Epileptic Patient Recognition

Abstract: This report presents a paper implementation on the epileptic patient detection via fMRI image of brain. The image is segmented into brain regions and the proposed method processes these regions by finding the connectivity of these brain regions and devises a methodology for epilepsy detection. The connectivity matrix is used as input features to train support vector machines and after successfully learning the input features. The proposed epileptic patient recognition system has been able to present 52%-63% accuracy in results.

Introduction

Since the medical applications of pattern recognition have become important part of the biomedical image processing, the accurate prediction of diseases related to general neuropsychiatric disorders has become possible on an individual basis. For this purpose resting-state functional magnetic resonance imaging (fMRI) is a helpful tool to have deep insight into a patients brain in imaging form. Despite the progress to chart the differences between the healthy controls and patients at the group level, the pattern classification of functional brain networks across individuals is still less developed. In this paper we identify two novel neuroimaging measures that prove to be strongly predictive neuroimaging markers in pattern classification between healthy controls and general epileptic patients.

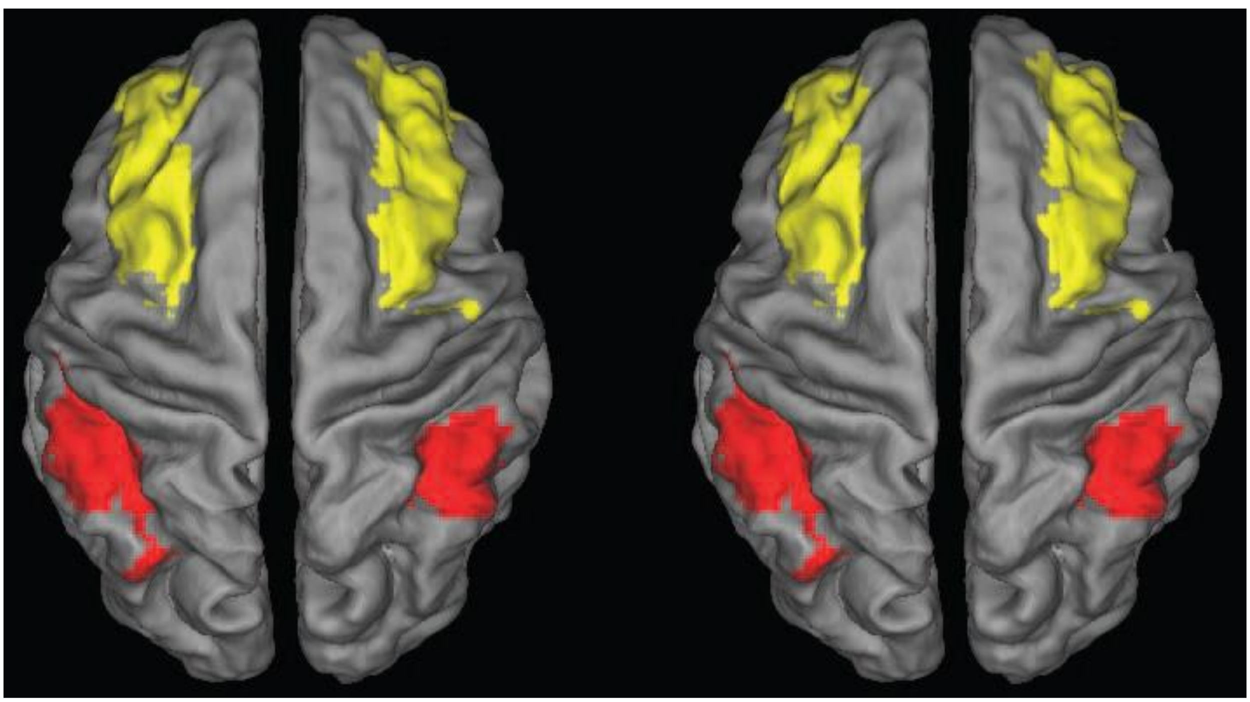

Figure. 1: fMRI image of brain of diseased and normal people

These measures characterize two important aspects of the functional brain network in a quantitative manner: (i) coordinated operation among spatially distributed brain regions, and (ii) the asymmetry of bilaterally homologous brain regions, in terms of their global patterns of functional connectivity. This second measure offers a unique understanding of brain asymmetry at the network level, and, to the best of our knowledge, has not been previously used in pattern classification of functional brain networks. Using modern pattern-recognition approaches like sparse regression and support vector machine, we have achieved a cross-validated classification accuracy of 83.9% (specificity: 82.5%; sensitivity: 85%) across individuals from a large dataset consisting of 180 healthy controls and epileptic patients. We identified significantly changed functional pathways and subnetworks in epileptic patients that underlie the pathophysiological mechanism of the impaired cognitive functions. Specifically, we find that the asymmetry of brain operation for epileptic patients is markedly enhanced in temporal lobe and limbic system, in comparison with healthy individuals. The present study indicates that with specifically designed informative neuroimaging markers, resting-state fMRI can serve as a most promising tool for clinical diagnosis, and also shed light onto the physiology behind complex neuropsychiatric disorders. The systematic approaches we present here are expected to have wider applications in general neuropsychiatric disorders.

Proposed Scheme

Proposed scheme works with the available dataset of epileptic patients and healthy persons, the dataset contains fMRI image segmented regions of 100 healthy people and 80 epileptic patients. Each fMRI brain image is segmented into 90 regions from cortex and each region is categorized by a BOLD signal of size two hundred. After extracting data the proposed scheme in [1],[2] employs roughly following steps to detect the epileptic patients from fMRI images.

(i) K-means clustering

K-means clustering is an efficient clustering technique out of unsupervised learning algorithms. It employs following steps to group the similar brain regions based on their connectivity.

Randomly initialize *K* cluster centroids
Repeat {
    for i=1 to m
    c(i) := index (1 to K) of cluster
    centroid closest to x(i)
    for k=1 to K
    μk := mean of points assigned to
    cluster *k*
    }

Code:

```
load('dianxian.mat')
```

```
feature_set = [];

x = dianxian(:,:,1);
c = kmeans(x',30);          % Applying K-mean clustering
```

(ii) Community Matrix

The important question here is what to use as features for recognition algorithm. Prior to this work correlation between the brain regions have been used as features but we propose a better mechanism as the community matrix where we employ k-means clustering to group the regions having same characteristics. The community matrix is achieved using following steps

The community matrix is The basic steps of calculating the
community matrix K are:

1. Initialize k centroids by randomly choosing k data points;
2. Assign each data point to the closest centroid according to the Euclidean distance Uij= |xi 2 xj|2;
3. For each cluster compute its mean as the new centroid;
4. Repeat Steps 2 and 3 until the centroids no longer move.

Code:

```
feature_set = [];
for i = 1:180
    x = dianxian(:,:,1);
    c = kmeans(x',30);          % Applying K-mean clustering
    C_matrix = [];
    for j = 1:90                % Making a community matix
        s = zeros(90,1);
        a = c(j);
        s( c == a ) = 1;
        C_matrix = [C_matrix s];
    end
    figure;
    imshow(C_matrix,[]);        % Community Matrix
    uperdiag = triu(C_matrix);
    figure;                     % Uper diagonal of community matrix
    imshow(uperdiag,[]);
    feature_vect = [];
end
X = feature_set;
Y = [ones(80,1); zeros(100,1)];
save('Features_Healthy_Epileptic_Patients', 'X','Y');
```

The achieved community matrix is displayed in Fig. 2 below one each for healthy and epileptic patient. The epileptic patient’s community matrix has more activity along its diagonals and it has particular patterns and boxes along the diagonal while these pattern’s are visible on the healthy people’s community matrix. Thus community matrix can be used as a marker for epileptic patient detection. As this matrix happens to be symmetric so only a half version of this matriz i.e. upper diagonal matrix (Shown in Fig. 3) or lower matrix can be used as feature. The feature set for one patient will have 90×45 = 4005 size.

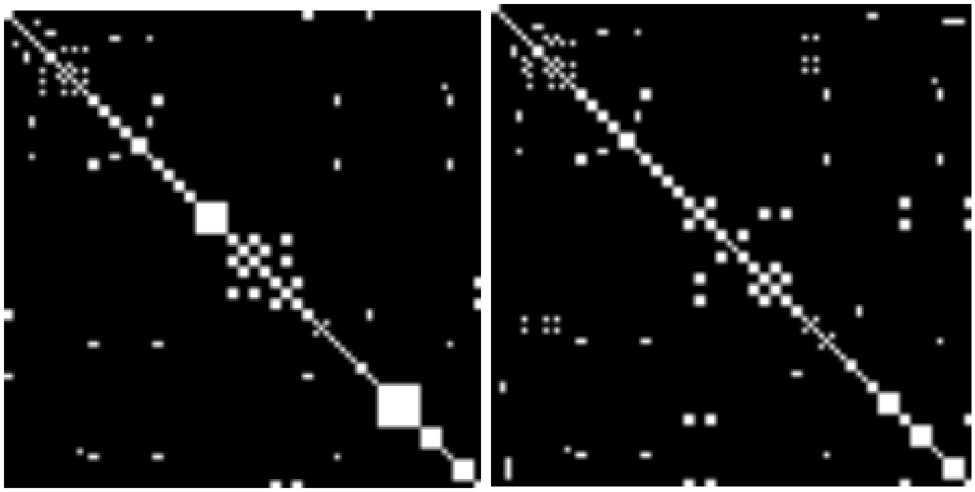

Fig.2: Community matrix of (Left) epileptic patients (right) Healthy

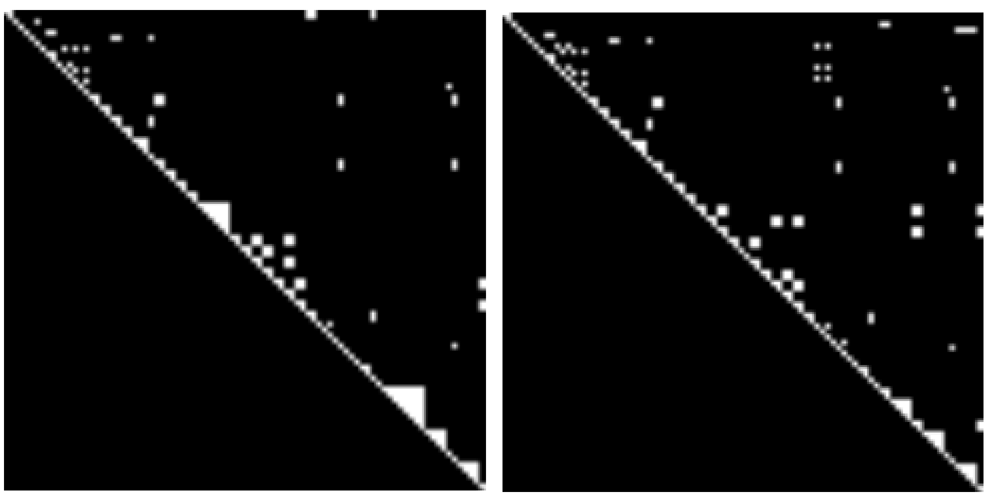

Fig. 3: Features and the upper triangle

(iii) Sparse Regression or Sparse Principle Component Analysis

While it is an established fact now that community matrix can be effective features for epileptic patient recognition but the large size of this feature set brings in the curse of dimensionality. Most of the information in this feature is useless to our cause, so in order to find the most relevant features we employed sparse regression or sparse principle component analysis which is a state of the art to find the most effective smaller feature set.

Code:

```
% coef = princomp(X);                                          % PCA
% PCs = coef(:,1:500);
```

```
% F = X*PCs;
K = 100;
delta = inf;
stop = -[250 125 100];
maxiter = 3000;
convergenceCriterion = 1e-9;
verbose = true;

[SL SD] = spca(X, [], K, delta, stop, maxiter, convergenceCriterion,
verbose);  %Sparse PCA
% M = SL*SD;
% [xx ind] = sort(abs(M),'descend');
% F = X(:,ind(1:100));
% SS = ((SD*ones(1,4005))').*SL;
F = X*SL;
```

(iv) Support Vector Machine (SVM)

The code given below is employed for training the SVM, 50% features are used for training and 50% are used for testing.

Code:

```
P = cvpartition(Y,'Holdout',0.50);
%Support Vector Machines
% Use a linear support vector machine classifier
svmStruct = svmtrain(F(P.training,:),Y(P.training),'showplot',true);
C = svmclassify(svmStruct,F(P.test,:),'showplot',true);
errRate = sum(Y(P.test)~= C)/P.TestSize;  %mis-classification rate
accuracy_Percentage = (1 - errRate)*100
conMat = confusionmat(Y(P.test),C) % the confusion matrix
```

The results show 58% to 63% accuracy and the confusion matrix is given below for one run.

accuracy_Percentage =

  58.8889

conMat =

29	21
16	24

Conclusion

This work shows the community matrix is an effective marker for detecting epileptic patients from fMRI images. However the recent AP clustering can be used for further improving the performance of the epileptic recognition system.

References

[1] J. Zhang, W. Cheng, Z. Wang, Z. Zhang, W. Lu, G. Lu, and J. Feng, \Pattern classi_cation of large-scale functional brain networks: identi_cation of informative neuroimaging markers for epilepsy," PloS one, vol. 7, no. 5, pp. e36733, 2012.

[2] A. Riaz, K. Rajpoot, and N. Rajpoot, \A connectivity di_erence measure for identi_cation of functional neuroimaging markers for epilepsy," in 6th International IEEE/EMBS Conference on Neural Engineering (NER), 2013, 2013, pp. 1517{1520.