

Insights into fMR data using Machine Learning

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Outline

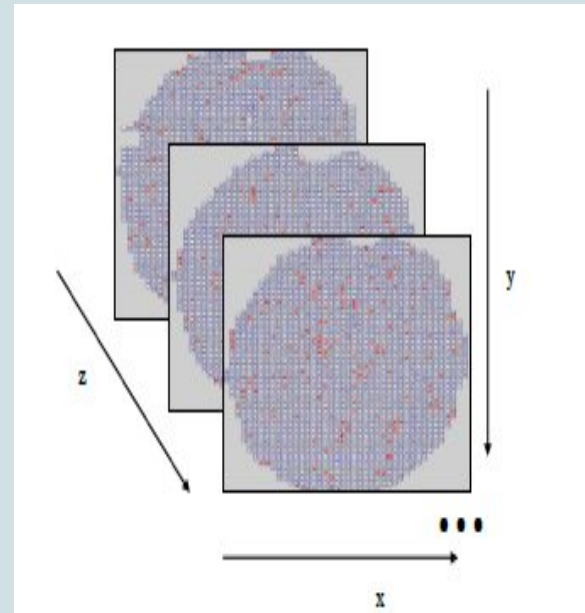
- ◆ Introduction to fMRI
- ◆ Objective
- ◆ Dataset Description
- ◆ Introduction to RFE
- ◆ Experimental Description
 - RFE Implementation
 - StarPlus Data
 - Probid Data
- ROI Analysis
- Across Subjects Analysis -- 7 ROIs
- Across Subjects Analysis -- 3 ROIs
- ◆ Conclusion
- ◆ References

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Introduction To fMRI

- ◆ fMRI -- functional Magnetic Resonance imaging
- ◆ Provides information about the functioning of the human brain
- ◆ Acquisition of the Blood Oxygen Level Dependent (BOLD) in fMRI
- ◆ Voxels and ROIs (Region of Interest).
- ◆ voxels intensity $\rightarrow f(x, y, z, t)$



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Objective

- ◆ Mapping of the brain corresponding to a cognitive state.
- ◆ Time stamp analysis.
- ◆ Region of activation analysis.
- ◆ Classification analysis across all the subjects

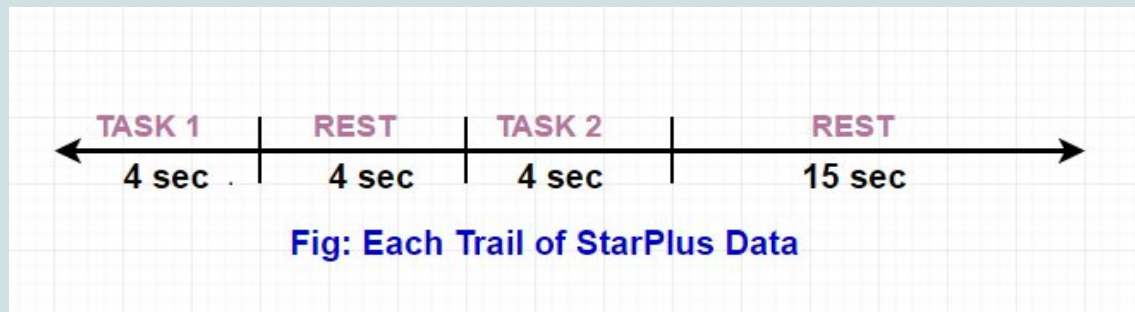
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Dataset Description

StarPlus Data

- ♦ 2 cognitive states(Picture and Sentence).
- ♦ 54 trials, each trials of 27 seconds.



Dataset Description

StarPlus Data

- ◆ Data is dimension of 64x64x8
- ◆ 5 subjects

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Dataset Description

Probid Data

- ◆ 3 cognitive states (Pleasant , Unpleasant and Neutral).
- ◆ 5 subjects.
- ◆ Dimension of 79x95x69, collected over 121 time points.

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Voxel Elimination ?

- ◆ Data is high dimensional.
- ◆ Minimum number of features 4500 for starPlus.
- ◆ Maximum number of features **219727** for probid.
- ◆ Solution --> RFE (Recursive feature Elimination)

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Sample Data in fMRI

Voxel 1	Voxel 2	Voxel 3	Voxel N	Label
value	value	value	value	Class 1
value	value	value	value	Class 1
value	value	value	value	Class 2
value	value	value	value	Class 2

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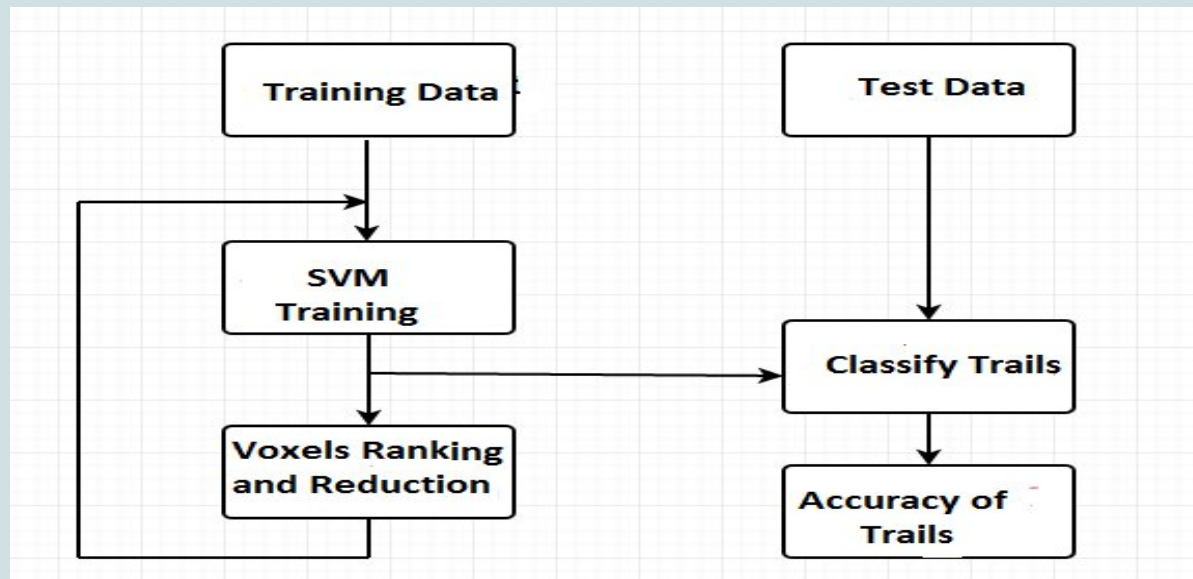
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Introduction To RFE

- ◆ Multivariate feature extraction algorithm.
- ◆ Recursively eliminates irrelevant features.
- ◆ SVM classifier --> for removing irrelevant voxels.

Introduction To RFE

Flow Chart



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Introduction To RFE

Algorithm

Algorithm 1 :RFE algorithm

while(stop)

1. Train SVM ($M_{Train_{RFE_i}}, Labels_{RFE_i}$) $i = 1, 2..L$
2. Compute scoring function for each voxel:

$$S_{RFE_i}(v) = \frac{\sum_{i=1}^L |(w_i(v))|}{L}$$

3. Sort V based on $S_{RFE}(v)$
4. Eliminate features with smallest scores

end

Activate Wi

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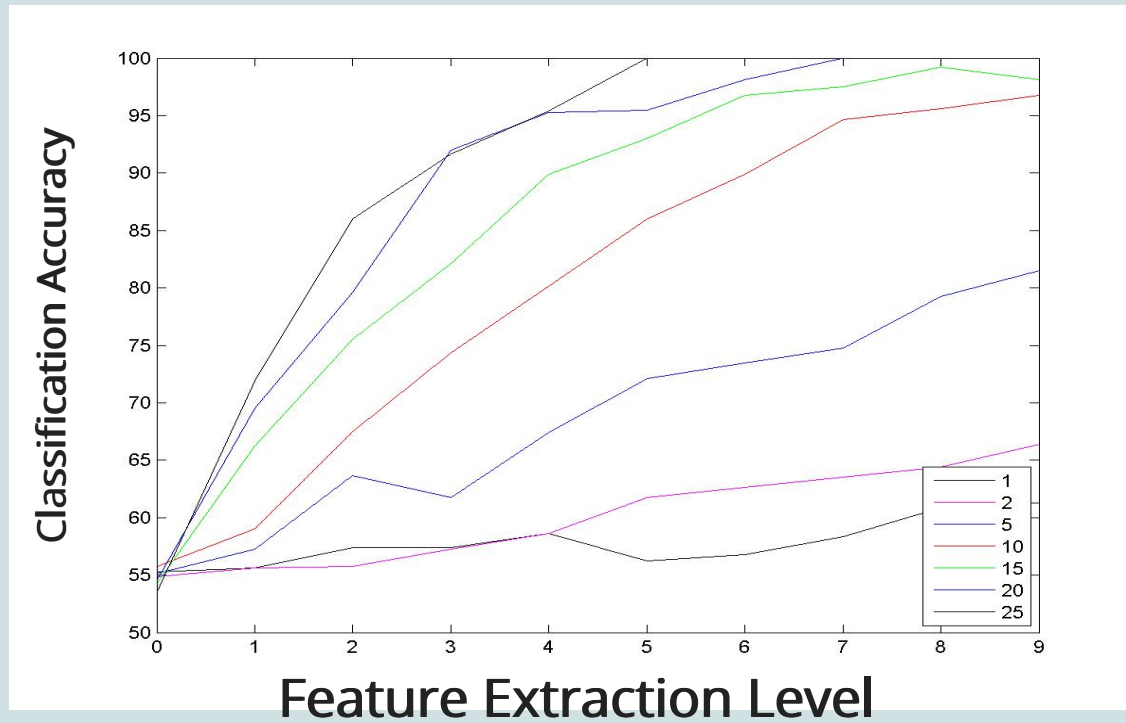
RFE implementation on starPlus

Picture Vs Sentence Classification

- ◆ Analysis for each subject
- ◆ Each task -- 8 seconds -- 16 images
- ◆ Number of features --> $16 * \text{number of voxels}$
- ◆ 40 rows for picture and 40 rows for

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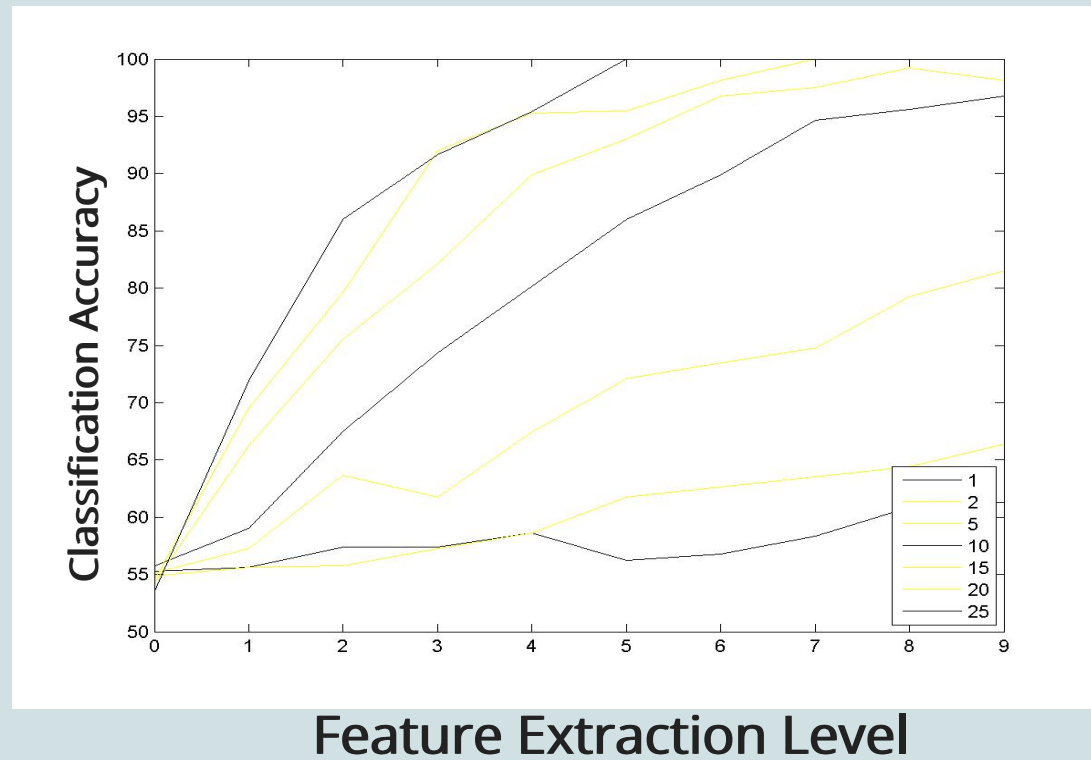
RFE implementation on starPlus Results



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RFE implementation on starPlus

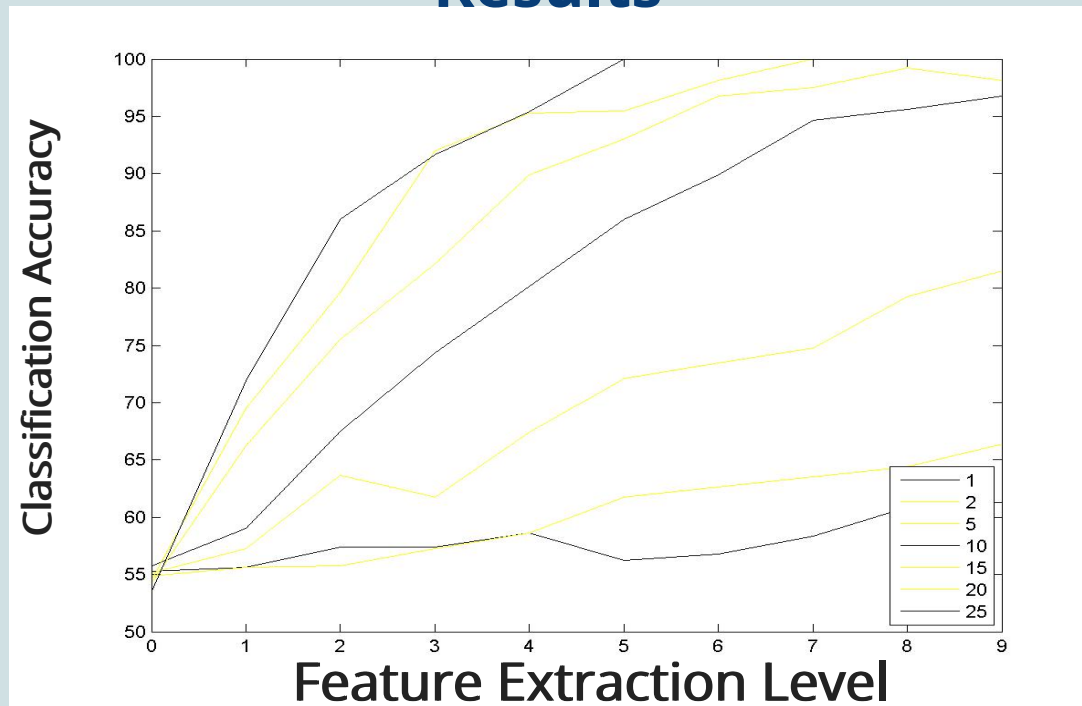
Results



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RFE implementation on starPlus

Results



Conclusion : As the feature extraction levels increases, accuracy also increases

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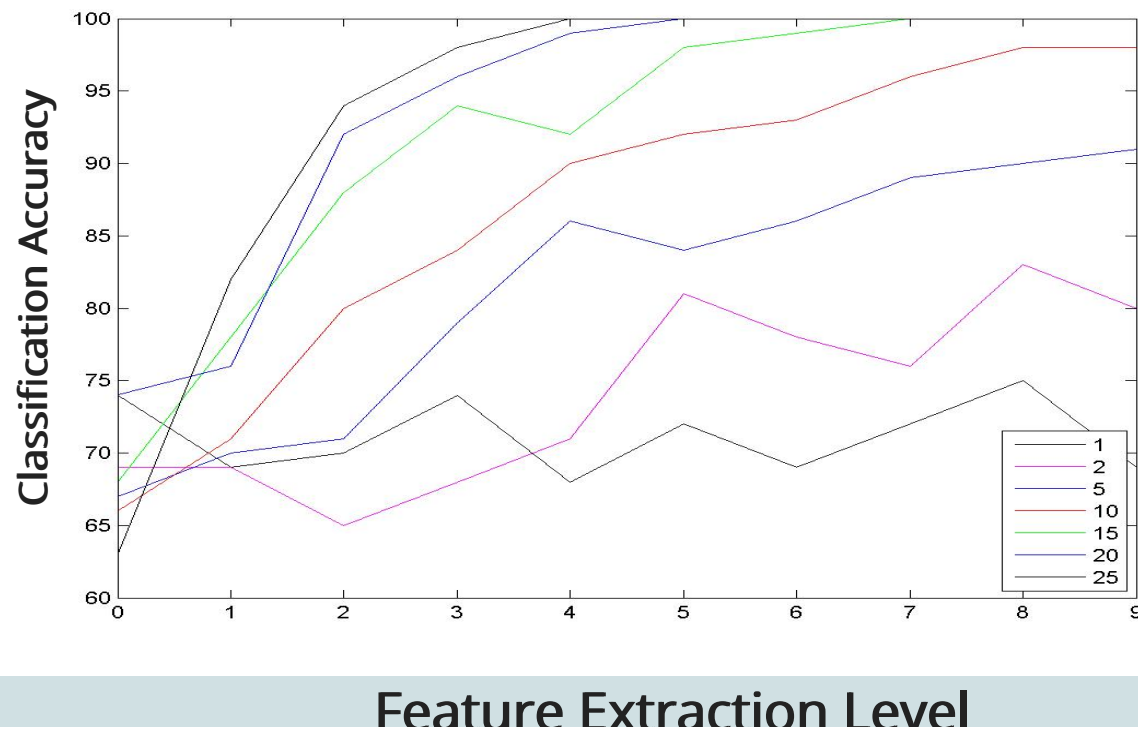
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RFE implementation on Probid

Pleasant Vs Unpleasant classification

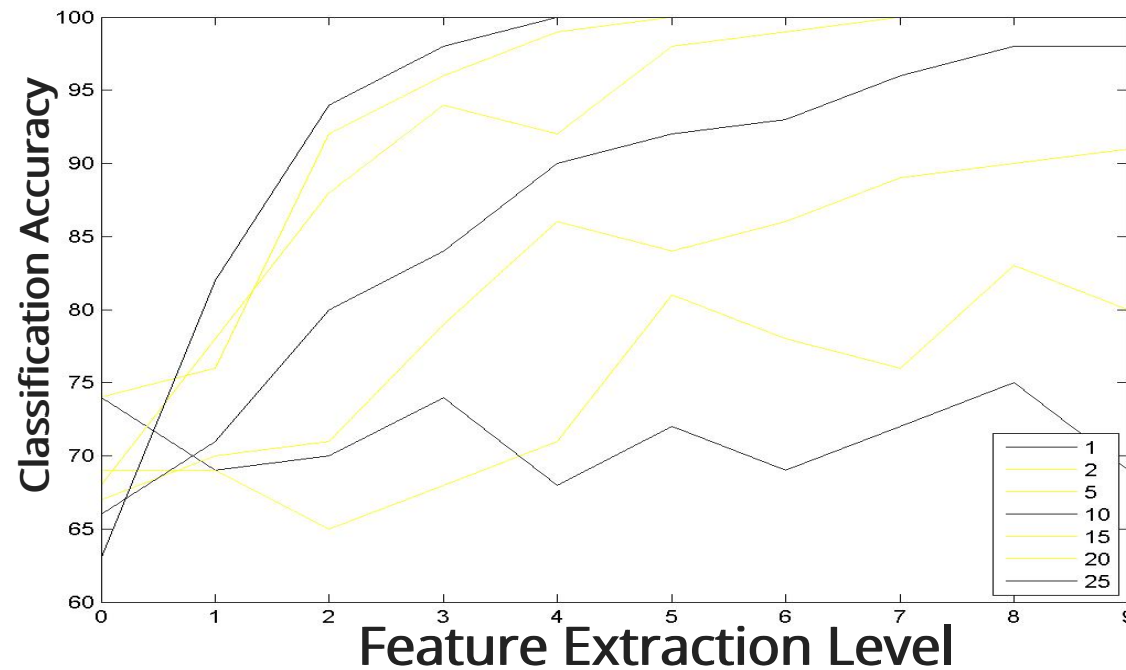
- ◆ 5 subjects.
- ◆ 50 rows for each of the task --> total 100 rows.
- ◆ Number of voxels : 219727.

RFE on Pleasant Vs UnPleasant Results



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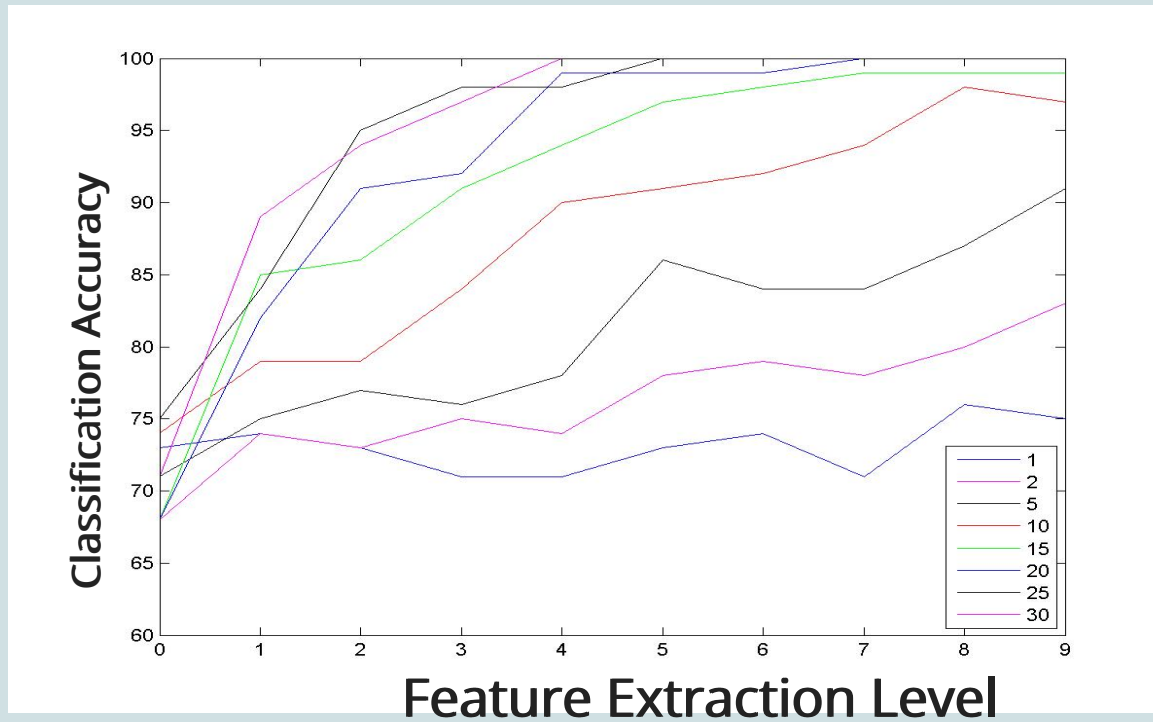
RFE on Pleasant Vs UnPleasant



Conclusion : As the feature extraction levels increases, accuracy also increases

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RFE on Pleasant Vs Neutral



Conclusion : As the feature extraction levels increases, accuracy also increases

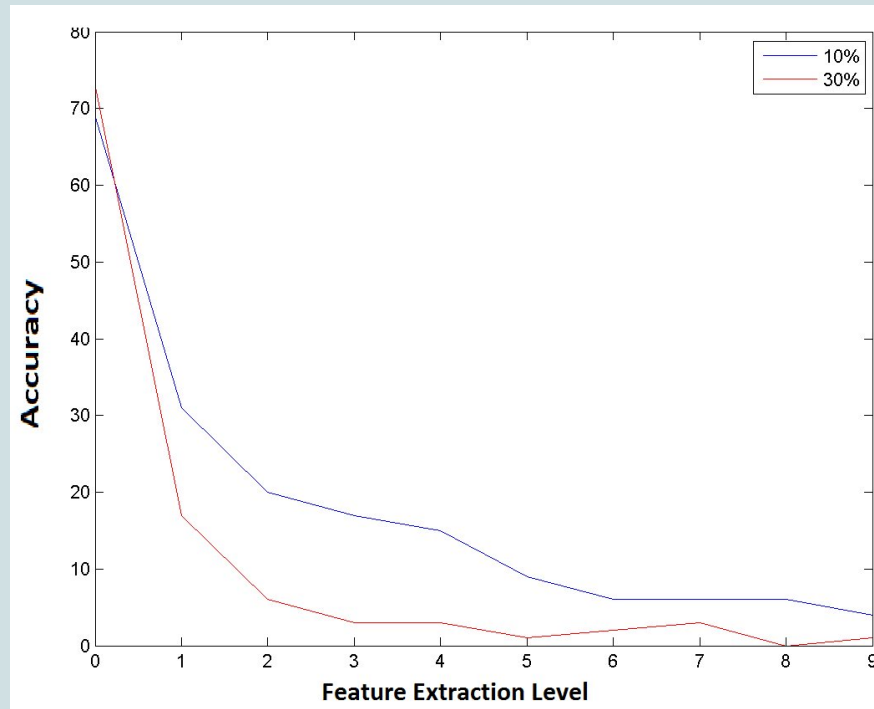
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RFE Experiment for correctness

- ◆ Picture vs Sentence StarPlus Data.
- ◆ Removed relevant voxels.
- ◆ Accuracy is decreased as feature extraction level increases.

Reverse RFE Experiment for correctness



Conclusion: More the relevant percentage of voxels removed, more sharply accuracy decreased.

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Time stamps analysis

Objective

Important Time Stamps analysis.

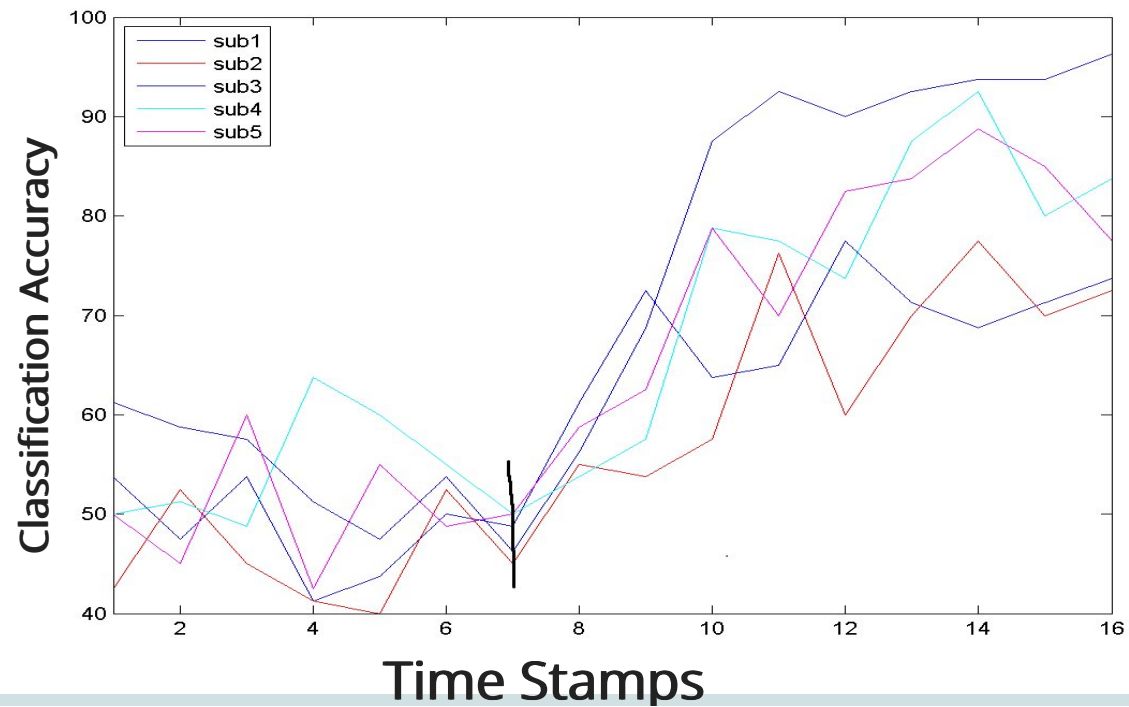
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Time stamps analysis Procedure

- ◆ Picture Vs Sentence data.
- ◆ Analysis is done for individual subjects
- ◆ Voxels from 7 ROIs
- ◆ Accuracy measured for each time stamp

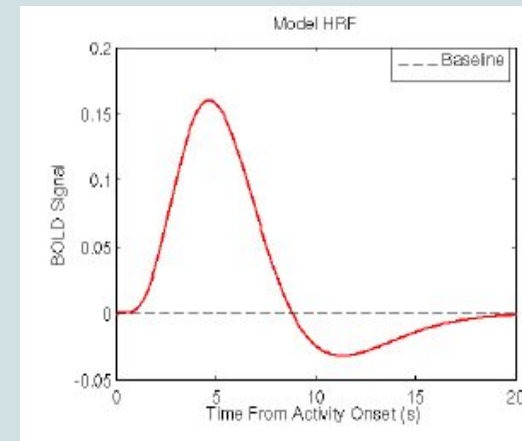
Time stamps analysis Results



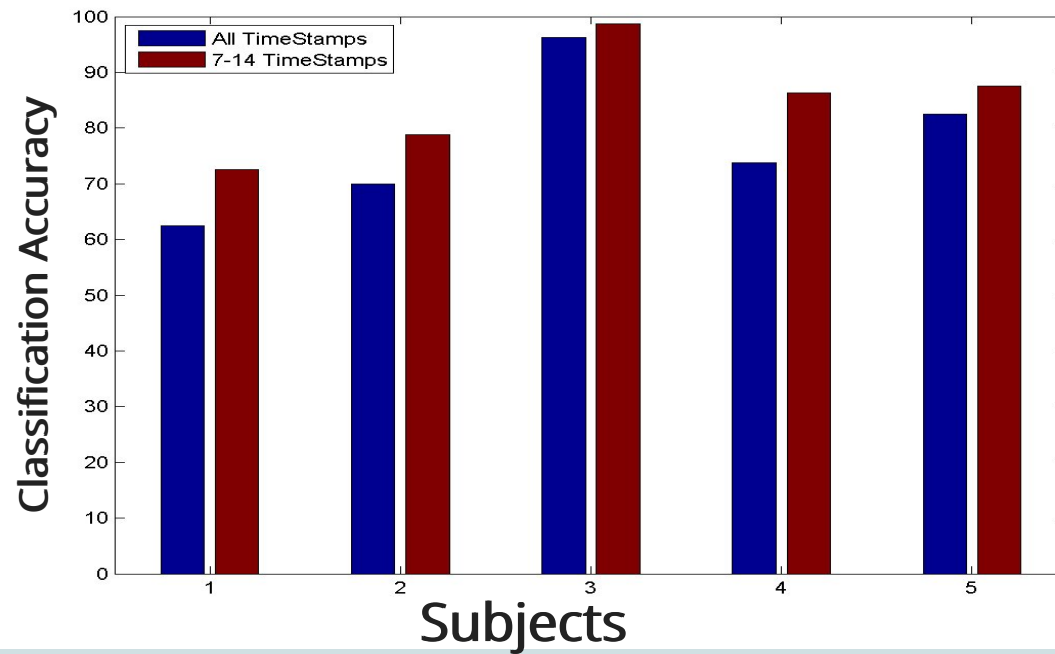
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Time stamps analysis Discussion

- ◆ Voxels from 7-14 time stamps (3.5 sec to 7 sec) are more discriminating.
- ◆ This conforms to the concept of HRF (Haemodynamic Response Function)



Time stamps analysis Results



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ROI analysis

Objective

Important Region of interest Analysis

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ROI analysis

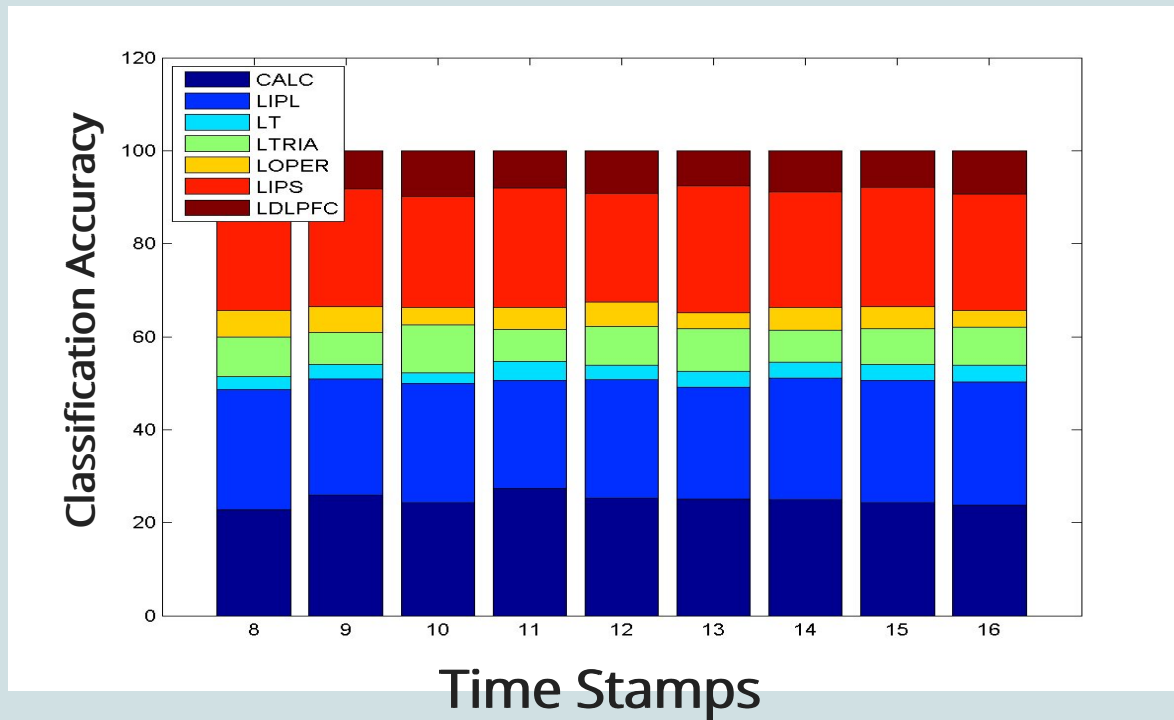
Procedure

- ◆ Picture Vs Sentence data.
- ◆ Voxels from 7 ROIs.
- ◆ Analysis -- individual subjects.
- ◆ Most discriminating Voxels are found from RFE.
- ◆ Distribution of these voxels are analyzed

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ROI analysis

Results



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ROI analysis

Discussion

- ◆ 3 ROIs (CALC, LIPL, LIPS) voxels are most discriminating.
- ◆ 70 % of the discriminating voxels are in this 3 regions.

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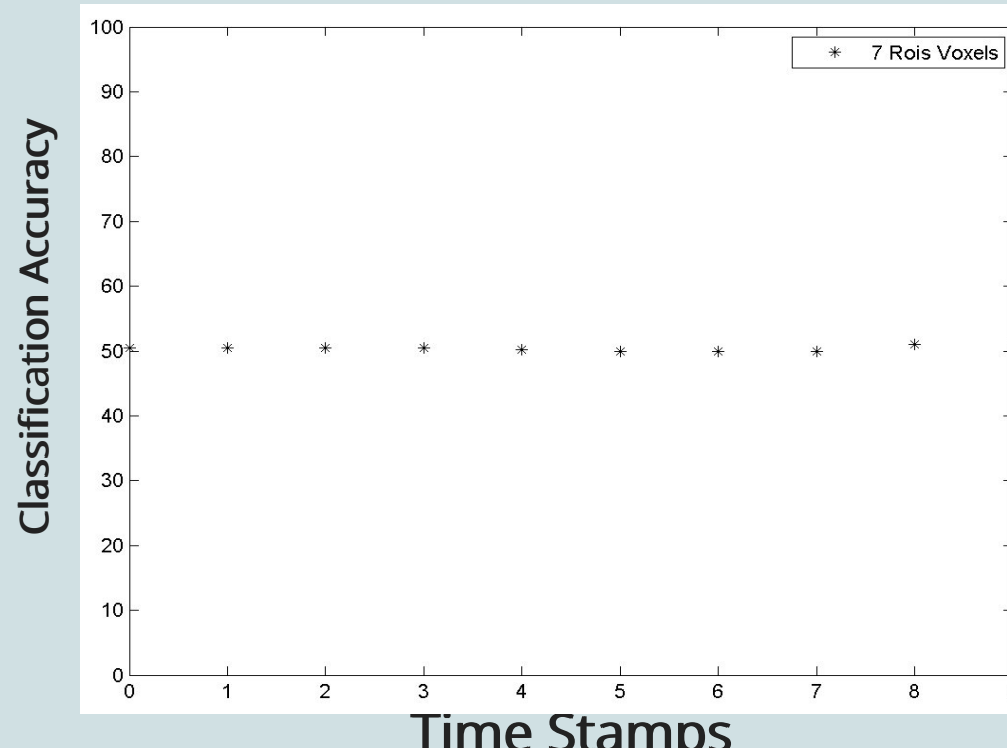
Across Subjects analysis -- 7 ROIs

Procedure

- ◆ Across all subjects.
- ◆ Picture Vs Sentence data classification using RFE.
- ◆ Purpose of this analysis, to find class for generalized test data.
- ◆ Mean value across ROIs is taken.

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Across Subjects analysis -- 7 ROIs Results



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Across Subjects analysis -- 7 ROIs

Discussion

- ◆ Data is not classified accurately from 7 ROIs voxels, across all the subjects.
- ◆ Some irrelevant features needs to removed

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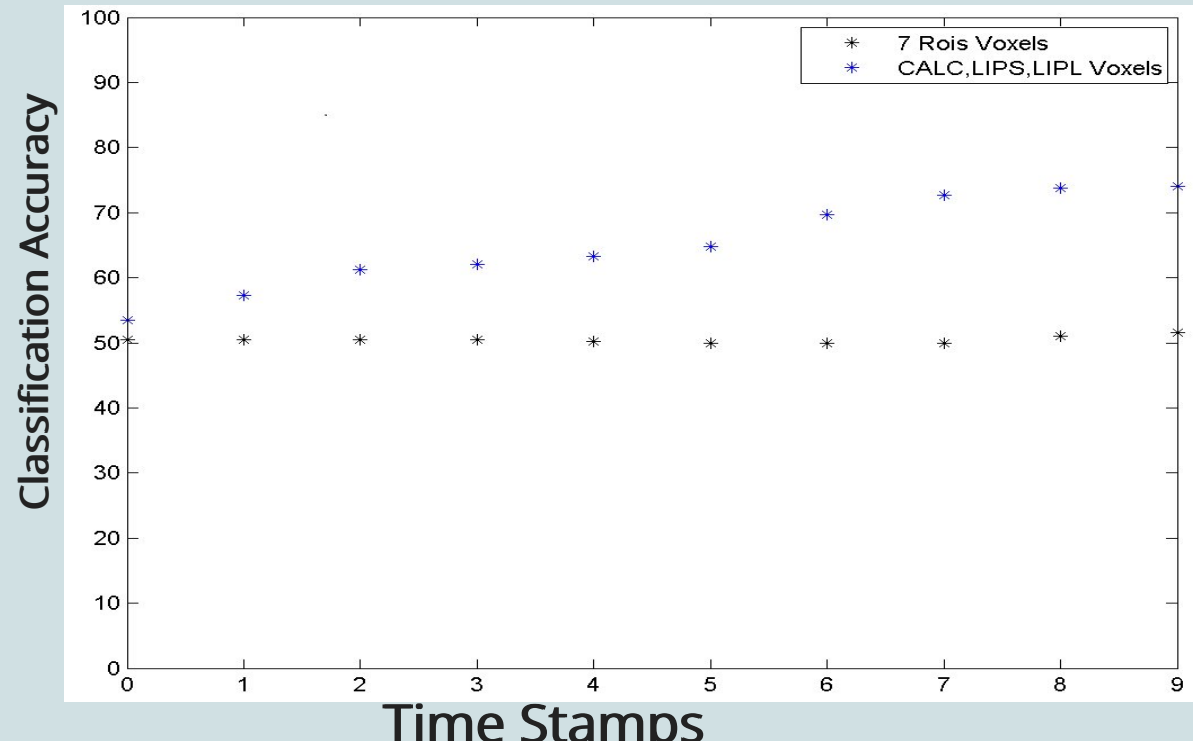
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Across Subjects analysis -- 3 ROIs

Procedure

- ◆ Only 3 ROI's (CALC, LIPS ,LIPL) voxels taken.

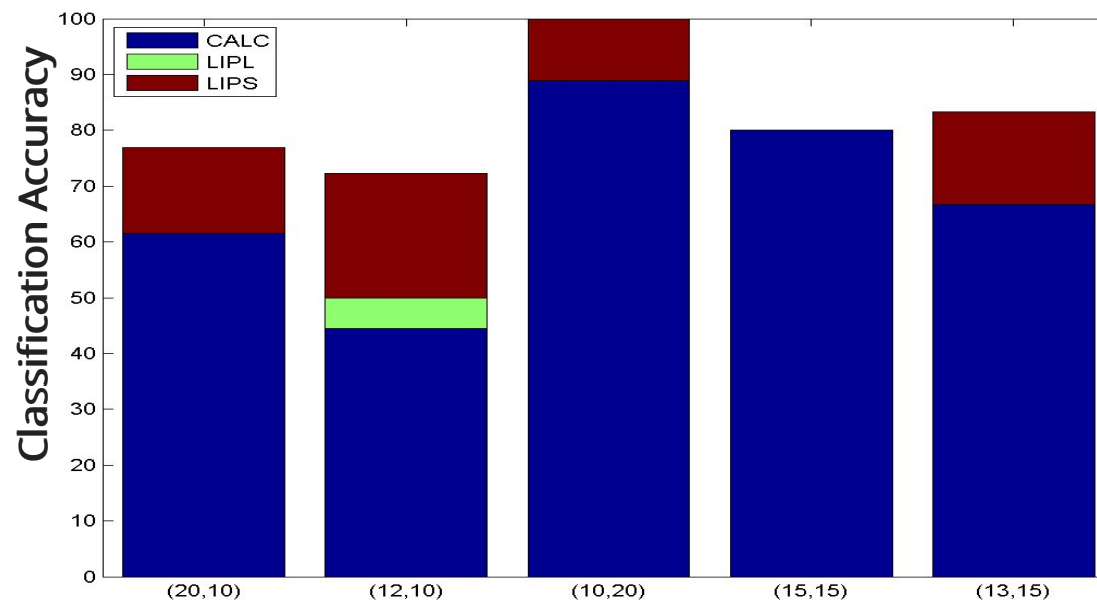
Subjects analysis -- 3 ROIs Results



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Across Subjects analysis -- 3 ROIs

Results



Feature extraction levels. voxels

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Across Subjects analysis -- 3 ROIs

Discussion

- ◆ Important voxels --> 3 ROIs (CALC, LIPS, LIPL)

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Conclusion

- ◆ Machine learning algorithm can be successfully utilized for fMR data analysis.
- ◆ Brain mapping corresponding to cognitive states established.
- ◆ 3 Important Regions are CALC, LIPS ,
LIP in Picture vs Sentence analysis

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