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Analyzing the similitude between Internet Service Providers and Brain Functional Networks

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Abstract— The objective of this paper is to compare the brain functional network with the ISP(Internet Service Provider) Topology. Even-though the current internet topology works well, there are some problems such as traffic, slow rate of transmission, robustness, scalability, QoS, etc. Networks fail in untold situations and they do not have self adaptive nature. To overcome these problems networks can be designed with some measures which improve the performance of the network. For the designing of such robust networks, we can use properties of a biological network particularly that of brain functional networks, as the human brain has self-adaptive nature and does not fail in most of the situations. By analyzing the similarity measures between ISP and brain functional networks, we can incorporate the features of the brain which make it fail-free into the architecture of ISP. The comparison is done by using measures such as degree, clustering coefficient, modularity, etc. This project will be helpful in designing more robust and self-adaptable networks.
Keywords: Brain functional network, fMRI, Internet Service Provider.

I. INTRODUCTION

The internet is defined as a collection of interconnected networks. They are maintained by different ISPs. In this paper we are going to compare the brain functional network with the ISP topology.ISP (Internet Service Provider) is an organization that provides service for accessing and using the internet.

A. Internet Architecture

Initially internet was developed for the purpose of communication among research faculties. But nowadays Internet is being widely used and it has changed our life in several aspects. We can use most of the services through Internet today. The current internet architecture has both advantages as well as limitations. The main disadvantage of the current Internet is that of its inability in handling data traffic.

Today's internet has another limitation, that it faces some difficulty when satisfying the needs of different users. To satisfy those different user needs, the Internet architecture should be designed with robustness, scalability, efficiency, reliability, better QoS, Mobility, etc.To overcome these problems we can use the principles of biological networks. As they have the capabilities of resilience and adaptability. Especially it has the protocol that combines the various processes to control different elements of an organism and it has a hierarchal structure [2].In this paper we consider the human brain functional network for the design of future internet architecture. Human brain faces so many problems in real world situation. But the brain does not fail in most of the situation so that the brain network is taken into the consideration for the design of the future network architecture.

B.ISP

An Internet Service Provider is a company which provides individuals and other companies access to the Internet and other related services such as website building and virtual hosting. The ISP topology can be extracted using the rocket fuel technology. For this project the VSNL network is considered. The example ISP topology for AT and T network is shown below.

Figure1: Example ISP Topology

C.Brain Network

Neuron is the basic unit of brain which is a specialized cell that process and transmits information through electrical and chemical signals. The connectivity between neurons is defined as the brain connectivity. There are three types of brain connectivity Structural connectivity, Functional connectivity, and Effective connectivity [1].The structural connectivity describes the connection between the set of neural elements anatomically. It represents the white matter projections linking cortical and sub cortical regions .These connections are stable for a shorter time and may get changed after a long time. The links in this structural connectivity are undirected. Functional connectivity describes the dynamic interaction among the regions. Also the functional connectivity describes the statistical dependence among the neural elements. It changes from time to time. The functional connections are undirected. Effective connectivity describes the causal effects between the neural elements. The links in the effective connectivity are directed. Any type of brain connectivity can be represented as a graph or network.

Node: In such a network neurons or neuron collection (group) can be represented as a single brain region. The node is defined as a connection point that can receive, create, store or send signals along distributed network routes.

Edge: The connections between the neurons are represented by edges .An edge is defined as a line that joins two vertices on the boundary or where faces meet.

Both the nodes and their connections can be represented by an adjacency matrix [3].The brain structure and activity can be measured using neuroimaging techniques such as MRI (MagneticResonanceImaging), fMRI (funcational Magnetic Resonance Imaging), DTI (Diffusion Tensor Imaging)and neurophysical recordings like EEG (Electroencephalography), MEG (Magnetoencephalogrpahy). Neuroimaging captures the images of brain during the activities. In neurophysical recordings only signals of brain is considered. Since we are considering the functional connectivity of the brain for our project the images of brain during activities has to be taken, so that we are using the fMRI technique.

C.fMRI

Functional Magnetic Resonance Imaging (fMRI) is a neuroimaging procedure using MRI technology which measures brain activity by detecting changes in the blood flow to brain. When an area of the brain is in use, blood flow to that region also increases. The fMRI uses the blood-oxygen-level dependent (BOLD), discovered by Seiji Ogawa. This is a type of specialized brain and body scan used to map neural activity in the brain of humans or other animals by the change in blood flow (hemodynamic response) related to energy use by brain cells.MRI has a high, spatial resolution while an fMRI has a long-distance, superior, temporal resolution. Since the images with respect to time are useful for our project, we have chosen the fMRI technique.

D.Retinotopy

Retinotopy is one of the medical field in which visual input from is mapped retina to neurons, specifically those neurons within the stream. Retinotopy mapping in humans is done with Functional Magnetic Resonance Imaging (fMRI). The fMRI machine focuses on a point of the subject. Then the retina is stimulated with a circular image or angled lines around the focus point. Even-though there are several mapping techniques retinotopy is taken up for this project. Other mapping techniques are tonotopy, somatotopy, etc. Tonotopy is the spatial arrangement of where sounds of different frequency are processed in brain.Tonotopic maps are a particular case of topographic organization, similar to retinotopy in the visual system.Somototopy is the point-for-point correspondence of an area of the body to a specific point on the central nervous system.

In this paper we are going to compare the brain functional network formed by using the fMRI (functional Magnetic Resonance Imaging) data during retinotopic experiment with the ISP topologies in India such as VSNL (Vidhesh Sanchar Nigam Limited), Airtel, etc. After the comparison similarity measures are observed to include it in the future network architecture.

In section II we discuss the existing system and their approaches to create brain network. In section III the proposed system is discussed in detail. Section IV contains the measurements which are taken from the networks and evaluation of those measures. Section V has conclusion and future works.

II. RELATED WORKS

In the existing system brain functional networks are formed by using the SPM (Statistical Parametric Mapping) toolbox and fMRI (functional Magnetic Resonance Imaging).The fMRI technology is used to take images of the brain by detecting the changes associated with blood oxygen level. SPM (Statistical Parametric Mapping) refers to the construction and assessment of spatially extended statistical processes used to test hypothesis about functional imaging data. These ideas have been instantiated in software called SPM.The SPM software package has been designed for the analysis of brain imaging data sequences. The sequence can be a series of images from different cohorts, or time series from the same subject. The current release is designed for the analysis of fMRI, PET (PositranEmissionTomography), SPECT (Single-Photon Emission Computed Tomography), EEG (Electroencephalography) and MEG (Electroencephalography).

In this work they considered the retinotopic experiment. First, the time series was extracted from the each voxel. Voxel is nothing but a value on a regular grid in three dimensional spaces. Then correlation between the time series is measured and correlation matrix is formed using the Pearson's coefficient

$$R_{i,\,j}=\frac{\langle v_i(t)v_j(t)\rangle-\langle v_i(t)\rangle\langle v_j(t)\rangle}{\sigma(v_i)\sigma(v_j)}$$

In statistics, the Pearson correlation coefficient also referred to as the Pearson's r or Pearson product moment correlation coefficient is a measure of linear dependence (correlation) between two variables x and y. it has a value between +1 and -1 inclusive where 1 is a total positive linear correlation and -1 is a total negative linear correlation. It was developed by Karl Pearson.

After this threshold masking r_c is applied to obtain the adjacency matrix. Finally the connected component or the network of the brain in concern with Center, Middle and Peripheral are formed. The brain (all) network is represented by combining these three networks.

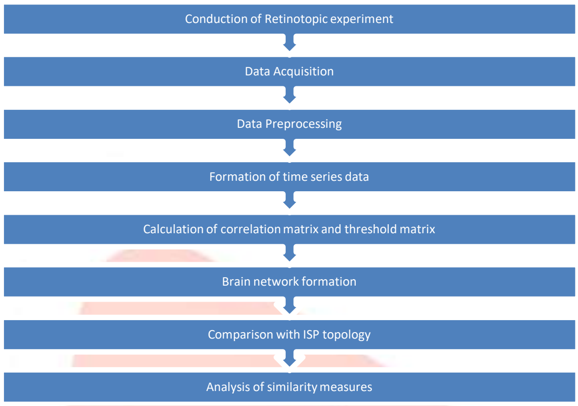
The brain network is compared with ISP topologies obtained through Rocket fuel ISP topology tool available online [4].Evaluation of networks is done with measures such as Degree, Characteristic path length, Modularity, within- module degree, etc. When comparing it is found that the human brain has more number of nodes, links, and degree than the ISP topology. Algebric connectivity is lower for brain networks than for ISPs [1].

The original Internet was designed mainly to allow users to exchange information. Today we see highly diverse sets of services, many of which are used to enhance our quality of life and to support various social problems. In order to fully support such diverse services, the future Network will require new architectural and protocol designs. To improve the new architectural design we need to integrate robustness, scalability, efficiency, and reliability.Bio-inspired solutions only have tackled specific problems for a particular type of network. Thus the Biological networks can be used for future network design. As The brain network does not fail in most of the situation so it can be used as the reference for architecture design in future [2].

III. PROPOSED SYSTEM

In the proposed system we are going to form a brain network from the fMRI data. The project has been divided into the following modules.

1. Conduction of the retinotopic experiment.
2. Data Acquisition
3. Data Preprocessing
4. Formation of the time series data
5. Calculation of correlation and threshold matrix
6. Brain network formation
7. Comparison with the ISP topology
8. Analysis of the similarity measures



Step1: Conduction of Retinotopic Experiment

The different regions of the brain are observed during the fMRI and the three stimuli views are taken and represented. Three stimuli are Center, Peripheral and Middle. The experiment is done for the resting state also. Each experiment is done only for 15seconds and repeated for 6 times.

Step2: Data Acquisition

After the retinotopic experiment completed images of brain are captured using the fMRI technology. The fMRI is a technique for measuring brain activity. The fMRI observes changes in blood oxygen level and flow that occur due to neural activity-when a brain area consumes more oxygen consequently the blood flow to that area will be increased.

Step3: Data Preprocessing

Data obtained from step2 is preprocessed to make it suitable for further operations. The preprocessing steps such as normalization, realignment are performed.

Step4: Formation time series data

The time series is formed from the preprocessed data. The time series is formed for each voxel.

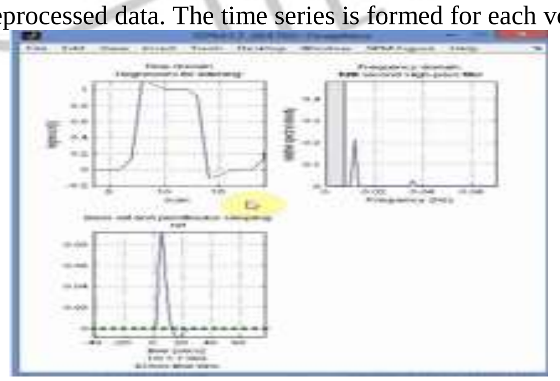


Figure2: Time-Series formation

Step5: Calculation of Correlation Matrix and Threshold Matrix

The output of the step3 is taken as input for this step. By considering the correlation between two or more time series correlation matrix is formed and by specifying threshold value threshold matrix is formed.

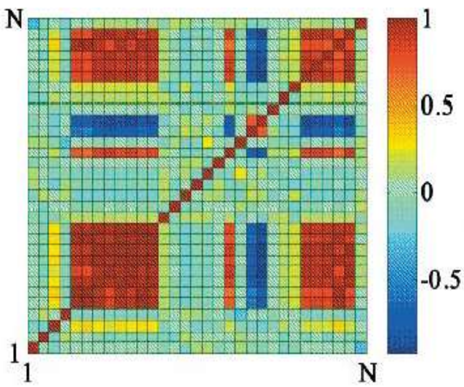


Figure3: Correlation Matrix

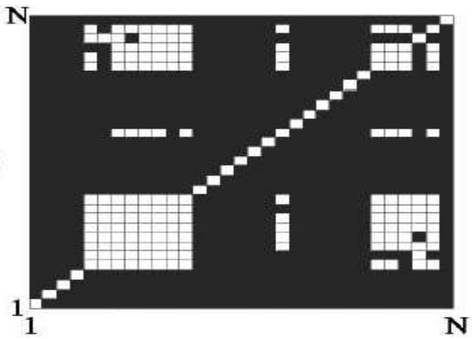


Figure4: Threshold Matrix

Step6: Brain network formation

The brain network can be formed using the threshold matrix. Here the surface, nodes, edges, and volume data which are measured using fMRI is given as input to the Brain Net Viewer tool which is an extension of SPM tool. The network is formed with the help of those data. It is shown in Figure5.

Step 7: Comparison with the ISP topology

After forming the brain functional network it is compared with the ISP topology in India. The ISP topology is obtained with the help of the Rocket fuel ISP mapping Engine[5].In the Rocket fuel a postgreSQL database stores all the information in a blackboard architecture. The use of the database allows us to run SQL queries for simple questions and integrate new analysis modules easily.

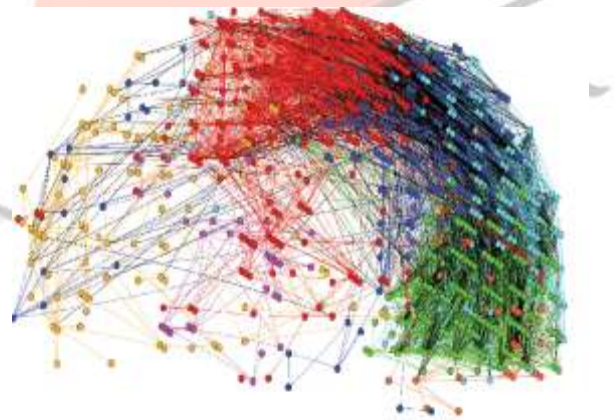


Figure5: Brain Functional Network

Step8: Analysis of the similarity measures

By comparing the functional brain network with the ISP topology using the similarity measures Degree, Shortest path length, Characteristic path length, Efficiency, Clustering coefficient, Transitivity, Betweenness centrality, Modularity, Within-module degree[1][6].By observing these measures we can include them while designing future networks.

IV. MEASURES USED FOR EVALUATION

Degree:

The number of neighbor nodes connected to a single node which is considered.

$$k_i = \sum_{j \in N} a_{ij}$$

Where,N-set of all nodes in the network
i, j-nodes
K-degree of the node
a-connection status between i and j

Shortest path length:

Shortest Path Length is the shortest length between i and j.

$$di,j = \sum_{a_{uv\in gi\Leftrightarrow j}} a_{uv}$$

where, i,j-nodes
a-connection status between u and v
d-shortest path length

Characteristic Path Length:

The average of all the shortest path length between all pairs of nodes in the network is known as characteristic path length.

$$L = \frac{1}{n}\sum_{i\in N} L_i$$

Where, L_i=average distance between node i and all other nodes.

Efficiency:

The average inverse shortest path length is known as Efficiency.

$$E= \frac{1}{n}\sum_{i\in N} E_i$$

Where E_i=efficiency of node
N-set of all nodes in the network

Transitivity:

Transitivity is the variant of the clustering coefficient.

$$T = \frac{\sum_{i\in N} 2t_i}{\sum_{i\in N} k_i(ki-1)}$$

where, k-degree of the node

Clustering coefficient:

The maximum no. of nodes that a single node can connect with is known as clustering coefficient.

$$C = \frac{1}{n}\sum_{i\in N} c_i$$

C_i=clustering coefficient of node

Betweenness centrality:

Fraction of all shortest paths in the network that passes through a given node is called as betweenness centrality.

$$b_i=\frac{1}{(n-1)(n-2)}\sum_{\substack{n,j\in N\\ h\neq j,h\neq i,j\neq i}} \frac{p_{h,j}(i)}{p_{hj}}$$

where,$p_{h,j}(i)$-no.of shortest path between h and j that pass through i.

Modularity:

The modularity describes how well the network is divided into modules of sub networks.

$$Q=\frac{1}{l}\sum_{i,j\in N}\left(a_{ij} - \frac{k_i k_j}{l}\right)\delta_{m_i m_j}$$

m_i, m_j-disjoint modules
a-adjacency matrix

Within-Module degree:

Within module degree of node i is

$$Zi=\frac{k_i(m_i)-\overline{k(m_i)}}{\sigma^{k(m_i)}}$$

where,
$\bar{k}(m_i)$-mean of within module m_i degree distribution.
$\sigma^{k(m_i)}$-Standard deviation of the within module m_i degree distribution.

V. RESULTS AND DISCUSSION

The output of the normalization technique is shown as below.

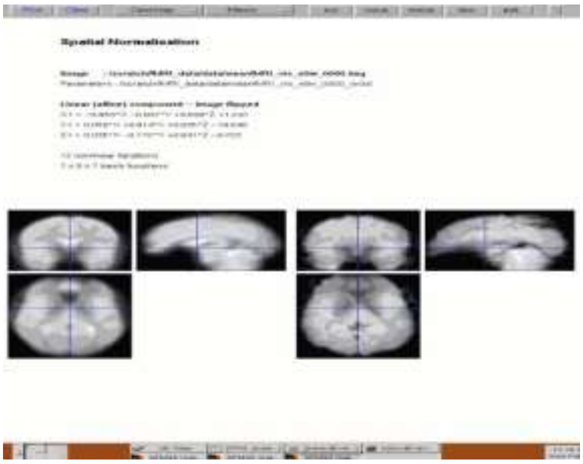


Figure 5: Normalization of the fMRI

The time series formed from fMRI data is as follows.

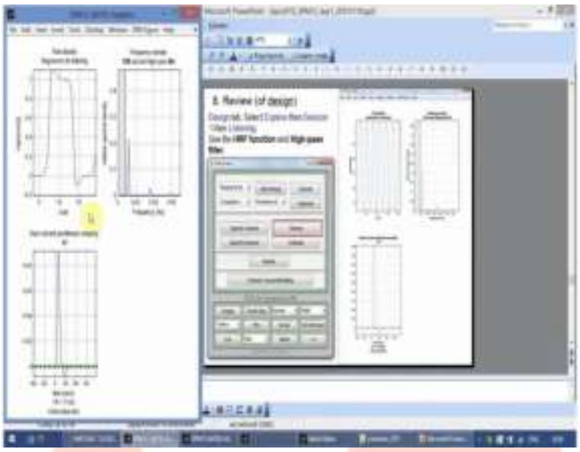


Figure 6: Time series

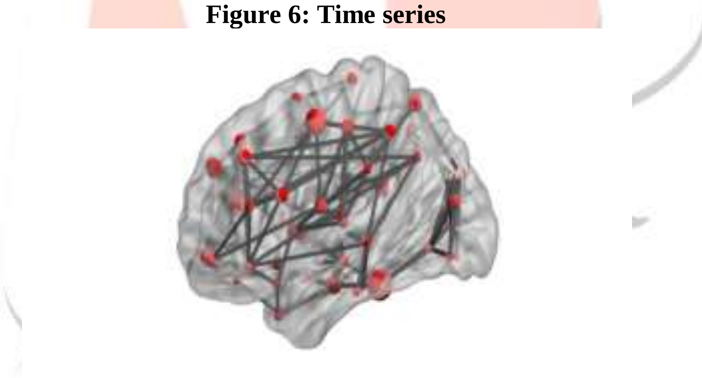


Figure 6: Brain Network

VI.CONCLUSION AND FUTURE WORK

In this paper we conclude that if design of the future networks includes similarity measures found by comparison with the brain network, then the ISP architecture can be made self-adaptable and robust. This can be used for the IoT (Internet of Things) network design in future.

REFERENCES

[1]KenjiLEIBNITZ, etsuyaSHIMOKAWA, Hiroaki UMEHARA and Tsutoma MURATA "Topological Comparison of Brain Functional Networks and Internet Service Providers IEICE TRANS. COMMUN., VOL.E95-B ,NO-5 MAY 2012.S

[2] S. Balasubramaniam, K. Leibnitz, P. Li`o, D. Botvich, and M. Murata, "Biological principles for future internet architecture design," IEEE Commun. Mag., vol.49, no.7, pp.44–52, July 2011.

[3] O. Sporns, Networks of the brain, MIT Press, 2010.

[4] H. Harai, K. Fujikawa, V.P. Kafle, T. Miyazawa, M. Murata,M. Ohnishi, M. Ohta, and T.Umezawa, "Design guidelines for new generation network architecture," IEICE Trans. Commun., vol.E93-B, no.3, pp.462–465, March 2010.

[5] N. Spring, R. Mahajan, D. Wetherall, and T. Anderson, "Measuring ISP topologies with rocket fuel," IEEE/ACM Trans. Netw., vol.12, no.1, pp.2–16, Feb. 2004.

[6] K. Leibnitz, T. Shimokawa, H. Umehara, and T. Murata, “Comparison of brain functional networks and internet topologies by complex network measures,” International Symposium on Nonlinear Theory and its Applications (NOLTA), Kobe, Japan, Sept. 2011.
[7] M. Rubinov and O. Sporns, “Complex network measures of brain connectivity: Uses and interpretations,” NeuroImage, vol.52, no.3, pp.1059–1069, Sept. 2010.
[8] Wellcome Trust Centre for Neuroimaging, “Statistical parametric mapping toolbox,” available online at: http://www.fil.ion.ucl.ac.uk/spm/