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A Survey on Detection of Neuro Degenerative Disorder with Tremor Signals Using Machine Learning

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ABSTRACT-

Parkinson's disease (PD) is a neurological disorder which increases significantly with age. With the progressive nature of PD, performance of voice gets degraded. Hence, dysphonia measures of tremor signals are used for detecting and tracking of PD symptom progression. Various studies reported that, speech is an earliest indicator of PD and 90% of PD patients suffer from some form of vocal impairment. Two approaches are proposed to track the Unified Parkinson's Disease score, thereby predicting the Algorithms and detect the severity level of the PD. Statistical and Regression techniques are used in the first approach to estimate the Risk score, elucidate monitoring the PD progression and tracking the UPDRS for a period of six month.

I. INTRODUCTION

With the advancement in IT sector, there has been a phenomenal increase in the accumulation of medical data. Many machine learning techniques have been applied and investigated on this medical data for the design of a diagnostic and prognostic system. In this section, the relevant techniques based on past work in design of diagnostic and prognostic system are discussed and detailed.

As people are getting many health problems in today's scenario, they are eagerly looking for good medical services. Due to increased usage of internet services, people are able and/or want to gather complete knowledge about any disease and also they want to know the correctness of their treatment. Also when a patient's case is complex and rare, doctors and medical practitioners need some expert's advice which would be given by an Expert system, which is one of the most widely used tools for diagnosing any disease and prognosis of any disease.

An expert system developed using machine learning techniques is used for various decision making tasks in medical field. The expert system used for screening, diagnosis and prognosis of breast cancer, diabetes and PD is based on classifiers. [14] This work is based on developing Artificial intelligence based diagnostic and prognostic system for PD.

The process of inferring the source of any anomalous or unpredicted behavior is referred as system diagnosis. [15] In any simple application, information about proper or improper functioning of a system is available during system operation. But, in any complex application, information about correct or incorrect behavior is observed directly or inferred from other parameters. This system behavior observation is termed as monitoring. In any system,the capability of monitoring is mandatory in diagnosing problems. [15]

Functional models, safety and mission assurance analysis, fault propagation models, failure modes, testability analysis and hazard analysis are the information collected in design phase and utilized in diagnostic applications. [15, 16]

In any system, with the knowledge of various failure modes and complexity of experimental data, a diagnostic system is designed using Artificial intelligence technique. [16] A comprehensive data analysis is done to generate a set of uncorrelated features that identifies various fault modes and the actionable knowledge to be applied for solving the problems.

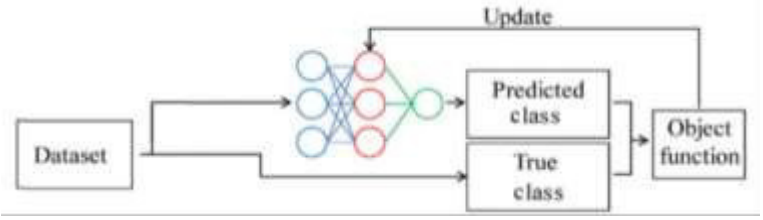

Figure 1 Basic Flow diagram of Parkinson Disease Prediction

Any diagnostic and prognostic system ideally performs,

- Fault Detection (Determining wrong things)
- Fault Isolation (Locating the place of fault)
- Fault Identification (Identifying what is wrong)
- Fault Prognostics (Finding how long the system works) [4]

A diagnostic system performs not only fault detection, but also fault identification and isolation. Hess et al [17] have proposed a working definition of prognostics as "the capability to provide early detection and isolation of precursor and/or incipient fault condition to a component or sub-element failure condition, and to have the technology and means to manage and predict the progression of this fault condition to component failure."

A prognostic system predicts the time at which a system or a component will fail and stop functioning. The prognostics system should not only detect the precursor of a failure, but also should predict, how much time remains for the occurrence of a failure. Among all the four tasks (Detection, Isolation, Identification and Prognostics), Prognostics is the most difficult one. [4]

One should be able to detect faults before diagnosing them. Similarly, one should diagnose them before the task of prognostics. In addition, to all the above four tasks, system should also include information about the decision to be taken for the corresponding failure. [4]

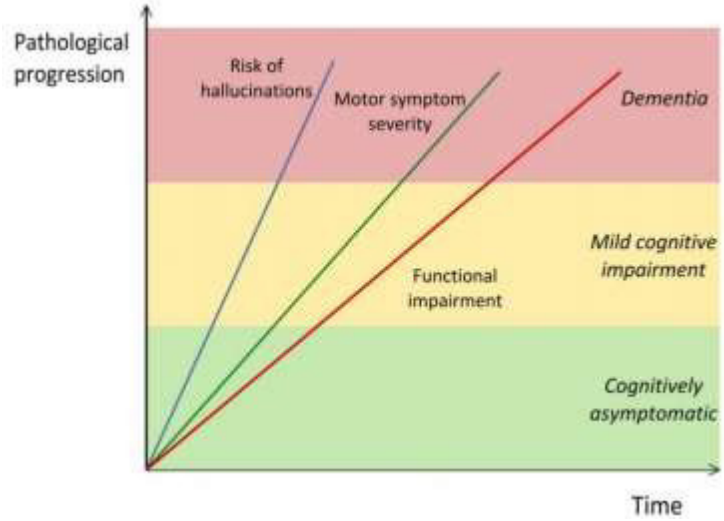

Figure 2 PD symptoms development over time

ARTIFICIAL INTELLIGENCE TECHNIQUES

Artificial Intelligence (AI) is the science and engineering of making intelligent machine especially intelligent computer programs. It is also the ability of computer software and hardware to do the intelligent things. The following are the activities in AI: Searching, Pattern recognition and Making logical inferences.

- Searching: Generating best solution in a large search space.
- Pattern recognition: Detection of object with similar characteristics, or finding new object with unknown characteristics.
- Making logical inferences: Finding inferences based upon the given hypothesis.

There are three approaches of AI for building diagnostics and prognostics system:

a) Rule Based Approach

b) Model Based Approach

c) Data Driven Approach

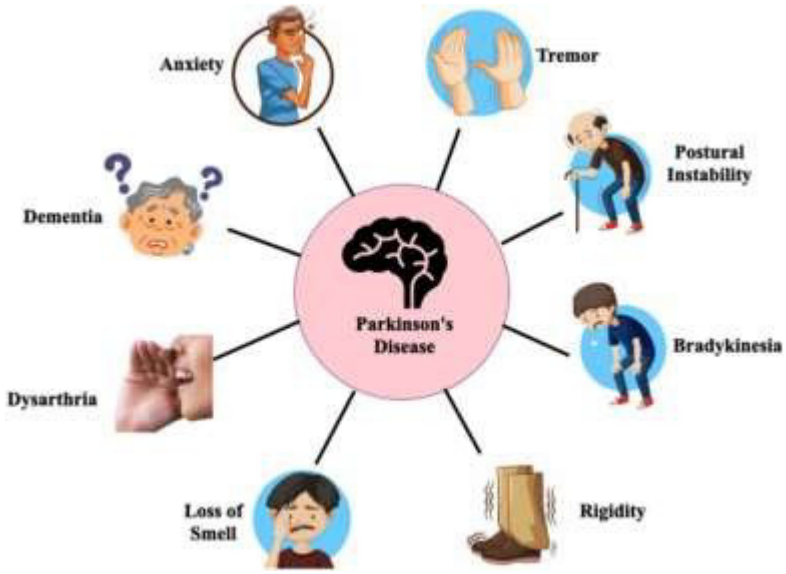

Figure 3 AI Based Parkinson Disease Detection

II. RELATED WORKS

(a) RULE BASED APPROACH

Many diagnostic systems are implemented using rule based approach. A rule is defined as the action(s) to be taken for the observed symptom. In this rule based approach, initially the procedures are split into many steps and are encoded in the form of rules. Then, a set of rules are imbibed into a rule-based expert system for generating the diagnostic solution. [15] The primary advantage of this approach is the available expertise and experience. The limitation is the non-availability of knowledge about the physical properties of the system or it is very costly to get the knowledge. The order of implementing the set of rules and determining the reliability, validity and completeness of derived rules are two challenges to be faced, in this approach and it follows top down approach. It is the process of testing the hypothesis. If the starting point is a goal or hypothesis, a backward chaining algorithm finds the set of rules that supports the hypothesis. [15]

(b) MODEL BASED APPROACH

Model based systems are more powerful because they rely on a deep understanding of the system. Model-based reasoning systems are inference methods in expert systems which are based on a model of the physical world. The expertise or experienced person who under- stands the physical, mechanical, data flow, or other details of the complex system develops the model based system. This approach takes more time to build the model. This model is quantitative or qualitative and it is based on mathematical equations or cause/effect models. In this approach, a suitable model is developed and then it is refined until it produces the de- sired results. In a model based system, human knowledge is encoded by a hand coded representation. In the hand coded model, only qualitative variables are used to define physical behaviour of the system. [4] This model is physics based system or AI based system such as fuzzy logic, neural network, etc. T. M Bearse applied fuzzy logic to compute a fault hypothesis in the model based diagnostic system. [18]

(c) DATA DRIVEN APPROACH

Data-driven approach refers to learning systems that are popular in cognitive modelling i.e modelling problem solving process. The system of data driven model is built directly from routinely observed system operating data. Learning systems are based on the following assumption: statistical characteristics of the data are stable, but for any fault event occurs in the system. [15] It does not represent physics of the modelled process, but builds the relationship between input and output variables. This model is useful for solving a problem when there is a considerable amount of data is available about the problem.

(d) SUPPORT VECTOR MACHINE (SVM)

SVM is a statistical classifier used for regression analysis. It analyses the system operational input data and recognizes patterns. [21] It is also referred as non-probabilistic binary linear classifier. SVM is often used for solving the multi-label class classification. When SVM is interleaved with other classification techniques to reduce the number of dimensions, it works effectively and contributes good result. [23]

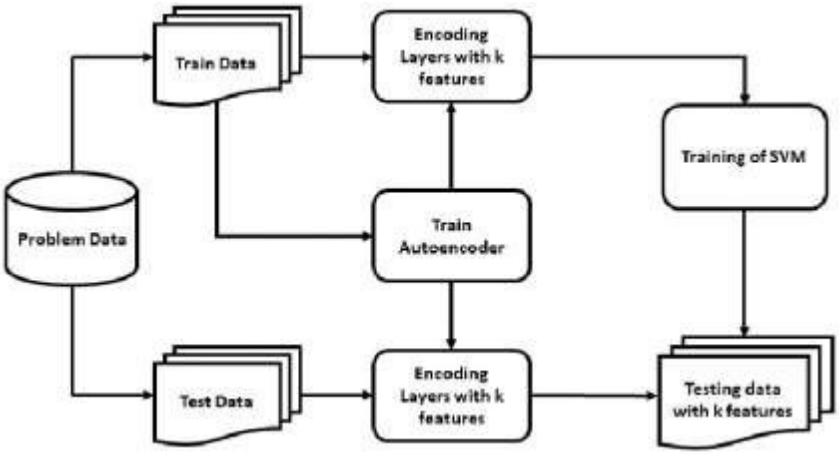

Figure 4 SVM Architecture

(e) K-NEAREST NEIGHBOR (KNN)

KNN is the instance based neighbor learning classifier which uses the instance to represent what is learned rather than inferring a rule set. [19] In this method the classification of object is based on the nearest training examples in input data space. It is a case-based learning technique introduced by Covert and Hart. This algorithm is based on a nearest distance such as Cosine similarity measures, Euclidean distance, etc.

It uses the training data to find the first k objects which are nearer to the new object. Then the most frequent class among those k objects is assigned to the new object. An object is classified by the majority vote of its adjacent object.

It is a non-parametric method, can be implemented easily and works effectively. Hence it can be applied in many applications, however, the difficult part is determining optimal value of k and also it takes more time for classification. With k=1, the training data distribution and prior probability are considered and with k=N only the prior probability of the class determines the class label. Also larger value of k reduces the effect of noise on the classification, but makes boundaries between classes less distinct. The best choice of k depends upon the data and a good k can be selected by various heuristic techniques.

The limitation of KNN is that all the features are used for computing distance between measures. Among all the attributes, only some attributes are more useful for classifying the instances and others are not relevant attributes. This limitation can be overcome by using weightage method. In Instance based learning, the key problem is finding the apt weights for the attributes from the training set. To overcome the drawback, Weight Adjusted k-Nearest Neighbor classification algorithm which is based on the KNN classification method is pro- posed.

The interleaving of SVM and KNN, a new classifier is proposed to improve the accuracy of the classifier. This new classifier performs well on balanced data. [23] It is sensitive to unbalanced training samples and the performance of the classifier declines significantly.

(f) NAIVE BAYES

Naive Bayes method is a module classifier under known priori probability and class conditional probability. It is finding the probability that document D belongs to class C. It is easy to implement and specifically used for pre-processing the data i.e. vectorization. [19] This method can be improved by finding dependencies among attributes. High correlation among the features leads to poorer performance of the naive bias classifier.

(g) BAYESIAN NETWORK

Bayesian network consists of directed acyclic graph with conditional probability tables annotating each node. [20] Each node in the graph is in one-to-one correspondence with feature (variable of interest in the problem domain) and arcs represent the relationship between variables. A feature (node) is conditionally independent from its non-descendants. Given two nodes (X1 and X3) and X2 is descendants of X1 and X3, then X1 is conditionally independent from X3. This classifier is not suitable for datasets with many features as creating a very large network is infeasible with respect to space and time. [20]

(h) DECISION TREE INDUCTION

This method follows greedy approach in which the tree is constructed recursively in top down fashion. The tree is constructed using 'divide and conquer' strategy. [19] This method is a NP-complete problem. CART, HUNT, C4.5, SLIQ, ID3 and SPRINT are some of the algorithms used to construct decision tree. The two phases in the construction of decision tree are Growth and Pruning phase.

In the first phase, a perfect tree is accurately constructed ensuring the classification of every record in the dataset. Initially, the tree starts with a single root node that represents the entire data set. For every partition P which contains set of records, a test criterion T is determined for further partitioning. Based on T, partition set P is further split into sub-partitions P1, P2….Pm and new nodes are created for every sub-partition, and then added to the decision tree as a child node of P. The node P is labelled with test criteria T and partitions P1, P2…Pm are further partitioned recursively in a similar way. A partition in which all the records be- longs to same class is not partitioned further, and the leaf node corresponding to it is labelled with the class.

However, an imperfect, smaller decision tree often achieves greater accuracy than a perfect tree. The reason is that this perfect decision tree is highly sensitive to statistical irregularities of the training dataset. Hence pruning (delete nodes iteratively), the second phase, is per- formed after the construction of a tree to obtain an accurate tree than a perfect tree.

A decision tree T1 is said to over fit training data if another tree T2 exists that has a larger error than T1 when verified on the training data, and smaller error than T1 when verified on the entire dataset. [20]

(i) BACKPROPAGATION NEURAL NETWORK

This algorithm works on multilayer feed forward network. Backpropagation neural network improves the accuracy of neural network classifier. High tolerance to noisy data and the capability of recognising the new object are the benefits of neural network techniques. With its capability of pattern recognition, neural network techniques are also applied in fault detection. [22]

The drawback of neural networks is that the learned knowledge which is in the form of weights is difficult to understand. Another drawback is that, neural network don't explain the reasoning. The neural networks don't recognize the way the problems are solved and are able to identify only few patterns. In total, the neural networks function is referred as 'black boxes'.[22]

(j) LINEAR LEAST SQUARES FIT

It is a mapping approach developed by Yang. The training data are represented in the form of input/output vector pairs where the input vector is an object in the conventional vector space model and output vector consists of categories of the corresponding object. It is one of the most effective classifiers but the computational cost is much higher. [20]

(k) GENETIC ALGORITHM (GA)

GA is an evolutionary approach and a stochastic search algorithm. It is based on natural selection process. [24] It generates chromosomes, a new population of strings from old ones in an iterative manner. A fitness measure is assigned to every string by an evaluation function which indicates its fitness for the problem. Selection, crossover and mutation are the genetic operators applied on the initial population to generate the entire new the initial population to generate the entire new strings. The probability of an individual chromosome is directly related to the goodness of the solution. Hence, the quality of the solution is improved successively until an optimal solution is obtained. Once the optimum solution is found the process gets terminated.

GA is a global search algorithm work on the principles of evolution. For a given problem, GA will examine each individual from the population as a potential solution. In addition, mutation factor modify the existing solutions randomly. It helps the GA to come out of local minima, thus aiding the search for a globally optimum solution. GA approach is an alternative to traditional machine learning algorithms because of their poor computational performance in large search spaces. With the benefit of excess large search space, GA solved many intractable problems.

III. CONCLUSION

From the literature review, the following limitations are identified. There is almost no re- search in the field about appointing the score of PD risk. The present system has determined the statistical mapping between the dysphonia measures and UPDRS score, but not piece- wise. The existing system does not provide errors effectively and does not identify the parameters of effectively and does not identify the parameters of dysphonia measure that influence errors. Also the existing diagnostic system of PD is based on the machine learning techniques and they lack in interpretation of the result and can't handle uncertain, vague or imprecise information present with a huge size of medical data. In few studies, fuzzy logic is adopted to address the above problem, but leads to more number of fuzzy rules. An increase in the size of the knowledge base decreases the rule access rate, and degrades the system performance. One more limitation in the existing system is: all the attributes of dysphonia measures are to be tested to derive the conclusion.

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