IIT KANPUR CS 771A

Predicting cognitive state of human through FMRI image.

1. Ravi Kuril (16111047)
2. Akash Singh (16111028)
3. Anmol Kumar (16111031)
4. Gaurav Kumar (16111036)
5. Preetam Chahar (16111045)
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1 ABSTRACT

The functional Magnetic Resonance Imaging (FMRI) has provided us with an approach of revealing the activity of brain.In this experiment FMRI image has been taken in three states

1. Seeing a picture
2. Reading sentences
3. Ideal state (No Task)

We are trying to build a classifier such that when given a FMRI image it can predict the state of mind among the above three cases. Due to the large amount of data in FMRI studies, feature selection techniques are used to select particular features for classifier. We have used three classification techniques Support Vector Machines (SVM) , Gaussian Naive Bayes (GNB) and KNN and compared the results obtained by these techniques.

2 EXPERIMENT

1. The experiment consists of a set of trials, and the data is partitioned into trails, (reading a sentence, observing a picture, and determining whether the sentence correctly described the picture). 2. For these trials, the sentence and picture were presented in sequence, with the picture presented first on half of the trials, and the sentence presented first on the other half of the trials. 3. There is a gap between picture and sentence , Each image contains approximately 5,000 voxels (3D pixels) across a portion of the brain. 4. There are 40 trials for each subject and images are taken every 30 secs.

3 FEATURE SELECTION TECHNIQUES

3.1 K-MEANS(IMPLEMENTATION DETAILS)

1. We assembled all the 40 trails together and got a Matrix of dimension 2200 × 5000 say A where each column is a voxel.
2. We then cluster the transpose(A) in K Clusters using K-Means. The intensity value for a cluster is the weighted average of all the voxels present in the cluster.
3. we have taken 9 K values at an interval of 25 (25,50,....,225). Thus a Matrix of dimension 2200 × 5000 is reduced to 2200 × K.
4.We Have got the best result for K =125 and K =150 using cross validation.

3.2 K-MOST ACTIVE VOXELS

1. We assemble the the data where the subject was either Seeing a picture or reading a sentence into a matrix of P × 5000 say A.
2. We assemble the the data where the subject was in Ideal State (We have taken the ideal state between Reading a sentence and Seeing a Picture) into a matrix of Q × 5000 say B.
3. Here Q>P thus we replicated the rows in A randomly to make it equal to size of B. We Now find the co-variance between each corresponding Voxel in Matrix A and B.
4. We Choose those K Voxels whose co-variance was most negetive out of 5000 voxels.

Choosing K :
1. We found that choosing a small K was not giving us a good result. Thus we took K at intervals of 100. (300.400,.....1300).
2.We found the best result for K = 1100, however we observed some pattern in the voxels in this case.

Observation :
We observed that the top voxels where very similar and spatially close to each other. Thus we were picking a lot of voxels of similar types.

Idea :
Thus if we pick 1 voxel for all these voxels which are similar we can reduce K and attain a similar accuracy.

3.3 Combining N-Most Active Voxels and K Means

1. Apply K-Means Clustering for large value of K(600) so that similar voxels are clustered together
2. Apply N-Most Active Voxels for these 600 Voxels for N at intervals of 25 (25,50,....200).

3.4 Spectral Clustering

1.Spectral cluster could tell the intrinsic features of the data, revealing the underlying cluster. The spectral clustering algorithm is based on the concept of similarity between points. The clustering is based on the co-variance among voxels.
2.We need to keep in mind that we might put two voxels which are very close to each other spatially in different clusters and vice-versa as we clustering based on similarity in properties of voxels. Here Clusters can be seen as Region of Interest.

Algorithm:

1. Merge all the trials together and and make a single large matrix. Here each column of this matrix represents a voxel and each row represent the image number.
2. Find the Correlation between each voxel vector. Now we have a correlation matrix C of size 5000 × 5000. Construct Affinity Matrix A, the affinity is defined as $A_{ij} = exp(C(i,j)^2/2\sigma^2)$ if $i \neq j$, and A_{ii} =0, where C(i,j) is the correlation between the two vectors of voxels.
3. Using this Affinity matrix make K clusters and find out a label vector that labels each voxel to its corresponding cluster.
4. For each cluster take the voxels vectors that lie in the cluster and average the values of these voxel vectors, the averaged value represent the value of each cluster vector.

The value of of K and σ can be chosen using cross validation. We have taken 9 K which are $\{25,50,75,100,125,150,175,200,225\}$ and 5 σ the σ is chosen such that the value of $2\sigma^2$ are $\{10*e^-2,10*e^-1,10*e^0,10*e^1,10*e^2\}$.

3.5 Combining N-Most Active Voxels and Spectral Clustering

1. Apply Spectral Clustering for large value of K(600) so that similar voxels are clustered together as described in the section above.
2. Apply N-Most Active Voxels for these 600 Voxels for N at intervals of 25 (25,50,....200).

4 Feature Selection Techniques

We have implemented 3 feature selection techniques.
1. SVM (Support Vector Machine)
2. GNB (Gaussian Naive Bayes)
3. KNN (K Nearest Neighbor).
We have picked a subject randomly and shown the performance with best parameters (K,N and Sigma) for each feature selection technique for different data produced by different feature selection methods.

4.1 SVM (Support Vector Machine)

Write Here and put Diagrams

4.2 GNB (Gaussian Naive Bayes)

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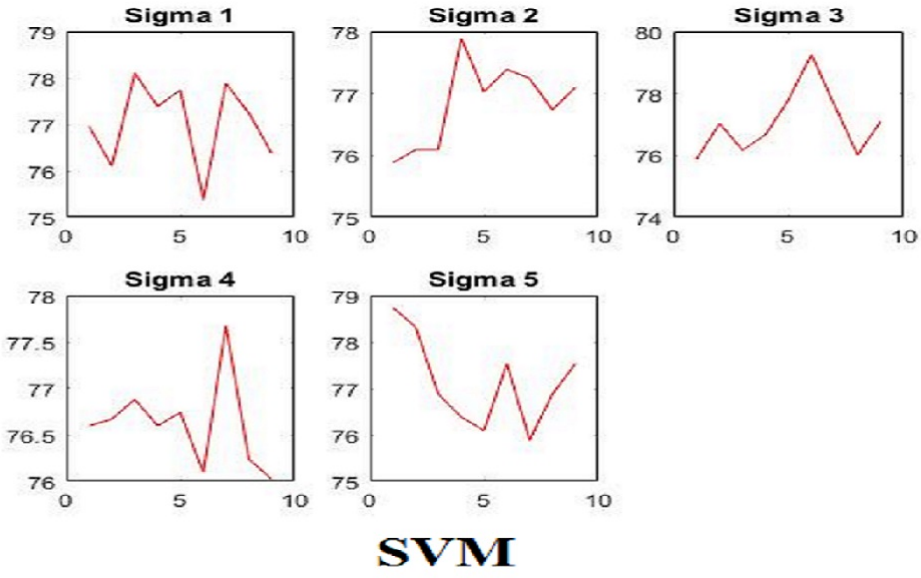
4.3 KNN (K Nearest Neighbor)

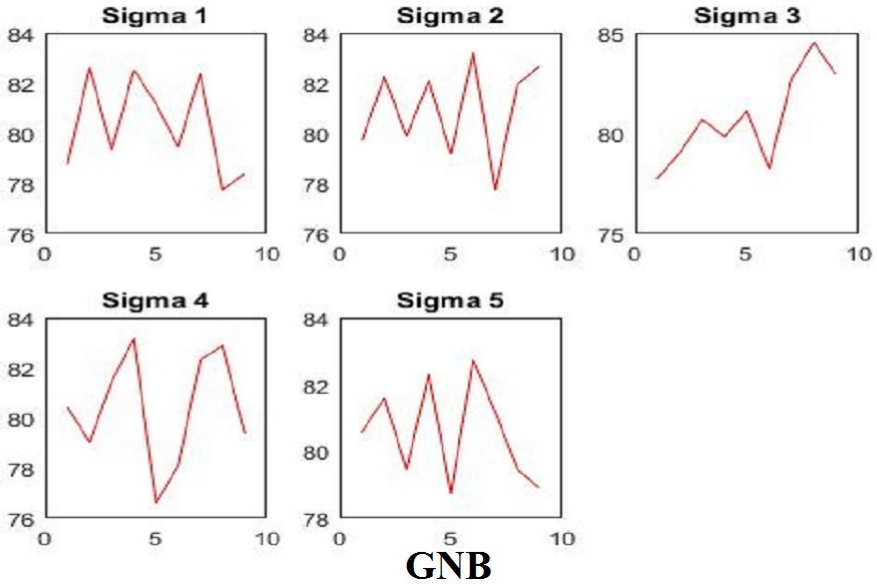
Write Here and put Diagrams

5 RESULTS

In the table below we have shown the average accuracy on all the subjects for each classification technique on different data produced by different feature selection techniques.

CLASSIFIER/ FEATURE EXTRACTION	K-MEANS	N-Most active voxels with k-means	Spectral clustering	Spectral clustering with N-most active voxels
GNB	74.21%	79.07%	78.86%	81.65%
SVM (with RBF kernel)	83.02%	85.34% ,N=100	88.79%,	89.81%
KNN	67.17%	68.24%	65.36%	62.32%





GNB

6 Future Work

1.Explore more Feature Selection and classification techniques.
2.Training on Subject X and testing on Subject Y (Training cognitive state of a human and testing on other humans).These techniques did not give acceptable results for training and testing on different subjects.

7 References

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3. Training FMRI Classifiers to Detect Cognitive States across Multiple Human Subjects ($http://www.cs.cmu.edu/\ tom/nips03-submitted.pdf$)
4. Feature Selection for FMRI Classification ($http://www.cs.cmu.edu/\ epxing/Class/10701-06f/project-reports/wu.pdf$)