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# An Approach for Systematic Study for Detection and Classification of Parkinson Disease using Machine Learning Techniques

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**ABSTRACT**: Parkinson disease (PD) is currently ranked as the sixth leading cause of death in the United States and recent estimates indicate that the disorder may rank third, just behind heart disease and cancer, as a cause of death for older people. Clearly, predicting this disease in the early stages and preventing it from progressing is of great importance. The diagnosis of Parkinsondisease (PD) requires a variety of medical tests, which leads to huge amounts of multivariate heterogeneous data. It can be difficult and exhausting to manually compare, visualize, and analyze this data due to the heterogeneous nature of medical tests; therefore, an efficient approach for accurate prediction of the condition of the brain using resting-state functional magnetic resonance imaging (R-fMRI) data. A targeted auto encoder network is built to distinguish normal aging from mild cognitive impairment, an early stage of PD. The proposed method reveals discriminative brain network features effectively and provides a reliable classifier for PD detection. Compared to traditional classifiers based on R-fMRI time series data. The proposed work also able to classify the different types of Parkinson's disease as well as particular stage of disease. The finally we will compare our deep learning approach accuracy with existing systems.In this research work to design and implement a system using deep learning with brain network and clinical relevant text information to make early diagnosis of Parkinson's Disease (PD). The clinical relevant text information includes age, gender and *ApoE* gene of the subject. The brain network is constructed by computing the functional connectivity of brain regions using resting-state functional magnetic resonance imaging (R-fMRI) data. A targeted auto encoder network is built to distinguish normal aging from mild cognitive impairment, an early stage of PD. The proposed method reveals discriminative brain network features effectively and provides a reliable classifier for PD detection.

## I. INTRODUCTION

Scientists are conducting studies to learn more about plaques, tangles, and other biological features of Parkinson's disease. Advances in brain imaging techniques allow researchers to see the development and spreadof abnormal amyloid and tau proteins in the living brain, as well as changes in brain structure and function. Scientists are also exploring the very earliest steps in the disease process by studying changes in the brain and body fluids that can be detected years before Parkinson's symptoms appear. Findings from these studies will help in understanding the causes of Parkinson's and make diagnosis easier. One of the great mysteries of Parkinson's disease is why it largely strikes older adults. Research on normal brain aging is shedding light on this question. For example, scientists are learning how age-related changes in the brain may harm neurons and contribute to Parkinson's damage. These age-related changes include atrophy (shrinking) of certain parts of the brain, inflammation, production of unstable molecules called free radicals, and mitochondrial dysfunction (a breakdown of energy production within a cell).

Parkinson's disease can be definitively diagnosed only after death, by linking clinical measures with an examination of brain tissue in an autopsy. People with memory and thinking concerns should talk to their doctor to find out whether their symptoms are due to Parkinson's or another cause, such as stroke, tumor, Parkinson's disease, sleep disturbances, side effects of medication, an infection, or a non-Parkinson's dementia. Some of these conditions may be treatable and possibly reversible. If the diagnosis is Parkinson's, beginning treatment early in the disease process may help preserve daily functioning for some time, even though the underlying disease process cannot be stopped or reversed.

An early diagnosis also helps families plan for the future. They can take care of financial and legal matters, address potential safety issues, learn about living arrangements, and develop support networks. In addition, an early diagnosis gives people greater opportunities to participate in clinical trials that are testing possible new treatments for Parkinson's disease or other research studies.

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## II. MOTIVATION

The classical approaches to PD diagnosis are thorough neuropsychological evaluation, patient interview, blood-sample analysis and imaging to exclude other, reversible forms of cognitive impairment. The use of CSF amyloid and tau analysis is a useful method because it provides information on specific protein changes in the brain, and is frequently used in Scandinavian countries. However, there is high inter- and intra-laboratory variation so the classical cutoff of pathological levels varies between centers performing the same methods. The major limitation of current approaches is that there are no useful markers of disease stage. Markers have been developed for brain atrophy, but the latter is not always present at early diagnosis. Other advanced methods like PET-amyloid camera are not available in every clinical setting, which limits the accuracy of diagnosis. Outside of universities and neurological clinics, diagnostic methods are simpler and even limited, thus misdiagnoses are more frequent. The testing of other cognitive domains besides memory impairment is still not standardized for PD. Furthermore, the knowledge of neuropathological processes in PD and normal aging are not entirely understood, especially in an elderly population where a similar clinical picture might have a different neurobiological background. We still have lot to learn from neuropathology. Earlier diagnosis is imperative, as it may enhance the ability to study disease course and clinical heterogeneity, predict the future and personalize treatment. We need a consensus approach.

### Challenges

- Classification and clustering has always been a challenging problem.
- Early-stage detection as well as Multi class classifier system like stage of disease.
- To incorporate the processing of imperfect data.
- Accuracy issues.
- Not any approach has work with early-stage detection of Parkinson 's disease using different classification approach.

## III. ISSUES OF RESEARCH

It is relatively easy to make a diagnosis of dementia, but to determine PD at an early stage is still a clinical challenge. PD is considered as a patho clinical continuum where neuro pathological changes start to accumulate in the brain probably 10–15 years before the first sign of clinical impairment. Dementia due to PD is, in fact, the last stage of the disease. The ability to diagnose PD at an earlier stage would enable intervention with drugs that can specifically target the pathological processes underlying the disease, thus modifying or even halting disease progression. This presents an obvious challenge, as the patient may show no clinical signs of dementia, but subjective cognitive impairment or seemingly unrelated cognitive changes, alterations in personality or mood such as depressive state, neuroticism or changes in social behavior, all of which may have other causes. There is, therefore, a need for biomarkers related to the pathological changes, as well as new imaging approaches that can detect early stages of PD. Understanding the patient's disease stage is very important for prognosis, treatment and appropriate recruitment into clinical trials. Some recent clinical trials may have failed because the patients hasan advanced form of the disease or were misdiagnosed (lacking amyloid as a target) and therefore promising antibodies were likely to be "ineffective".

### Objectives and scope

- To design and impellent a system for early stage Parkinson's Disease Based on Resting-State Brain Networks and Deep Learning approach.
- To implement a system some synthetic as well as some real time dataset from IoT environments.
- To increase the prediction accuracy using DCNN and ensemble classification approach.
- To implement a system training module using both synthetic and real time data, which can extract both features for creating the Background Knowledge (BK).
- To implement and test a system in distributed and stand alone environment and analyze the different computation values.

### Problem definition

The proposed research works of brain analysis and AD/MCI detection. Our MCI detection model can extract functional connectivity features of the brain and distinguish the differences of brain images between MCIs and NCs. This could

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help us prevent and treat many challenging brain diseases early. In some existing approaches as well as real world its too much hard to identify the PD in early stage, this research work carried out the early stage detection feature for PD.

## IV. LITERATURE SURVEY

### Background

Parkinson's disease is an irreversible, progressive brain disorder that slowly destroys memory and thinking skills and, eventually, the ability to carry out the simplest tasks. In most people with Parkinson's, symptoms first appear in their mid-60s. Estimates vary, but experts suggest that more than 5 million Americans may have Parkinson's. Parkinson's disease is currently ranked as the sixth leading cause of death in the United States, but recent estimates indicate that the disorder may rank third, just behind heart disease and cancer, as a cause of death for older people. Parkinson's is the most common cause of dementia among older adults. Dementia is the loss of cognitive functioning—thinking, remembering, and reasoning—and behavioral abilities to such an extent that it interferes with a person's daily life and activities. Dementia ranges in severity from the mildest stage, when it is just beginning to affect a person's functioning, to the most severe stage, when the person must depend completely on others for basic activities of daily living. The causes of dementia can vary, depending on the types of brain changes that may be taking place. Other dementias include Lewy body dementia, frontotemporal disorders, and vascular dementia. It is common for people to have mixed dementia—a combination of two or more disorders, at least one of which is dementia. For example, some people have both Parkinson's disease and vascular dementia.

### Changes in the Brain

Scientists continue to unravel the complex brain changes involved in the onset and progression of Parkinson's disease. It seems likely that damage to the brain starts a decade or more before memory and other cognitive problems appear. During this preclinical stage of Parkinson's disease, people seem to be symptom-free, but toxic changes are taking place in the brain. Abnormal deposits of proteins form amyloid plaques and tau tangles throughout the brain. Once healthy neurons stop functioning and lose connections with other neurons, they die. The damage initially appears to take place in the hippocampus, the part of the brain essential in forming memories. As more neurons die, additional parts of the brain are affected, and they begin to shrink. By the final stage of Parkinson's, damage is widespread, and brain volume has shrunk significantly.

### Signs and Symptoms

Memory problems are typically one of the first signs of cognitive impairment related to Parkinson's disease. Some people with memory problems have a condition called mild cognitive impairment (MCI). In MCI, people have more memory problems than normal for their age, but their symptoms do not interfere with their everyday lives. Movement difficulties and problems with the sense of smell have also been linked to MCI. Older people with MCI are at greater risk for developing Parkinson's, but not all of them do. Some may even go back to normal cognition. The first symptoms of Parkinson's vary from person to person. For many, decline in nonmemory aspects of cognition, such as word-finding, vision/spatial issues, and impaired reasoning or judgment, may signal the very early stages of Parkinson's disease. Researchers are studying biomarkers (biological signs of disease found in brain images, cerebrospinal fluid, and blood) to see if they can detect early changes in the brains of people with MCI and in cognitively normal people who may be at greater risk for Parkinson's disease. Studies indicate that such early detection may be possible, but more research is needed before these techniques can be relied upon to diagnose Parkinson's disease in everyday medical practice.

### Moderate Parkinson's Disease

In this stage, damage occurs in areas of the brain that control language, reasoning, sensory processing, and conscious thought. Memory loss and confusion grow worse, and people begin to have problems recognizing family and friends. They may be unable to learn new things, carry out multistep tasks such as getting dressed, or cope with new situations. In addition, people at this stage may have hallucinations, delusions, and paranoia and may behave impulsively.

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**Mild Parkinson's Disease**

As Parkinson's disease progresses, people experience greater memory loss and other cognitive difficulties. Problems can include wandering and getting lost, trouble handling money and paying bills, repeating questions, taking longer to complete normal daily tasks, and personality and behavior changes. People are often diagnosed at this stage.

**Severe Parkinson's Disease**

Ultimately, plaques and tangles spreadthroughout the brain, and brain tissue shrinks significantly. People with severe Parkinson's cannot communicate and are completely dependent on others for their care. Near the end, the person may be in bed most or all of the time as the body shuts down.

**Techniques used**

**According to Gavin C. Cawley et. Al. [1] proposed the** effects of this form of over-fitting are often of comparable magnitude to differences in performance between learning algorithms, and thus cannot be ignored in empirical evaluation. Furthermore, we show that some common performance evaluation practices are susceptible to a form of selection bias as a result of this form of over-fitting and hence are unreliable. We discuss methods to avoid over-fitting in model selection and subsequent selection bias in performance evaluation, which we hope will be incorporated into best practice. While this study concentrates on cross validation based model selection, the findings are quite general and apply to any model selection practice involving the optimization of a model selection criterion evaluated over a finite sample of data, including maximization of the Bayesian evidence and optimization of performance bounds.

**According toYan Chao-Gan [2]** proposed a systemSPM and REST, DPARSF is user friendly
toolbox for "pipeline" data analysis of resting-state fMRI. It can help the users to save time for data processing and reduce errors in cumbersome setting of parameters. DPARSF can also create a report for excluding subjects with excessive headmotion and generate a set of pictures for easily checking the effect of normalization. This toolbox is freely available at http://www.restfmri.net. We hope this user-friendly toolbox could make the relatively novel technique of resting-state fMRI easier to study, especially for clinical studies.
According to Dong Hye Ye [3] proposed a system presents an image-based classification method, and applies it to classification of brain MRI scans of individuals with Mild Cognitive Impairment (MCI). The high dimensionality of the image data is reduced using nonlinear manifold learning techniques, thereby yielding a low dimensional embedding. Features of the embedding are used in conjunction with a semi-supervised classifier, which utilizes both labeled and unlabeled images to boost performance. The method is applied to 237 scans of MCI patients in order to predict conversion from MCI to Parkinson's Disease.

**According to Susanne Neufang et. Al. [4]** proposed a system effective connectivity of top-down attention control in patients with prodromal Parkinson's disease.We scanned 15 patients and 16 healthy elderly using the Attentional Network Task and determined effective connectivity within a cingulo-fronto-parietal network using Dynamic Causal Modeling. We related connectivity parameters to structural and behavioral parameters (gray matter volume as well as reaction time) to examine the relation between affected domains.

**According to Frederik Barkhof et. Al. [5]** proposed a system Resting-state (RS) functional MRimaging overcomes limitations of task-based MR imaging by probing multiple neuronal networks simultaneously during a 5–10-minute acquisition and reveals brain physiology. RS functional MR imaging can be used to identify alterations in functional connectivity in many neurologic and psychiatric diseases, even in neonates and in patients with coma or dementia. Data analysis techniques are still evolving from simple region of interest–based correlation analyses to data-driven methods, graph theory, and pattern recognition. Neurologic and psychiatric diseases are often characterized by complex alterations in the pattern of multiple functional networks, not only by single networks such as the default mode network.

**Tools used data set used**

- ADNI longitudinal data set for training as well as testing
- MRI measures Dataset
- Kaggle Dataset
- http://usa.ipums.org

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- http://cps.ipums.org
- http://international.ipums.org
- http://www.ihis.us
- http://www.nhgis.org
- http://www.atusdata.org
- http://usa.ipums.org

**Limitations research gaps**

- In most of existing algorithms having accuracy issues for detection.
- Many existing systems has not efficient for work on text as well as image data consecutively.
- The images go through many stages. Programming is difficult to achieve the same quality input for learning algorithms
- Many existing system provides poor performances and it do not directly provide probability estimates.
- Most of input Similar samples are not always near each other, so it can generate the misclassification issues.

**Table 1 : Experimental results and comparison discussion**

| Techniques | Advantages | Disadvantages | Specific Problem For Selecting The Techniques |
|---|---|---|---|
| Magnetic Resonance Imaging (MRI) | MRI is used for detecting and scanning of abnormalities in soft tissue like the cartilage tissues and soft organs like the brain or the heart | MRI scanners are very expensive. | MRI used to find changes in Tissue Atrophy. It is more specific in grey matter. |
| Positron Emission Tomography (PET) | Can help diagnose, treat, or predict the outcome for a wide range of conditions. | Radioactive material may cause allergic or injection-site reactions in some people. | It's used to find Changes in cerebral perfusion. |
| Single Photon Emission Computed Tomography (SPECT) | Tracing the blood flow and the metabolic activities are occurring and enabling of brain functions | Radioactive compounds quite expensive. | It's used to find Changes in glucose metabolism. |
| Non-Negative Matrix Factorization (NMF) | Reduce the large dimensionality of the input data. | Non negativity constraints can restrict correct clustering to only non-negative data. | NMF is used to find the reduced linear representations of non-negative data, being a useful decomposition tool for multivariate data. |
| Partial Least Squares (PLS) | Feature extraction is more effective for extracting the exactly correct information's from the data. | Measuring process more complex. | PLS yields a significant improvement in the out-of-bag error rate. |
| Gaussian Mixture Model (GMM) | GMM requires less feature vectors and produce good result. | GMM take time consuming and more samples. | GMM mainly for classical clustering and also used intensively for density estimation. |
| Neuropsychological And Functional Measures (NM) | NM was performed using a filter method. NMs are very separable between NC and PD groups | Different assessment procedures for nearly every patient. Different assessment procedures across different examiners. | NM achieved better prediction performance and good accuracy. |
| Principal Component Analysis (PCA) | Reduce the redundant features and large dimensionality of the data. | PCA only takes into account pair-wise relationships between | PCA used to extract the most significant features from a dataset. |

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|---|---|---|---|
| | | voxels of the brain images. | |
| Independent Component Analysis (ICA) | The ICA transformation is used for capturing groupdifferences from high order voxel relations, generating from the original average images sources. | Don't exist a criteria for determining how many components represent the dynamic of the data. | Basic concept is motivated by the theory of redundancy reduction. |
| Fuzzy C Means (FCM) | It's used to partition a finite collection of elements into a collection of fuzzy clusters with respect to given rules. | Segmentation is not clear and the noise is present in the image. | FCM algorithm considered as efficient clustering method. |
| Total Variation regularize Fuzzy C Means (TVFCM) | TV method eliminates the noise and makes the segmentation result better. | It has the stair casing effect, smooth, destroy, small scale structures with high bending edges. | The value of the regularizing parameter is select manually for the best segmentation result and also get the good visual quality of the image. |
| Anisotropic Diffused Total Variation Fuzzy C Means (ADTVFCM) | Mainly used to reduce image noise without removing the image content, edges, lines and other details of the image. | Clusters number specify first. | ADTVFCM is to eliminate the stair casing effect and reducing the time. |
| Constrained Gaussian Mixture Model (CGMM) | It capture the complicated spatial layout of the individual tissues. | Time consuming for taking the spatial information and decision making of data into consideration. | Each tissue Gray Matter, White Matter, CSF is modeled with multiple 4D Gaussians. |
| Dynamic NeuroFuzzy Technique | The natural rules representation make easy interpretation of the results. | It answers only to what is written in its rule base. | It's an effective method to segment the normal and mental tissues in the MRI brain images. |
| K-Means Clustering Algorithm | If variables are few, then K-Means faster than hierarchical clustering, if we keep k smalls. | It does not work well with clusters of Different size and Different density. | K-Means used to segment the abnormal portion on the datasets classified by its type, size, and number of clusters. |
| Random Forest (RF) | It's used to estimate the missing data and maintains good accuracy when a large proportion of the data's are missing. | It has the noisy classification with some datasets. | It's based on majority voting and produces good results. |
| Support Vector Machine (SVM) | SVM is a powerful classification algorithm. | It give poor performances and it do not directly provide probability estimates. | SVM for pattern recognition, classification and accuracy was good |
| K-Nearest Neighbour (KNN) | It's the simplest technique that provides good classification accuracy. | It has a slow running time. | Classification is satisfactory in terms of accuracy. |
| Artificial Neural Networks (ANN) | It can handle large amount of data sets. | The images go through many stages. Programming is difficult. Again to run the program, experts are not needed. ANNs are black-box modeling. | ANN is the biologically inspired by connections inside the brain used to carry information. |

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|---|---|---|---|
| Pulse Coupled Neural Network (PCNN) | It was originally presented in order to explain the synchronous neuronal burst phenomena in the cat visual cortex. | The problem of PCNN is properly setting the various parameters so that a uniform response is achieved over a set of imagery. | It's the ability to perform extraction of edges, texture information from images and image segmentation. |
| Self-Organizing Map (SOM) | Visualization of highdimensional data. It easy to understand. It's very simple. | Similar samples are not always near each other. | SOM has higher learning rate and less iterative time |

## V. RESEARCH METHOD

### Existing techniques

The existing approaches to PD diagnosis are thorough neuropsychological evaluation, patient interview, blood-sample analysis and imaging to exclude other, reversible forms of cognitive impairment. The use of CSF amyloid and tau analysis is a useful method because it provides information on specific protein changes in the brain, and is frequently used in Scandinavian countries. However, there is high inter- and intra-laboratory variation so the classical cutoff of pathological levels varies between centers performing the same methods. The major limitation of current approaches is that there are no useful markers of disease stage. Markers have been developed for brain atrophy, but the latter is not always present at early diagnosis. Other advanced methods like PET-amyloidal camera are not available in every clinical setting, which limits the accuracy of diagnosis. Outside of universities and neurological clinics, diagnostic methods are simpler and even limited, thus misdiagnoses are more frequent. The testing of other cognitive domains besides memory impairment is still not standardized for PD. Furthermore, the knowledge of neuropath logical processes in PD and normal aging are not entirely understood, especially in an elderly population where a similar clinical picture might have a different neurobiological background. We still have lot to learn from neuropathology. Earlier diagnosis is imperative, as it may enhance the ability to study disease course and clinical heterogeneity, predict the future and personalize treatment. We need a consensus approach.

### Experimental research

We have observed that for a classification model with different algorithms, the R-fMRI time series yields lower prediction accuracy compared with the correlation coefficients. Moreover, deep neural network outperforms other traditional methods given the same training features. The following two facts contribute to the improvement in classification. The proposed overview, multiscale analysis-based Hurst's exponents were used for the classification of healthy brain images versus PD by a SVM with fourth-order kernel. The obtained results show the potential of using multi scale fractal analysis to differentiate healthy brain images from ones affected by Parkinson's disease. Finally, although we have obtained better result than the literature in general, it is difficult to draw definite conclusions since we used a different image database.

## VI. CONCLUSION

In the proposed research work to design and implement a system using deep learning with brain network and clinical relevant text information to make early diagnosis of Parkinson's Disease (PD). The clinical relevant text information includes age, gender and ApoEgene of the subject. The brain network is constructed by computing the functional connectivity of brain regions using resting-state functional magnetic resonance imaging (R-fMRI) data. A targeted auto encoder network is built to distinguish normal aging from mild cognitive impairment, an early stage of PD. The proposed method reveals discriminative brain network features effectively and provides a reliable classifier for PD detection.

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