Ceng491 Project Proposal: Cognitive State Representation and Visualizing of Human Brain

Kernel Panic

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1 Problem Definition and Background Information.

The human brain is a complex system which is topologically represented as structural and functional connectomes [1]. Mapping the human brain connectome and uncovering its underlying organizational principles are fundamentally important in neuroanatomy, neurodevelopment, cognitive neuroscience and neuropsychology. Recent studies have suggested that the human brain connectome can be mapped using neuroimaging data and further characterized through sophisticated analytic strategies based on graph theory[1].

The products invented until now is used to examine some issues such as aging, development, gender, intelligence and genetic, and used on individuals with a variety of neuropsychiatric disorders, including Alzheimer's disease (AD), mild cognitive impairment (MCI), schizophrenia and epilepsy. Recently, several freely available toolkits for extracting brain network topological properties have emerged:

[1] map of neural connections in the brain.

- Brain Connectivity Toolbox (BCT)[3],
- eConnectome[4],
- Graph-Analysis Toolbox (GAT)[5],
- Pipeline for Analyzing brain Diffusion images (PANDA)[6],
- NetworkX[7],
- Brainwaver[8],
- Graph-theoRETical Network Analysis toolkit (GRETNA)[9]
- CEREBRA

Which have greatly assisted with the investigation of the brain connectome.

However, toolkits for visualizing the brain connectome as nodes and edges are still lacking. One of such toolkits is:

- BrainNet Viewer

The main problem we will work on is simplifying the complex graph view of the brain networks and representing it in a smooth 3D animation of neuroimages. Down sampling and quantization will be used to achieve this goal.

Before this project, human brain has been modeled as nodes which represent voxels in neuroimaging data and edges which links nodes. With the neuroimage obtained, it was shown the active parts of the brain under some specific circumstances. Now, our project involves visualization of the fmri data in space-time. 3-d animations will be done for visualizing the cognitive processes in the brain.

Given the nature of graph theoretical approaches and the huge complexity of brain networks, it is important to develop easy-to-use and efficient toolkits for 3d animations.

2 Significance of the Problem and Motivation

This problem aims to help those who want to examine the most complex machine in the universe, human brain. We will take an input which is obtained by using functional magnetic resonance imaging (fMRI) machine and convert it to a smooth and understandable 3D animation. There are some challenging areas we have to deal with them. First of all, we will deal with large data. A single input could be reach up to one terabyte. We must deal efficiently and effectively with this data. Secondly, we want to visualize the brain animation in 3D. This means we must work with voxels. Each one represents a tidy cube of brain tissue a 3-D image building block analogous to the 2-D pixel of computers screens. Each voxel can represent a million or so brain cells. We will try to obtain a smooth 3D image and animation with those voxels (group of brain cells).Finally, we will deal with human brain, which has very complex working principles.

We have looked up every other project ideas, talked with some of our teachers. We do not want to work with a company because we do not want to work as a free employee to any company. Also, other projects does not fulfill our interests. After talking to Prof. Dr. Fatoş Yarman VURAL, we found that this project conforms to our expectations from a graduation project. Also, three of our members are taking Image Processing course from Prof. Dr. Fatoş Yarman VURAL and all of our members are taking Computer Graphics course and have some basic ideas on unity and other computer graphics concepts. Furthermore, we found interesting to work with human brain, analyzing it and doing it with computer graphics and image processing.

The products mentioned at Section 1 have greatly assisted with the investigation of the brain connectome. However, toolkits for visualizing the brain connectome as nodes and edges are still lacking. BrainNet Viewer is one of such toolkits but it works with only small sized data. Our aim is to create a similar tool but allows us to work with large data compared to Brainnet Viewer and CEREBRA and to form an brain animation from a time series data.

Neuroscientists can benefit from this tool to evaluate how risky brain surgery or similar treatment is for a patient and to learn how a normal, diseased or injured brain is functioning. They can map the brain with this tool to identify regions linked to critical functions such as speaking, moving, sensing, or planning. This is useful to plan for surgery and radiation therapy of the brain. Clinicians also can benefit from this to anatomically map the brain and detect the effects of tumors, stroke, head and brain injury, or diseases such as alzheimer's[2].

We are not planning to turn this project into a commercial/academic business/product for now. To do such a thing, we have to consult to Prof. Dr. Fatoş Yarman Vural.

3 User Story

End product will consist of an easy-to-use user interface and three dimensional animated display of brain data recorded by a functional magnetic resonance imaging (fMRI) device.

The data recorded by fMRI device will be given as a grid to our tool by the user. Then, the program will create an image and animation which visualizes data into a three dimensional representation.

As a/an (Type) User	**I want to**	**so that … (optional)**
Neuroscientist	see the detailed animation of the brain by using fmri time series data	I can recognize the diseases by seeing anomalies.
Neuroscientist	save the images and videos of the 3d representation of the brain in an accepted format	I can evaluate easily and update it more than once.
Neuroscientist	take clearer and more quality image and animation	The results can be more comprehensible and qualified.
Neuroscientist	see the anatomic regions of the brain namely frontal, parietal, occipital, limbic and temporal lobes, in three dimensional geometry	I can see what happens in the different parts of the brain.
Neuroscientist	See the time series data with a graphic which belongs to clicked region	I can see my data in different ways.
Neuroscientist	give a large fmri input to program	I can get effective and efficient results which is not possible in other applications.
Neuroscientist	filter the 3d image of the brain	I can focus on different parts of the brain.
Medical student	be closely acquainted with brain regions and activities	I can learn it easily thanks to the 3D animations.
Stakeholders	finish my huge project	I can use this senior project of students as a module.
Developers	improve us in computer graphics, image processing by analyzing brain activities	We can use this project as a reference and contribute to the science.
Developers	Use and create different algorithms	We can improve our algorithm an programming skills.

We will benefit from the source code of Brainnet Viewer to import five main regions of brain to Connectome and the code generated by CEREBRA which is previous year final project. We cannot directly use Brainnet Viewer because it cannot handle large data (up to 1 TB) efficiently since it is written in MATLAB. Therefore, we aim to implement our project in Unity. After importing the brain regions to Connectome, we will deal with

Simplifying the complex graph into an understandable graph. To achieve this, we will use some image processing and computer graphics techniques namely down sampling, quantization etc.

4 Support

We are supported by Prof. Dr. Fatoş Yarman Vural and those who are members of Pattern Analysis of Functional Magnetic Resonance Imaging Laboratory[2].

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References

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[7]http://networkx.lanl.gov/index.html

[8]http://cran.r-project.org/web/packages/brainwaver/index.html

[9]http://www.nitrc.org/projects/gretna

[2] http://neuro.ceng.metu.edu.tr