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Finding Similar Interaction Patterns Among the Brain Regions Using Clustering Technique

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Abstract— Brain is an important part, which controls all the functions of the human body.These functions are very complex and difficult to understand.If there is any problem related to brain, it will considered as psychotic disorder or brain disorder. To understand such complex functions and the psychiatric disorders of the brain, it is necessary to first understand the different brain activities of brain functions. Brain activity is the only resource to understand brain disorders. Functional Magnetic Resonance Imaging (FMRI) helps to study human brain function or activity in a non-invasive way.The Functional Magnetic Resonance Imaging (FMRI) measures the Blood Oxygen-Level Dependent (BOLD) signal. The main objective is to find out objects having a similar intrinsic interaction pattern to a common cluster as well as identify brain disorders by data clustering technique.To formalize this idea,s paper introduces a partitioning clustering -EM algorithm. The Expectation Maximization (EM) algorithm is Gaussian Mixtures which begins with an initial guess to the cluster centers, and iteratively refines them an efficient algorithm for partitioning clustering. An EM algorithm gives a guarantee that at each iteration it will increase the likelihood,which will use to find out the similar patterns.So the system approach is to understand the complex interaction patterns among brain regions using clustering, fast mining and easy to identify disorders.

Keywords— Clustering Technique; Functional Magnetic Resonance Imaging(FMRI);Interaction patterns among brain regions;multivariate time series; Expectation Maximization

I. INTRODUCTION

Brain is an important part of the human body which performs many functions simultaneously.Brain disorders or mental illnesses involve psychological or behavioral patterns that are usually associated with distress or disability, which are not part of the natural evolution of a person or culture. As such, mental disorders can be defined generally through a combination of features that reflect the feelings of a person or his actions and explain his thinking and perceptions.Many psychiatric disorders still neither be identified by biomarkers, nor by physiological or histological abnormalities of the brain.The brain functions are very complex and difficult to understand. To understand such complex functions and the psychiatric disorders of the brain, it is necessary to first understand the different brain activities of brain functions. Brain activity is the only resource to understand brain disorders.

Functional Magnetic Resonance Imaging (FMRI) helps to study human brain function or activity in a non-invasive way.The Functional Magnetic Resonance Imaging (FMRI) measures the Blood Oxygen-Level Dependent (BOLD) signal.The main objective is to find out objects having a similar intrinsic interaction pattern to a common cluster as well as identify brain disorders by data clustering technique.To formalize this idea,this paper introduces a partitioning clustering -EM algorithm which is used to find out the similar interaction patterns among the brain and help to study brain related disorders.

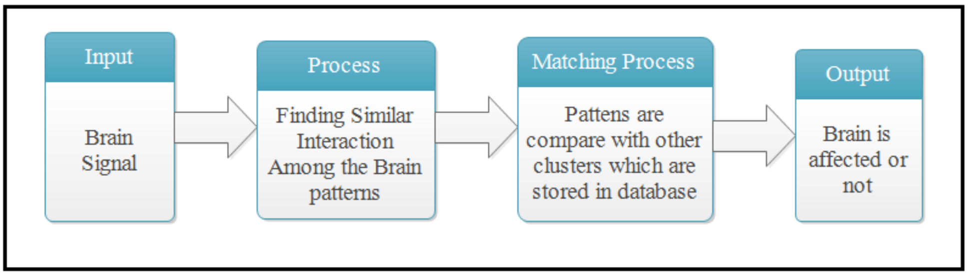


Fig.1:Abstract view of the System

The above diagram(Fig.1) shows abstract view of the system.The main objective is to create a similar interaction pattern among the brain regions.So the input will be the brain signals that are taking from each region of the brain.Then by applying partitioning EM algorithm,it will find the similar interaction patterns in the form of clusters. Afterwards,these clusters will be used to find out the brain disorders.

II. BASIC CONCEPTS

This section explains a brief overview about the basic concept which is required is used for identification of brain disorder.

A. CT Scan

To view activities or problems within the human brain without invasive surgery we use scanning techniques. Computed tomography (CT) scanning builds up a picture of the brain based on the differential absorption of X-rays. During a CT scan the subject lies on a table that slides in and out of a hollow, cylindrical apparatus. An x-ray source rides on a ring around the inside of the tube, with its beam aimed at the subject's head. After passing through the head, the beam is sampled by one of the many detectors that line the machine's circumference. Images made using x-rays depend on the absorption of the beam by the tissue it passes through. Bone and hard tissue absorb x-rays well, air and water absorb very little and soft tissue is somewhere in between. Thus, CT scans reveal the gross features of the brain, but do not resolve its structure well.the brain but do not resolve its structure well.

B. EEG(Electro Encephalography)

Electroencephalography (EEG) is the measurement of the electrical activity of the brain by recording from electrodes placed on the scalp. The resulting traces are known as an electroencephalogram (EEG) and represent an electrical signal from a large number of neurons.EEGs are frequently used in experimentation because the process is non-invasive to the research subject. The EEG is capable of detecting changes in electrical activity in the brain on a millisecond-level. It is one of the few techniques available that has such high temporal resolution.

C. PET (Positron Emission Tomography)

PET (Positron Emission Tomography) measures blood flow by injecting people with radioactive water and measure changes in radiation.FMRI produce images at higher resolution than PET. It involves rapid scanning of the brain to see which area of the brain becomes activated. It is highly sensitive, so small changes also detected and multiple scans can be done on the same subject.

D. Magnetic Resonance(MR)

Magnetic Resonance(MR) is one of the technique which is used to study brain activities. To understand the brain activity there are two types of magnetic resonance,depending on whether the goal is structural or functional imaging. The goal of structural MR is usually to measure the density of water molecules. The vast majority of Functional MR(FMRI) experiments measure the blood oxygen-level dependent (BOLD) signal. The MR scanner uses super conducting electromagnets to produce a static, uniform magnetic field of high strength. An MR signal requires radio frequency coils that generate magnetic pulses. Turning a pulse on changes the magnetic alignment of protons (typically within water molecules) within the magnetic field. When the pulse is turned off, the protons relax to their original equilibrium alignment, which releases energy detected by the coils as the raw MR signal.Spatial resolution is provided by additional magnetic fields known as gradients. The strength of each gradient changes linearly along a single spatial dimension. Thus, three mutually orthogonal gradients are used to localize a signal in three spatial dimensions. The software that controls all these magnetic fields is typically called the pulse sequence.

E. Functional Magnetic Resonance Imaging(FMRI)

Functional Magnetic Resonance Imaging (FMRI) helps to study human brain function in a noninvasive Way. The basic signal of FMRI depends upon the blood-oxygen-level-dependent (BOLD) effect, which allows indirect imaging brain activity by changes in the blood flow related to the energy consumption of brain cells.It detects the changes in blood oxygenation and flow that occur in response to neural activity.When a brain area is more active it takes more oxygen and to meet this increased demand blood flow increases to the active area. FMRI can be used to create activation maps showing which parts of the brain are involved in a particular mental process.FMRI data are time series of 3-dimensional volume images of the brain.

F. Clustering Techniques

Clustering and classification are both essential tasks in Data Mining. A cluster is a collection of objects which are "similar" in their group and are "dissimilar" to the objects belonging to other groups. So mainly we use clustering technique to detect and make a group of similar patterns.

G. Interaction K-means (IKM)

The Interaction K-means (IKM) is the existing algorithm which is based on k-means technique. IKM is a partitioning clustering used to detect clusters of objects with similar interaction patterns. The algorithm IKM is a common technique for clustering multivariate time series using FMRI data. IKM achieves good results on synthetic data and on real world data from various domains, but generally giving a good result on EEG and FMRI data. The interaction patterns detected by IKM are easy to interpret, but it will take more time for clustering. So the IKM partitioning clustering is time consuming.

H. Expectation Maximization (EM)

This paper introduces an innovative partitioning clustering technique which is Expectation Maximization. Expectation Maximization finds a similar interaction pattern between the brain regions which helps to detect the brain disorders. The EM algorithm is used to find the maximum similar parameters of a statistical model. The EM iteration interchanges between performing an expectation (E) step, which creates a function for the expectation of the log-likelihood calculated using the current estimate for the parameters, and a maximization (M) step, which calculates parameters maximizing the expected log-likelihood found on the E step. An EM algorithm gives a guarantee that at each iteration it will increase the likelihood,which will use to find out the similar patterns.

We use Expectation Maximization(EM) because:

- Strong statistics.
- Robust against noisy data.
- It can accept a desired number of clusters as an input.
- Accurate.
- Faster than other algorithm.
- Effective.

III. LITRATURE REVIEW

M. D. Fox and M. E. Raichle, Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging[1] : M. D. Fox and M. E. Raichle introduces a spontaneous fluctuation in brain activity with functional magnetic resonance imaging (fMRI) blood oxygen level dependent (BOLD) signal method and spatial and temporal properties of spontaneous BOLD fluctuations. According to him modulation of the functional magnetic resonance imaging (fMRI) blood oxygen level dependent (BOLD) signal attributable to the experimental paradigm can be observed in distinct brain regions, such as the visual cortex, allowing one to relate brain topography to function.However, spontaneous modulation of the BOLD signal which cannot be attributed to the experimental paradigm or any other explicit input or output is also present. Because it has been viewed as noise in task-response studies, this spontaneous component of the BOLD signal is usually minimized through averaging.

Claudia Plant, Andrew Zherdin, Christian Sorg, Anke Meyer-Baese, and Afra M.Wohlschlger Mining Interaction Patterns among Brain Regions by Clustering[2] : This paper introduces interaction K-means (IKM), an efficient algorithm for partitioning clustering technique for mining the different interaction patterns in healthy and diseased subjects by clustering. Interaction K-means. (IKM) simultaneously clusters the data and discovers the relevant cluster-specific interaction patterns. IKM achieves good results on synthetic data and on real world data. It is scalable and robust against noise.Algorithm improves the efficiency of the clustering result, there is no separate algorithm for feature selection process Complexity is high. Auto class technique is not applicable if the number of time points varies among the objects, a case frequently occurring in FMRI data. There is no separate mechanism for feature selection.

Chuanjun Li, Latifur Khan, and Balakrishnan Prabhakaran Feature Selection for Classification of Variable length Multi-attribute Motions[3] : To capture the motion is a new type of multimedia. Recognizing the patterns of human motion there is use of a 3D camera. The idea of this paper is to capture the data of motions with the multiple attributes. To capture the movements of multiple joints of a subject, having a different lengths for even similar motions. To classify and recognize, multi-attribute motion data of different lengths, Chuanjun Li, Latifur Khan, and Balakrishnan Prabhakaran introduced a new type of multimedia technique which is Support Vector Machines (SVM). By applying Support Vector Machines (SVM) to the feature vectors, we can efficiently classify and recognize real world multi-attribute motion data using only a single motion pattern in the database to recognize similar motions allows for less variations in similar motion real time recognition of individual isolated motions accurately and efficiently.

T. W. Liao, Clustering of time series data A survey[4]: Mainly the survey is based on three key components of time series clustering algorithm, the similarity/dissimilarity measure, and the evaluation criterion. The author has observed the goal of clustering is to identify structures in an unlabeled data set by objectively organizing data into homogeneous groups where the within-group-object similarity is minimized and the between group object dissimilarity is maximized. None of these in the paper which included in this survey handle multivariate time series data with different length for each variable**.**

H.-P. Kriegel, P. Krger, A. Pryakhin, M. Renz, and A. Zherdin,Approximate clustering of time series using the compact model based descriptions[5]: In every field, measurements are performed over time. A time series represents a collection of values obtained from sequential measurements over time. The purpose of time-series data mining is to try to extract all meaningful knowledge from the unlabeled set of data. The benefit of this paper is that the size of our approximation depends only on the number of coefficients of the model (i.e. the number of reference time series). The distance computation requires rather high run times and, if the time series are indexed by a standard spatial indexing method such as the R-Tree or one of its variants, this index will perform rather badly due to the well-known curse of dimensionality. The key issue for approximate clustering is of course to generate accurate results.

C. Bohm, L. Laer, C. Plant, and A. Zherdin, Model-based classification of data with time series-valued attributes [6]: The primary goal of the knowledge discovery process is classification, which is the task to automatically assign class labels to data objects In this paper classification decisions are supported by class-specific interaction patterns within the time series of a data object. It would be also interesting to design model-based classifiers for FMRI data and combined FMRI-EEG data sets which are very challenging because of the large number of time series in FMRI data kind of object representation is very natural and straightforward in many applications, not much research on data mining methods for objects of this particular type.

P. Cheeseman and J. Stutz, Bayesian classification (autoclass) :Theory and results[7]: The author P. Cheeseman and J. Stutz provide enough information to allow anyone to reproduce Auto Class, or to use the same evaluation functions in other contexts where these models might be relevant. We will only deal with real and discrete attributes the task of supervised **c**lassification: A related problem is unsupervised classification, where preparing cases are also unlabeled.

D. Arthur, B. Manthey, and H. Rglin, Smoothed analysis of the k-means method[8]: This paper introduces the smoothed running time of the k-means method.The k-means method is in fact a perfect candidate for smoothed analysis: it is extremely widely used, it runs very fast in practice, and yet the worst-case running time is exponential. It did not make a huge effort to optimize the exponents as the arguments are intricate enough even without trying to optimize constants. The smoothed analyses so far are unsatisfactory as the bounds are still super-polynomial in the number n of data points.

Veeraraghavan and A. K. R. Chowdhury, The function space of an activity[9]: This paper provides a systematic approach to learn the nature of such time warps while simultaneously allowing for the variations in the descriptors for actions. Activity recognition is not very robust to intra- and interpersonal changes of the same action, and are extremely sensitive to warping of the temporal axis due to variations in speed profile activity recognition are not very robust to intra- and interpersonal changes.

H. Heekeren, S. Marrett, and L. Ungerleider, The neural systems that mediate human perceptual decision making[10]: In this paper H. Heekeren, S. Marrett, and L. Ungerleider introduces a new view about the neural basis of human perceptual decision-making processes. It is also tempting to speculate that the general principles derived from the studies of simple perceptual decision processes reviewed here extend to other settings. Seen in this light, it is not surprising that motor structures seem to have a role in decision formation. It is not yet clear how these structures contribute to decisions that are not linked to particular actions.

IV. EXISTING SYSTEM

- The Interaction K-means (IKM) is the existing algorithm which is based on k-means technique.
- To understand, the complex interaction patterns among brain regions, existing system uses k-means (IKM) algorithm, an efficient algorithm for partitioning clustering.
- Interaction K-means (IKM) simultaneously clusters the data and discovers the relevant cluster specific interaction patterns. Existing approaches to clustering multivariate time series do not consider interaction information.
- IKM clusters only the particular region or function of the brain or the rest of the nervous system.
- IKM takes a more time for clustering so the IKM partitioning clustering is time consuming.

V. PROPOSED METHODOLOGY

Brain is the central part of the human body. Brain is responsible to control all the function of the human body. The functions or the activities related to brain become a very complicated and not easy to understand. If there is any problem in human body related to the brain it will be considered as a brain disorder. Many psychiatric disorders are still not identified.

To understand the complex functions and the psychiatric disorders of the brain, we have to first understand the different brain activities. Brain activity is the only resource to understand psychiatric disorders. Functional magnetic resonance imaging (FMRI) helps to study human brain function in a non-invasive way.FMRI captures the signal through pulse sequences which helps to understand the brain activity.FMRI measure the blood oxygen-level dependent (BOLD) signal. The paper introduces a new partitioning clustering technique that is Expectation Maximization which is responsible to reduce the time taken to form clusters of an object having a similar interaction pattern. With the Expectation Maximization algorithm we add more efficiency with the correct result, decrease complexity with clustering. The Expectation Maximization algorithm starts with initial guess which defines an iterative process that allows maximizing the likelihood function of the model. In the EM algorithm, we first assign each sample to a component (E step) and then fit (or maximize the likelihood of) each component separately (M step). Expectation Maximization in statistics for finding maximum likelihood estimation (MLE) of parameters in probabilistic models, where the model depends on unobserved data.

EM algorithm is an iterative method which starts with initial guessing.In an EM algorithm alternates between performing an expectation (E) step and maximization step(M) step. Expectation step: Expectation step computes an expectation of the log likelihood with respect to the current estimate of the distribution of observed data. Maximization step: Maximization computes the parameters which maximize the expected log likelihood found on the E-step. An EM algorithm gives a guarantee that at each iteration it will increase the likelihood,which will use to find out the similar patterns. The basic idea is to make two different clusters from the group of persons. With the Expectation Maximization clustering method we will get the two different clusters, i.e. one is of healthy or normal and another one is deceased.

A. Algorithm Expectation Maximization

1. Start with the initial guess of parameters.
2. Expectation step: E-step, a probability distribution over possible completions is computed using the current parameters.

3. Maximization step: M-step, new parameters is determined using the current completions.
4. After several repetitions of the E-step and M-step, the algorithm calculates the closer similar values.
5. Stop.

B. System Architecture

Many psychiatric disorders are still not identified by biomarker or by any psychological treatment.It is necessary to understand such disorder for the further treatment.The system architecture will help to detect or identify brain disorder using a clustering algorithm.

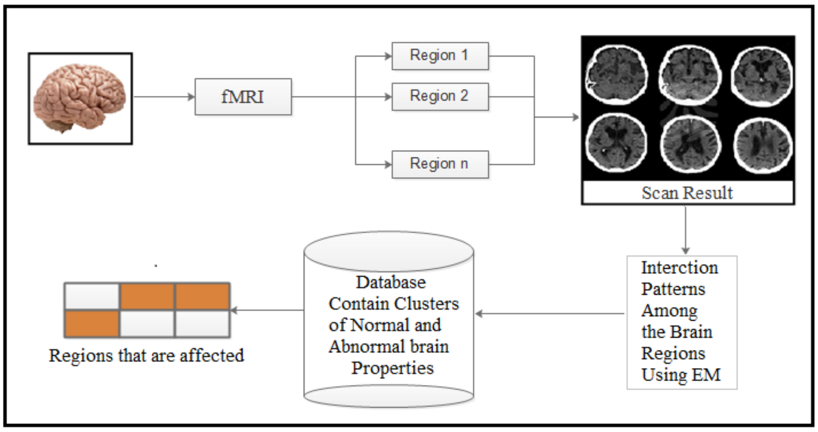


Fig.2 System Architecture

The fig.2 Shows the architecture of identification of brain disorders.The architecture describes how to find out whether the brain is affected or not.In the initial step brain will get scanned in the scanner machine. Functional magnetic resonance imaging, or FMRI, is a technique for measuring brain activity. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity. When a brain area is more active it takes more oxygen and to meet this increased demand blood flow increases to the active area. fMRI can be used to create activation maps showing which parts of the brain are involved in a particular mental process. A sensor detects the energy and a computer turns it into a picture.This picture is a scan result.This scan result is then use for finding the interaction patterns among the brain.The expectation maximization algorithm is used for finding the interaction patterns among the brain.With the help of expectation maximization algorithm it will form a clusters.This cluster contain the similar interaction patterns among the brain regions.This cluster will be then compared with the database clusters,The database contain two types of clusters-one is normal brain cluster and another one is diseased brain cluster.The normal brain cluster contain the properties of normal human brain and the diseased brain cluster contain the properdies of abnormal(diseased) human brain.The cluster finally compaired with the database cluster.After comparison, the result will show us which part of brain is affected or not.If the brain is affected then which part of the brain is affected.In this way,EM algorithm help for finding similar interaction patterns among the brain region as well as detect the brain disorders.

C. System Workflow

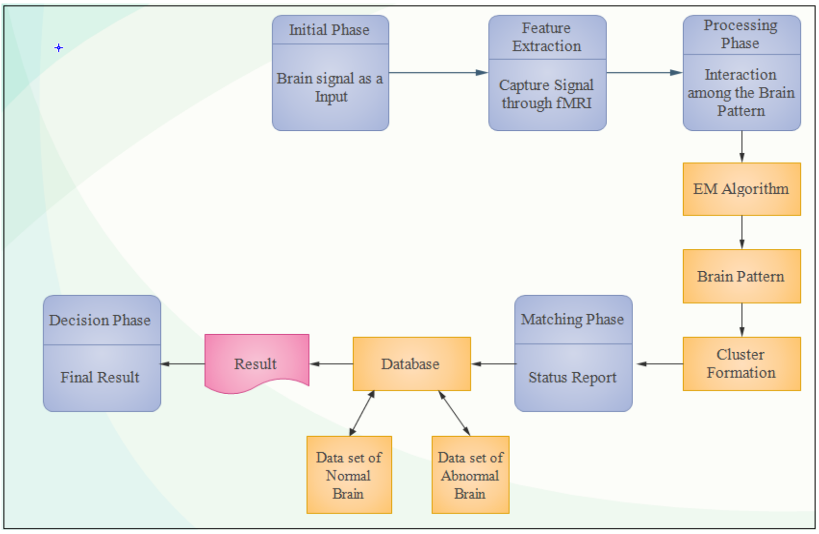


Fig.3 The System Workflow

The System flow is having following phases :

1) *Initial Phase*
2) *Feature Extraction.*

3) *Processing Phase.*
4) *Matching Phase.*
5) *Decision Phase.*

1) *Initial Phase:*

Initial phase is responsible for taking input. In the initial phase brain signal is considered as a input.FMRI helps to study human brain function or activity. Functional magnetic resonance imaging (FMRI) is a relatively new procedure that uses MR imaging to measure the tiny metabolic changes that take place in an active part of the brain.

2) *Feature Extraction :*

After receiving the data from the initial phase, extraction phase capture the signal through FMRI. FMRI is based on the idea that blood carrying oxygen from the lungs behaves differently in a magnetic field than blood that has already released its oxygen to the cells. In other words, oxygen-rich blood and oxygen-poor blood has a different magnetic resonance. The most active areas of the brain receive more oxygenated blood. The FMRI picks up this increased blood flow to determine greater activity. The measurement of blood flow, blood volume and oxygen use is called the blood-oxygen-level-dependent (BOLD) signal. When you lie inside the cylindrical MRI machine, it aims radio waves at protons -electrically charged particles in the nuclei of hydrogen atoms in the area of your body. As the magnetic field hits the protons, they line up.Then the machine releases a short burst of radio waves, which knocks the protons out of alignment. As the magnetic field hits the protons, they line up.Then the machine releases a short burst ended, the protons fall back in line, and as they do, they release signals that the MRI picks up. The protons in the areas of oxygenated blood produce the strongest signals. A computer processes these signals into a three-dimensional image of the brain that doctors can examine from many different angles. Brain activity is mapped in squares called voxels. Each voxel represents thousands of nerve cells (neurons).

3) *Processing Phase:*

In this processing phase the FMRI result (scan result) will process. The Expectation Maximization(EM) algorithm is used for finding the similar interaction patterns among the brain regions.With the help of an expectation maximization algorithm, it will form a cluster.This cluster contains the similar interaction patterns among the brain regions.Following are the steps involved in the processing phase:

- Read observation files of signals from electrodes placed in the brain.
- Generate arff file for each signal.
  – Format of arff file:

```
@relation Schizophrenia
@attribute 'a0' numeric
:
:
:
:
@attribute 'a178' numeric
@attribute 'a179' numeric
@data
```

- Create clusters according to each file as follows:
  – Create an object of the instance's class which create instances of objects according to input of the file.
  – Create an object of EM
  – Set number of cluster equal to 2
  – Build clusters for given instances.
  – Cluster building will work as follows:

  EM cluster will set two latent models and will try to find out which model may have been generated each value in each instance.Update the models according to the current probability distribution of instance and stop iterations when models are not being updated.
  Updation of model works in two steps:
  E step: In this step it will calculate which model may have produced this value from current models. A probability distribution over possible completions is computed using the current parameters.
  M step: In the M-step, new parameters of the model are determined using the current completions.
  After several repetitions of the E-step and M-step, the algorithm converges. So up to this step EM will calculate the distribution of instances over models according to attribute values of instances.Probability distribution for instance over which model is greater to that model the instance will belong to an instance will be clustered to that cluster represented by that model.
- Find clusters according each arff file.
- Keep best clusters out of these and discard all others and note those signals in which clusters are better.
- Conclusion: Signals which creates better signals are interacting with each other.

In this way EM algorithm gives a guarantee that at each iteration it will increase the likelihood, which will use to find out the similar patterns. The EM algorithm forms a cluster having a similar interaction pattern among the brain regions.After cluster formation it will send to the matching phase.

4) Matching Phase:

In this matching phase, the database contains two kinds of cluster sets. One is a normal brain cluster and another one is the diseased brain cluster.The normal brain cluster contains the properties of normal human brain and the diseased brain cluster contain the properties of abnormal(diseased) human brain.The processing phase gives the formation of the cluster, that cluster will be compared with the data sets which is already present in the database. It will compare the properties or patterns of signals with are present in the cluster.If cluster match with the more patterns in the normal set means the patient is normal, but if the patterns will get matched with the diseased set, that means the patient is having a brain disorder.

5) Decision Phase:

Decision phase is responsible for giving the final result.The matching phase gives the result of patterns matched with which dataset.If the patterns are matched with normal dataset means the brain is not affected by any disorder and if the patterns are matched with diseased data set means the patients is having the brain disorder.In this way the result will be given by the decision phase.

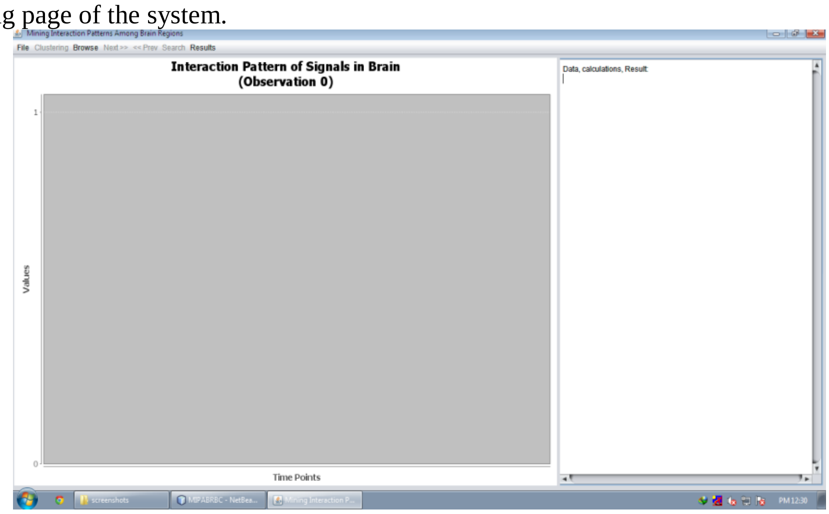
In this way we can understand the complex interaction patterns among brain regions as well as identify the disorders related to brain.

VI. IMPLEMENTATION AND RESULT

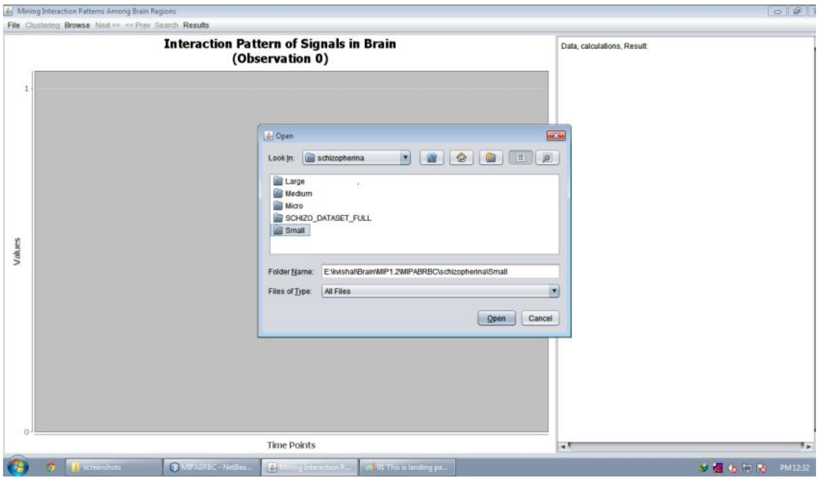
A. Implementation

The Expectation Maximization algorithm is used for mining the interaction patterns among the brain region.Following are the stepwise implementation of the algorithm in the system:

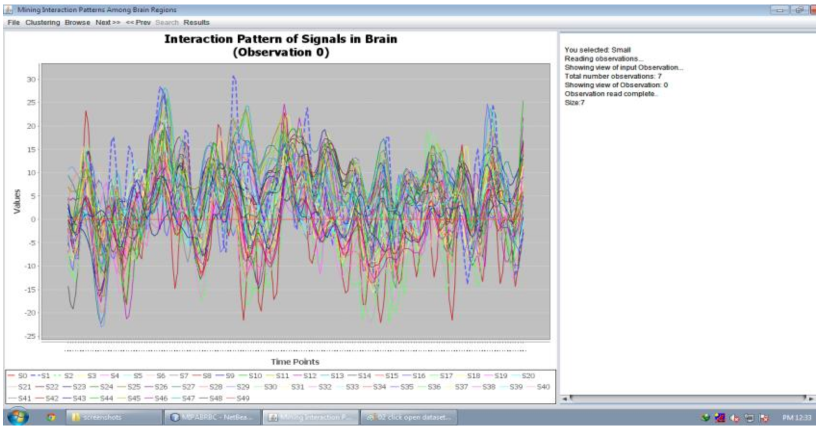
1. This is the landing page of the system.



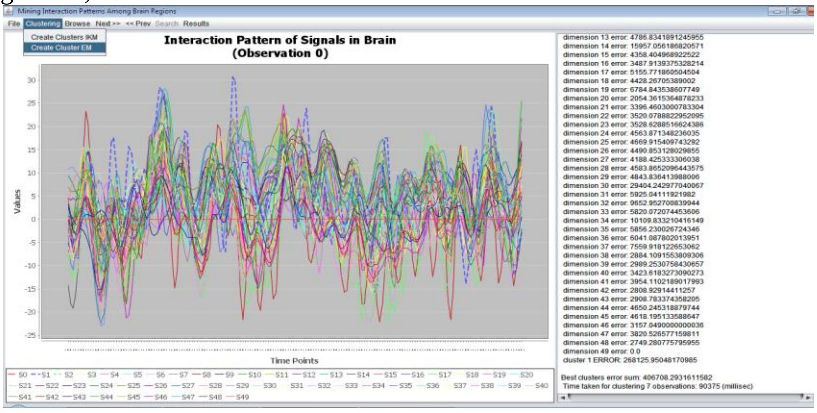
2. Click on file → Open.
   Select a data set folder and select small data set file from dataset folder.



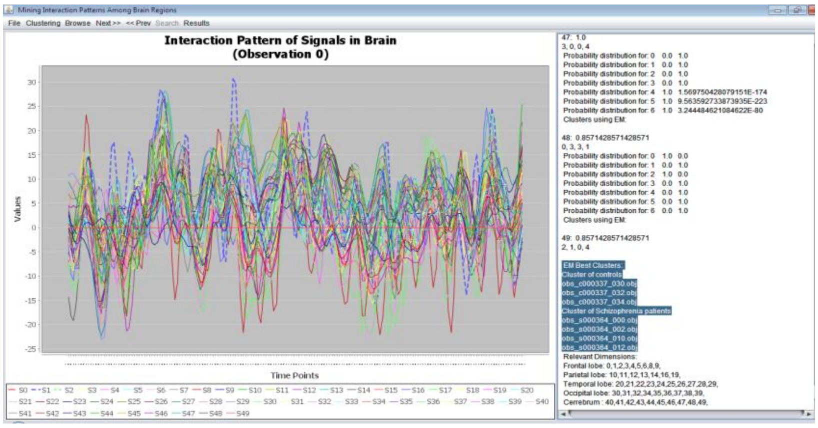
3. Display the patterns of each object from the dataset small.
   The object patter ns names are observation 0,observation 1,… likewise.



4. Click on clustering menu and select create cluster EM.
   With the EM algorithm, it will start to create a clusters.

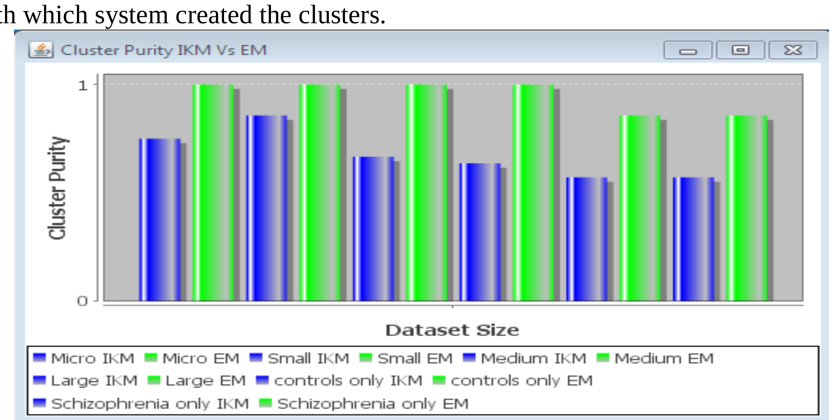


5. It starts with 0th initialization and interchange between E-step and M-step.
   It will find EM bet cluster.

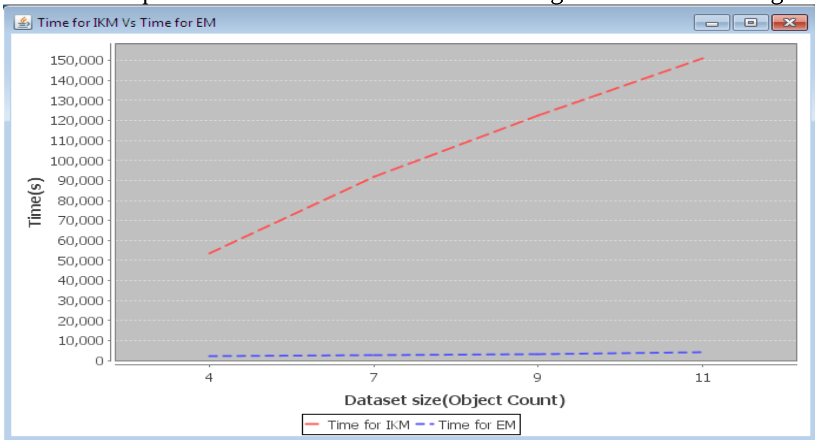


B. Result

- The result gives a comparison of purity of clusters formed by IKM algorithm and EM algorithm.It depicts accuracy with which system created the clusters.



- The graph shows the time required for clustering objects by IKM algorithm Vs EM algorithm for data sets of different sizes.The time required for IKM is more than the EM algorithm for clustering



VII. CONCLUSION

The proposed system is responsible for finding the similar interaction patterns among the brain region as well as used to identify the brain disorders.

The system uses Expectation Maximization (EM) algorithm which is gaussian mixtures which begins with an initial guess to the cluster centers, and iteratively refines them an efficient algorithm for partitioning clustering. An EM algorithm gives a guarantee that at each iteration it will increase the likelihood,which will use to find out the similar patterns.The clustering technique-Expectation Maximization techniques used to define a cluster of interaction patterns of healthy and diseased object which is used to detect the brain disorder.Expectation Maximization which is responsible to reduce the time taken to form clusters of an object having a similar interaction pattern. The Expectation Maximization algorithm adds more efficiency with the correct result, decrease complexity with clustering. The EM clustering method achieves good result with high accuracy.

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