanding more of that subject, visualization is needed. So the subjective of this project is to provide a type of visualization of brain node connectivity between multiple subjects. The visualization will have to be clear to be able to identify each node and each individual subject. The proposed result will be coded in D3.

There are three category of patient: Healthy Patient (HC) , patient with memory problem (MCI) and patient with Alzheimer`s Disease(AD). Each of those category are contained inside three separate csv file named MCI,AD and HC respectively. Those files contain 19 patient whose brain network is represented in an adjacency matrix and a weight value to each link.

Each adjacency matrix has the size of 234 X 234. It represents the connectivity of 234 nodes and the significance of the connections between nodes. Due to there is no direction for the connections, the data is symmetric over the diagonal.

These brain nodes are essentially distributed in three dimensions over the brain. In this project, nodes are instead be visualized in two dimensions. The idea is by getting rid of the original position distribution of the brain nodes, a new visualization way is to be explored by applying physical force among nodes based on the factors: nodes connectivity, connection significance, charge force, gravity and the initial position of nodes. Then, two experiments are conducted to extract potential meaningful information.

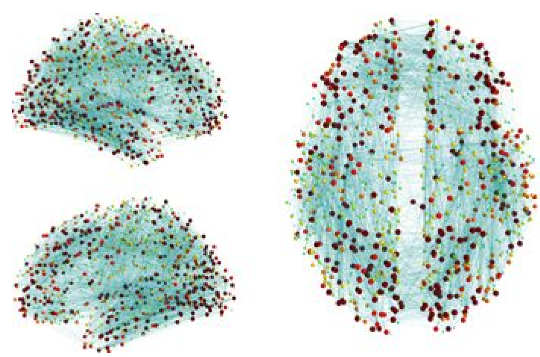

Figure 1: 3D brain nodes distribution

Technique Description

D3 force layout

It is a flexible force-directed graph layout that applying physical simulations for each node. At the beginning, each node will be pulled or pushed due to the pre-set force parameters. The node's movement will eventually stop when the force among the system comes to a mechanical equilibrium state.

Pre-processing

The design of force layout graph is to draw the graph by two data objects: node object and link object. Unlike some object oriented file formats such as Json, the data provided for this project is adjacency matrix in csv file. Therefore, finding a way to convert it into node and link objects are necessary. To solve this, csv file is first loaded and read as text. Then an iterator is implemented on the text data. Since each cell in an adjacency matrix is the weighted value between two nodes, each cell have a row and column node correspond to it. So the row and column are stored as node name and weight as value in link object. Then they are place into a hashmap to remove duplicated node object.

Aiming for fixed final position

Due to the characteristic of force layout, nodes are displaced by the force charges and other parameters in the graph, and it made the already randomly displaced node more displaced because of the random initial position of nodes. The suggested method is to set initial position for each node and have them arranged in uniformly distributed space, so the ambient charge force of each node become constant.

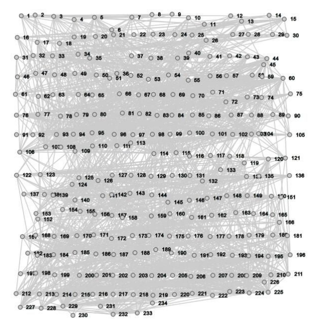

Figure 2

Figure 2 shows the distribution of initial position of nodes at the beginning of the drawing. (this is the result after some ticks of calculations)

Measuring difference between graphs

Despite the node network graph of patients appears to be different, it is hard to describe the difference. So a measurement is needed to calculate the difference. The method applied in this project is using Standard Deviation and Euclidean Distance.

In the first experiment, the Standard Deviation of coordinate position of each node among graphs is calculated and by hovering over the node, Standard Deviation value will be shown. Then using the Standard Deviation range value , a node color is assigned to each node using a heat map.

In the second experiment, the Euclidean Distance of graph is calculated and the final result is adding up all the deviation between each node. The final result is displayed at the top of graph in a div tag.

Results

For the first experiment, only one category of brain nodes is used to calculate the displacement of node-i ([1, 234]) among different patients. Each category contains 19 patients brain node adjacency matrix. Considering the computation of the force simulation of force layout, only first three adjacency matrices of each category are used to perform the experiment. The measurement of the displacement of node-i is to use the standard deviation value.

At the first round of graph drawing, three force layout graphs with the same category is drawn. Then, the program passes all node's final positions to the second round. At the beginning of second round, the program calculates the standard deviation among three node-i (same node name among three graphs) based on the coordinate positions. Then, based on the range of standard values, each node-color is assigned according to its SD value (Heat map). In this way, nodes with lighter color has lesser position-difference between patients; Darker color, vice versa.

AD category: http://cs.iupui.edu/~caozh/CSCI_55200/Project/Three_AD.html

HC category: http://cs.iupui.edu/~caozh/CSCI_55200/Project/Three_HC.html

MCI category: http://cs.iupui.edu/~caozh/CSCI_55200/Project/Three_MCI.html

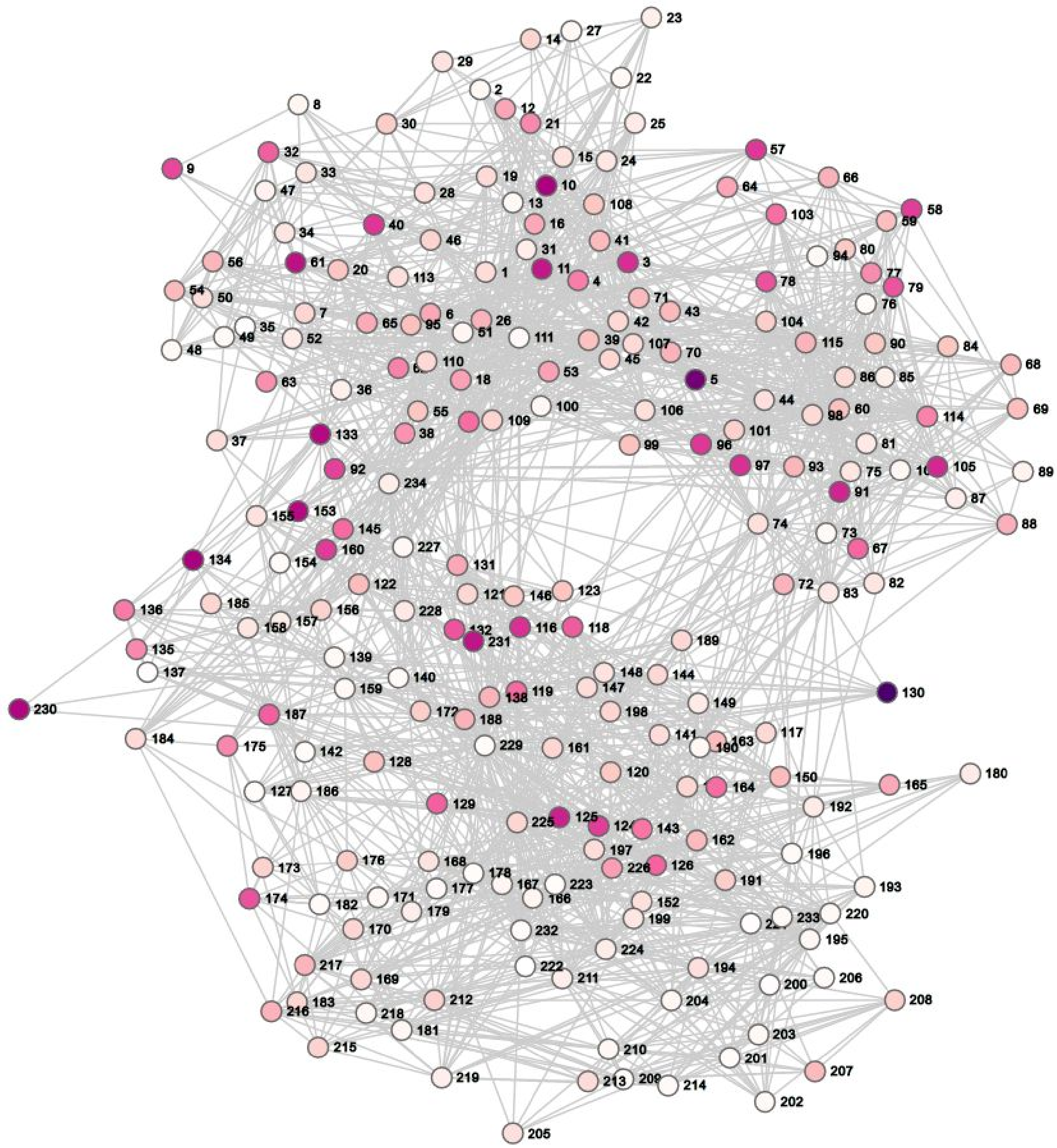

Figure 3: The heat map graph of one patient from category AD

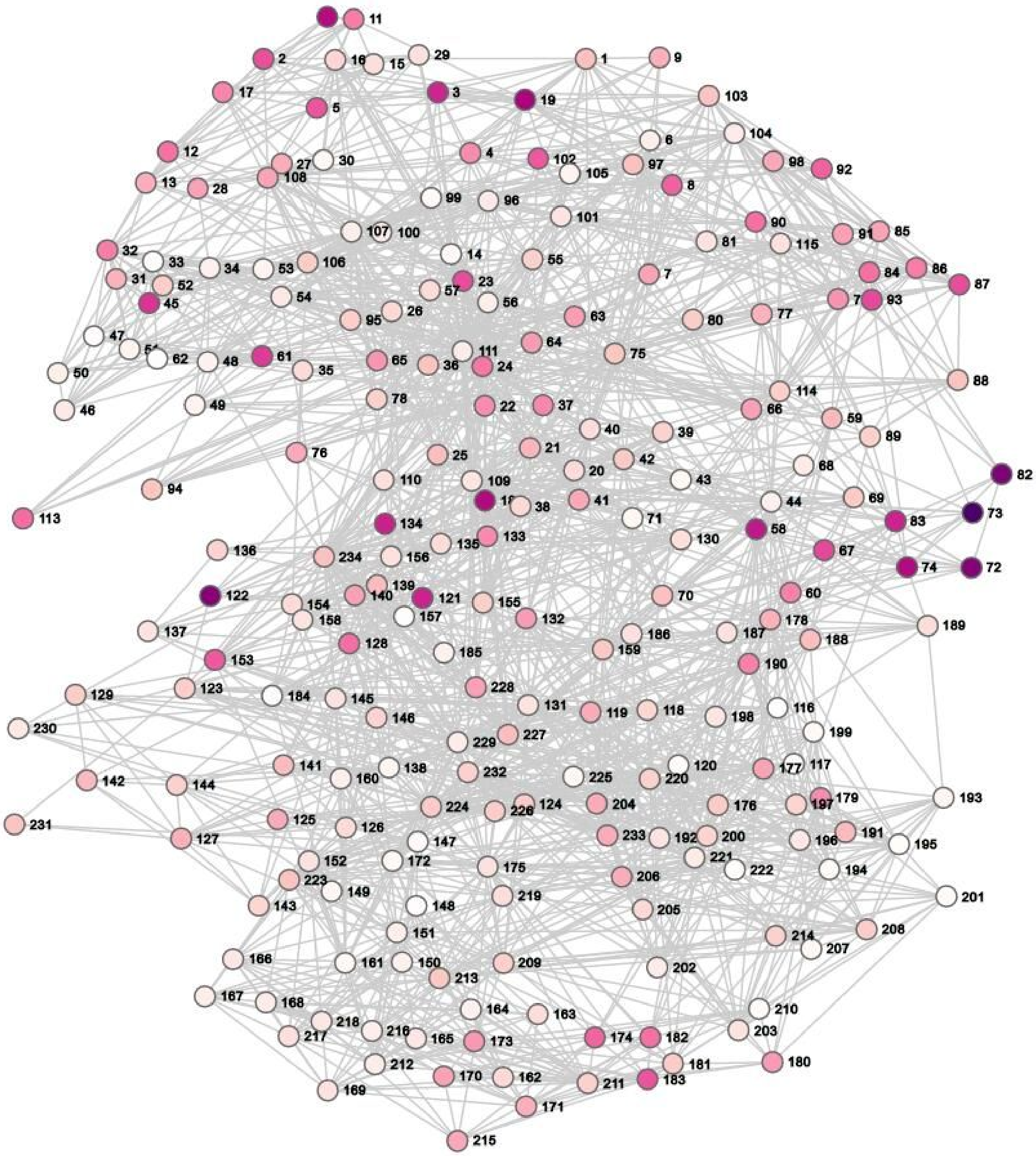

Figure 4: The heat map graph of one patient from category AD

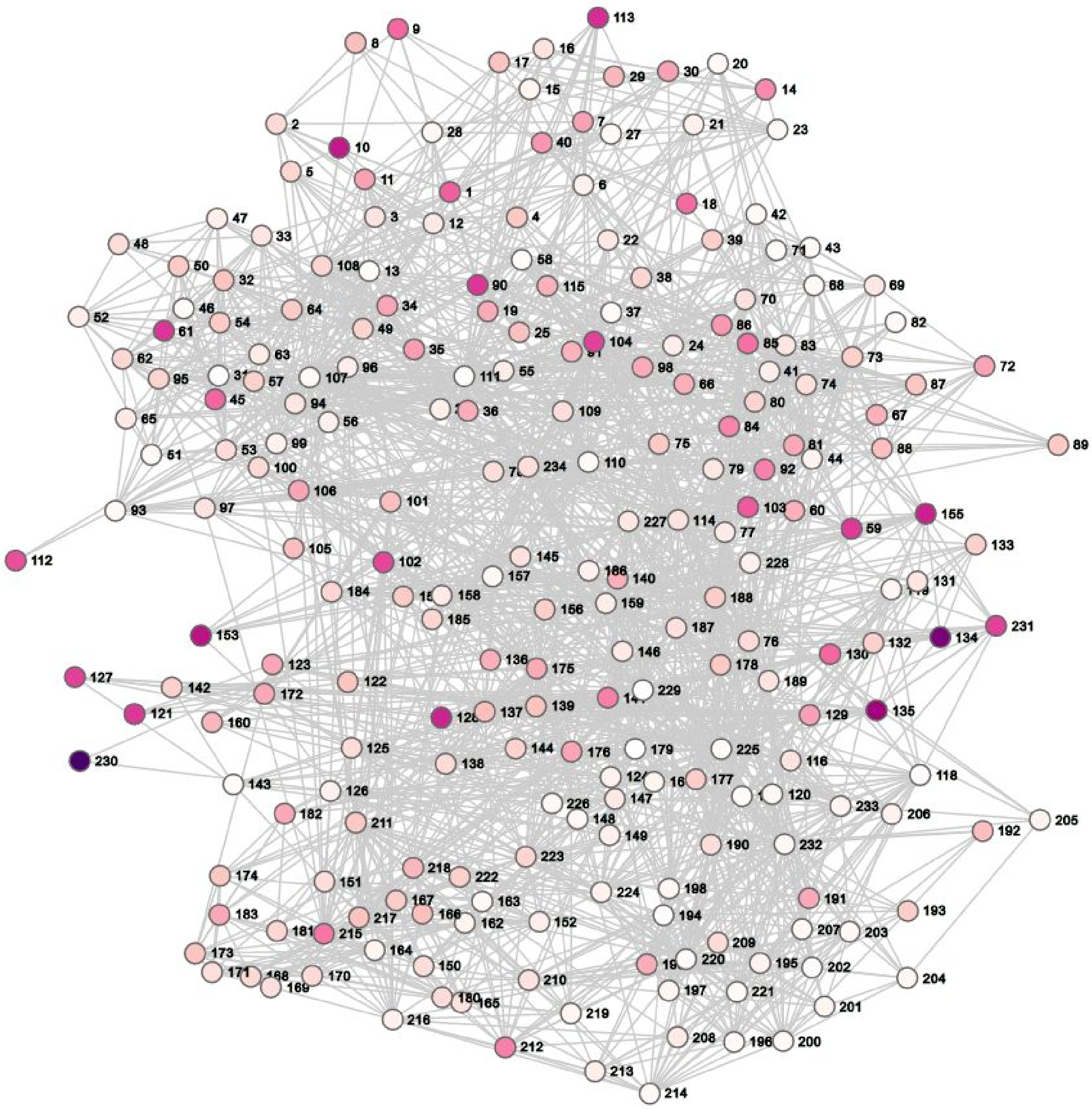

Figure 5: The heat map graph of one patient from category MCI

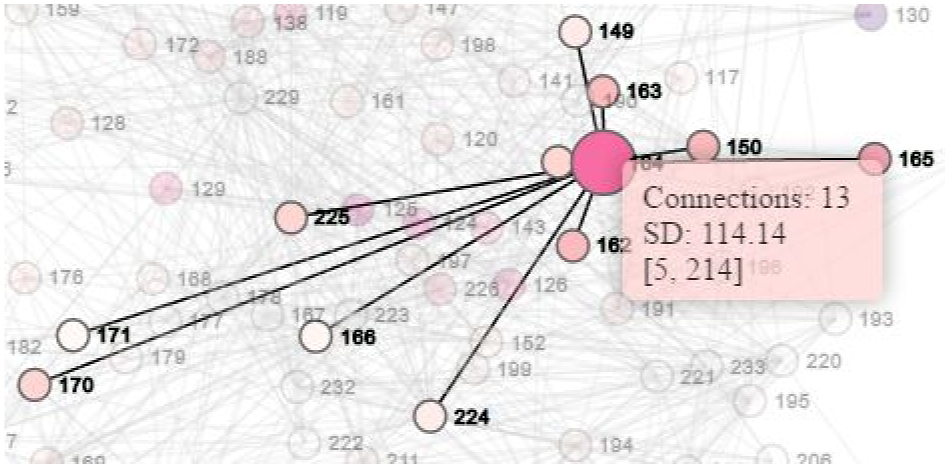

Figure 6: highlighting the nodes by mouse

Here is a feature that helps researchers focus on the nodes that they are looking at. It highlights the links associated with the node that mouse is pointing at and transparentize any other unassociated nodes. Meanwhile, a text box will appear near the mouse to show information of the node. As the figure 6 shown, “Connections” stands for the links associated with the selected node; “SD” stands for the standard deviation value of the node-164 among first three patients of category AD. “[5, 214]” stands for the range of 234 standard deviation values.

For the second experiment, two patients with different categories use Euclidean distance to measure the difference.

ADvsMCI: http://cs.iupui.edu/~changsz/CSCI_55200/ADvsMCI.html

HCvsAD: http://cs.iupui.edu/~changsz/CSCI_55200/HCvsAD.html

MCIvsHC: http://cs.iupui.edu/~changsz/CSCI_55200/MCIvsHC.html

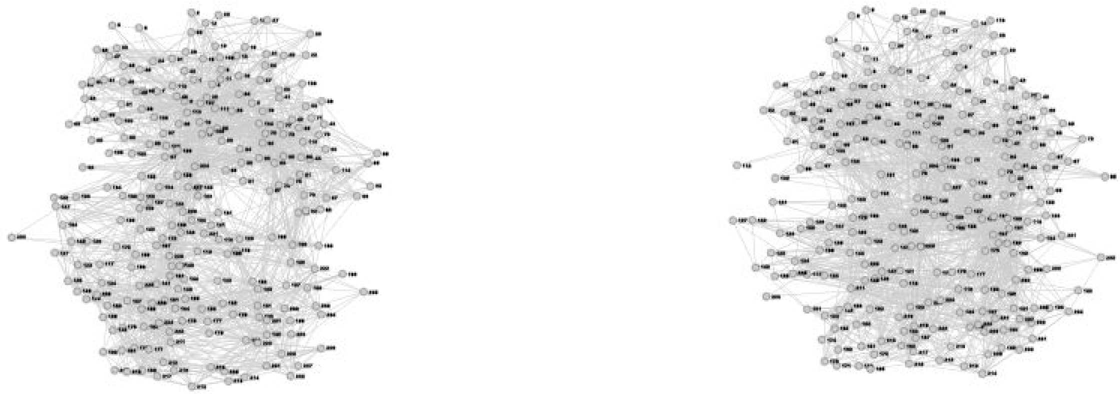

Figure 7: Graph of Patient with Alzheimer's Disease category(left) and Graph of Patient with Memory Problem (Right)

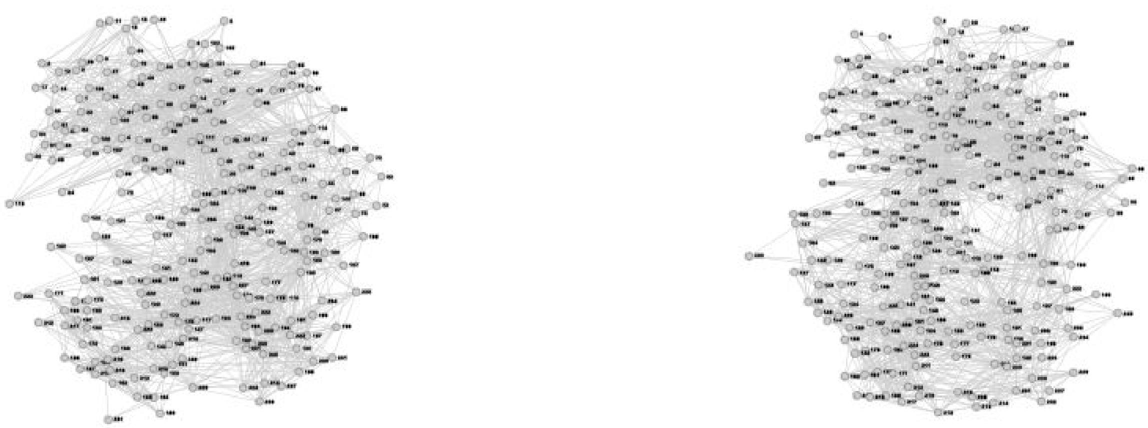

Figure 8: Graph of Patient with Health Body category(left) and Graph of Patient with Alzheimer's Disease(Right)

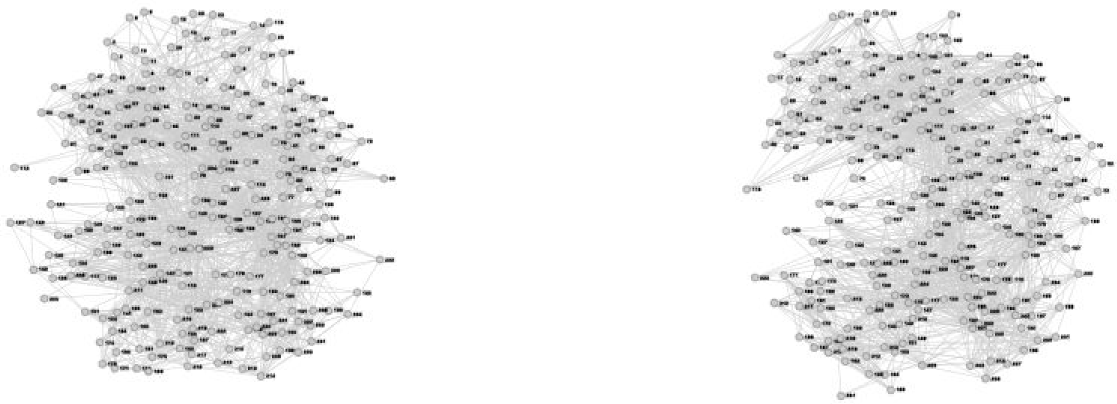

Figure 9: Graph of Patient with Memory Problem category(left) and Graph of Patient with Healthy Body (Right)

Discussion

We have learnt a great deal in the implementation of D3 and have better understanding of its component such as force layout in this project. InfoVis is a surprising profound field and through this, we learn to appreciate more of it. Furthermore, by applying information visualization, we could extract more information from the data and through customization , exact details could be seen.

For future work

- Do the experiments using all patients' data. Thus, the Standard Deviation value and the Euclidean value will be much more accurate.
- Have a way to overlap graphs on top of another. Then have nodes of the same name be identify together.
- Using 3D force layout technique, get a more accurate network displayment based on actual brain node location

Reference

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