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Analysis and Identification of Parkinson disease based on fMRI

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***Abstract*—*Parkinson's disease (PD)* is a neurodegenerative disorder that affects the motor system. In this disease, symptoms are shaking, slowness of movement, and difficulty with walking. Thinking and behavioral problems may also occur.The main motor symptoms are collectively called "parkinsonism", or a "parkinsonian syndrome". In present study functional magnetic resonance imaging (fMRI) data has been used to analysis and identification of PD and normal subject.**

In this paper, features like ALFF, fALFF , ReHo , functional connectivity are calculated and correlation between the feature maps has been analyzed. Its showed that some specific regions in our brain have different activity level in PD patients and normal (control) persons

Keywords— Neurodegenerative, fMRI, ALFF, fALFF, ReHo functional connectivity

I. INTRODUCTION

Parkinson's disease (PD) is a neurodegenerative disorder which generally begins with asymmetric motor symptoms that persevere over time. This suggests that the dysfunction in the nigrostriatal motor circuit may be lateralized [1]. The disease is symptomatically deciphered tremor, rigidity, bradykinesia and postural instability [2].

The neuroimaging techniques *viz* fMRI, PET, etc. (non invasive methods) and invasive electroencephalography (invasive) method are applied for the diagnosis of disease state

[3]. Functional magnetic resonance imaging (fMRI), a non invasive method, has proven useful for studying the behavior

(neural activity) of human brain through functional brain network analysis of the generated images. [4]. fMRI primarily, measures the hemodynamic response which is a reflection of the blood oxygenation level and the current locations can be used to decipher how the brain responds to various stimuli [5]. The Parkinson's disease (PD) is a particularly suitable target for intervention because imbalance between cortical and sub cortical motor circuits is at the heart of path physiological models [6]. The neuroimage analysis depends upon the identification of significant features which is deployed for computation and prediction model generation [7]. This has always posed a challenge before research community [5]. Moreover the early detection of PD is always a pacesetter step in diagnosis and treatment. The present investigation is carried out in the understanding and exploring the statistical analysis of various inherent features of neuroimages; functional magnetic resonance imaging (fMRI) and compare the brain activation of the subject (patient) and normal.

The paper is described as follows. We will firstly state our experiment environment and methodology

in Section II. The discussion and analysis of the results are followed in Section III. Section IV presents the conclusion of this study and lists some future perspective.

II. Material and Methodology

A. Dataset

The study uses resting state fMRI scans of 10 healthy individuals, 6 male and 4 female, and 10 PD patients (subjects) 5 male and 5 female. The scans amount for a period of 504 seconds with a brain scan repetition time (TR) of 2.4 seconds for each patient. The age group of subjects is 40-75 years [15]. The data was obtained from the PPMI IDA Search and clinical detail of subjects shown in **Table -1**. Flow chart of data analysed have been shown in fig I.

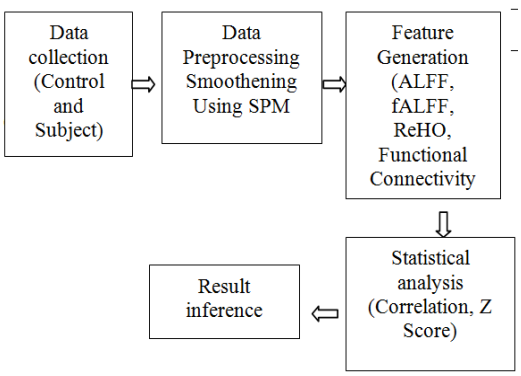

Fig:-I Flowchart of data analysis

Table 1 –clinical detail of subjects

SR. NO.	PPMI SUBJECT ID	GROUP	AGE	SEX	VISITS
1.	3310	Control	66	M	5
2.	3569	Control	45	F	11
3.	3565	Control	58	M	11
4.	3563	Control	64	M	11
5.	3361	Control	61	F	90
6.	3357	Control	48	M	11
7.	3353	Control	60	F	90
8.	3351	Control	72	M	90
9.	3106	Control	74	F	11
10.	3769	Control	71	M	5
11.	3108	PD	54	F	11
12.	3105	PD	71	M	7
13.	3116	PD	66	M	5
14.	3132	PD	52	M	7
15.	3364	PD	41	F	7
16.	3380	PD	71	F	5
17	3574	PD	67	F	7
18	3118	PD	62	M	7
19	3128	PD	61	F	21
20	3130	PD	44	M	1

B. Features Extraction:

- **plitude of Low Frequency Fluctuations (ALFF):** resting state of brain is characterized by low frequency (delta) oscillations, and the default mode network of brain is expected to show highest amplitudes [8]. ALFF measures low frequency band power (0.01-0.08 Hz) and hence helps compare regions of activity during resting state.
- **Fractional ALFF (fALFF):** ALFF is sensitive to physiological noise. Hence to immunize the measures, a ratio of the power of each frequency in range (0.01–0.08 Hz) to total power in frequency range (0–0.25 Hz) is computed [9].
- **Regional Homogeneity (ReHo):** It is a measure of similarity of time series of voxels and their nearest neighbors. The Kendall's coefficient of concordance (KCC) is computed for clusters of 27 voxels on smoothed functional images [10]. It helps in identifying connection between regions of brain.
- **Functional Connectivity:** the connectivity of a specified region of interest (ROI) is found by taking the average time course of ROI and correlating it with time series other voxels and mapping the results [11].

C. The steps performed during the analysis are –

1) The neuro-images were downloaded from PPMI categorized as PD patient or a normal person.

2) Each image set was processed using SPM8 REST [12-15] tool to standardize the scans and remove anomalies due to noise, motion and timing correction. Firstly, the image slices are corrected for acquisition time differences within same brain scan using Slice timing correction utility. Next, the images are corrected for translation and rotation of patient during scanning time using Realign utility. The high resolution T1 image of patient is then coregistered to the mean realigned functional image using Coregister utility. The resulting coregistered image is used for segmenting white matter, gray matter and other tissues structures using Segment utility. A standardized map is created out of the tissues identified and used to prepare standard shape brain images of processed functional images, using the Normalize utility. Finally, the time series of each voxel is smoothed to suppress high frequency noise using Smooth utility [16].

3) The normalized and smoothed images were placed in separate folders. Both types were

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processed to remove linear trend and filtered for frequency range 0.01 – 0.08.

4) The normalized-detrended-filtered images were used to calculate the ReHo map for the person using REST toolkit for resting state fMRI data processing.

5) ALFF and fALFF were calculated on smoothed-detrended-filtered images for each person.

6) The functional connectivity was found on smoothed –detrended-filtered images voxel-wise in the cerebellum region using the MNI_1mm parcellation_map_thrP10 from NITRC.org.

7) The ReHo, ALFF, and fALFF maps were grouped as PD group and control group, and t-test was performed for each feature on the two groups [17].

8) The Functional Connectivity maps were grouped similarly (as in step 7) and paired t-test was applied to the two group sets [17-18].

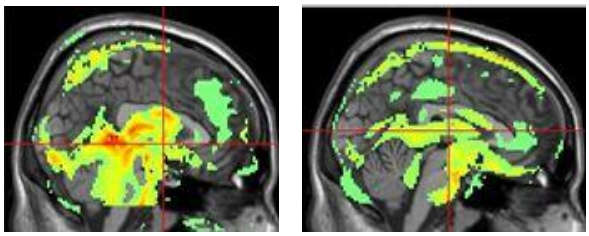
The correlation between the two groups was found for each feature using 'corrcoef' function of MATLAB, which works out the formula:

$$corr(X,Y) = \frac{\mathrm{E}([X-\mathrm{E}(X)][Y-\mathrm{E}(Y)])}{\mathrm{sd}(X)\mathrm{sd}(Y)}$$

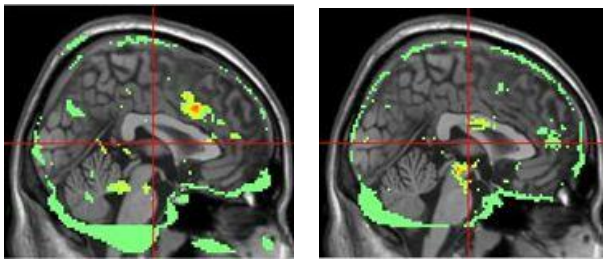
III. RESULT AND DISCUSSION

The t-tests performed on ALFF, fALFF and ReHo feature maps for control group and PD group for show the different regions activated in the two groups, with trend of more activity in the PD patients. The regions in red hold the highest numerical values for the corresponding feature mapped, followed by yellow, light green and blue-green in decreasing order of values. The test on ALFF maps shows significant amount of activity in cerebellum for PD group (fig 2: 1.(a)) compared to control group (fig 2: 1.(b)). Similar analysis of fALFF maps shows more activity in cingulate gyrus for PD group (fig 2: 2.(a)) than for control group (fig 2: 2.(b)). The analysis of ReHo maps displays contrast in density of activity points in the parietal lobe and cerebellum, between the control group (fig 2: 3.(b)) and PD group (fig 2: 3.(a)). The functional connectivity maps were generated with reference to cerebellum as the region of interest for PD group and control group. Paired t-test was performed on the resulting two functional connectivity map sets, and the regions of significant differences between the two sets are shown in figure 3: (a) and (b). The main region of difference is on the left, a little above the cerebellum and lies in the occipital lobe.

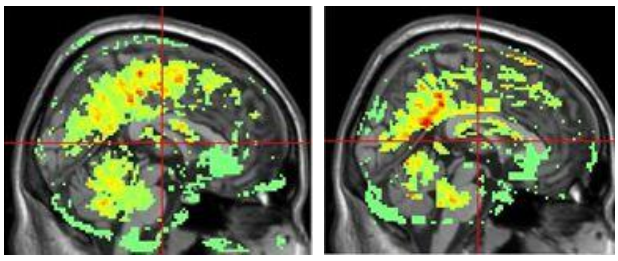
The results of correlation between feature maps of PD patients group and control group (made into pairs, 1 control with 1 PD patient, the feature maps of ALFF, fALFF, ReHo and FC for the control checked for correlation with the respective features of PD patient) are shown in **Table 2**. The mean of correlations ranges between 0.5-0.7 while the inter group correlations were found to be significantly higher.



1.(a) 1.(b)



2.(a) 2.(b)



3.(a) 3.(b)

Fig 2: t-test (performed on ALFF, fALFF and ReHo feature maps of control group and PD group) results ($p<0.05$) superimposed on sagittal section of anatomical template (Ch2.nii) from *MRIcro* software [reference] 1.(a) ALFF features for PD group 1.(b) ALFF features for Control group 2.(a) fALFF features for PD group 2.(b) fALFF features for control group 3.(a) ReHo features for PD group 3.(b) ReHo features for control group

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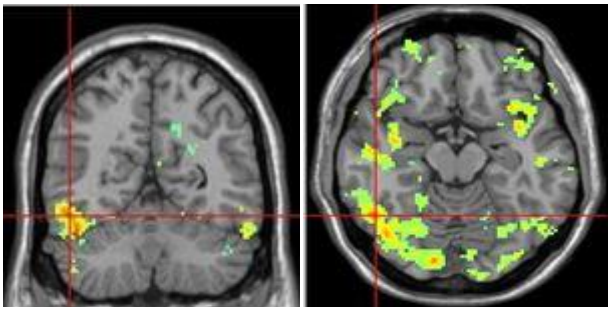

(a) (b)

Fig 3: paired t-test (performed on functional connectivity maps of control group and PD group) results ($p<0.05$) superimposed on anatomical template (Ch2.nii) from *MRIcro* software [reference]. Figure shows significant regions of connectivity difference between the two groups (a) coronal cross section view (b) transverse view

Table 2 – correlation coefficients between feature map

PAIR NO.	ALFF	FALFF	FC	REHO
1	0.4775	0.7679	0.3621	0.5726
2	0.6936	0.7986	0.7918	0.7079
3	0.4025	0.7645	0.4455	0.6284
4	0.628	0.8146	0.5322	0.7164
5	0.4752	0.7698	0.3349	0.6049
6	0.3703	0.7664	0.4981	0.5808
7	0.6413	0.7228	0.6551	0.6058
8	0.6791	0.7783	0.7265	0.5847
9	0.6067	0.7579	0.6842	0.6328
10	0.6382	0.7635	0.6909	0.6105
MEAN	0.5612	0.7704	0.5721	0.6245

IV. CONCLUSION

In this study, it was observed that there are activity differences in the specific regions of brain. The comparison was done between the normal (control) person and the PD patient on bases of features (ALFF, fALFF, ReHo, functional activity and correlation coefficients). The behavioral changes in PD patients are the consequence of the functional variations in specific regions of brain.

The measure of Correlation Coefficient depicts the dissimilar/similarity of the extracted features extracted for the two groups.

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