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Dementia Prognostication using Machine Learning

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Abstract: ***Since the introduction of Machine Learning in the field of disease analysis and diagnosis, it has been revolutionized the industry by a big margin. And as a result, many frameworks for disease prognostics have been developed. This paper focuses on the analysis of three different machine learning algorithms – Neural network, Naïve bayes and SVM on dementia. While the paper focuses more on comparison of the three algorithms, we also try to find out about the important features and causes related to dementia prognostication. Dementia is a severe neurological disease which renders a person unable to use memory and logic if not treated at the early stage so a correct implementation of fast machine learning algorithm may increase the chances of successful treatment. Analysis of the three algorithms will provide algorithm pathway to do further research and create a more complex system for disease prognostication.***

Keywords: Machine Learning, SVM, Neural Network, Dementia, Naïve Bayes

I. INTRODUCTION

As current disease diagnostics systems have grown so has the number of labels in which they are classified, such that now we have a separate field related to disorders of brain and sensory motors known as Neurodegenerative Disorders. It influences our cerebrum and engine works legitimately and leave one unequipped for performing various actions. These compromises include intelligent thinking issues, recalling names and numbers, and so on. And yet methods for early expectations of these infections have created at a similar pace and one such strategy is Machine Learning. These algorithms which when coordinated with deep learning and Artificial Intelligence can bring about a compelling disorder indicator. As Machine Learning centers around the advancement of intelligent programs that can access past information and use it to learn for themselves, we can utilize distinctive Machine Learning models to gain from past symptomatic information and make an ideal forecast model. The neurodegenerative malady is an umbrella term for a scope of conditions which principally influence the neurons in the human mind. Neurons are the structure squares of the sensory system which incorporates the cerebrum and spinal rope.

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Neurons ordinarily don't replicate or supplant themselves, so when they become harmed or pass on, they can't be supplanted by the body. Instances of neurodegenerative sicknesses incorporated in this paper is Dementia. Neurodegenerative sicknesses are hopeless and incapacitating conditions that outcome in dynamic degeneration and/or the passing of nerve cells. This causes the basic environment for growth of ataxias or dementias. With Disorders related to the brain, the damage is usually irreversible so an early detection may help in preventing long-term damage and may even help in curing the disorder. The techniques accessible for the discovery of these disarranges are particularly structured tests which incorporate penmanship examination, coherent test, mind filter and utilization of diverse Machine Learning algorithms. Here we test out 3 different algorithms for model classification and testing Neural network, Naïve Bayes and SVM.

II. MATERIALS AND METHODS

The workflow of our research consists of following steps: pre-processing data, data visualization, Machine Learning Model classification and Analysis. First, we describe our validation and training set. Next each of the steps in the pipeline process will be explained in more details.

A. Training and Validation data

The data is ADRC clinical trial data, which is provided by OASIS open Source Central library. The data contains values of different test results like MMSE test, memory testacid value and many more. The data is split with the ratio of 7:3 for training and testing respectively. The initial analysis on the data provides info about the trends and value range of different parameters. The initial analysis divides the result classes into Cognitively normal, AD Dementia and Uncertain Dementia while giving Gender, MMSE, age at entry, CDR, judgment, memory, orient, height and weight as features.

B. Pre-processing Data and Data Visualization

Data pre-processing includes imputing missing values, Standardization of data and analysing data with different seaborn and matplotlib graphs.

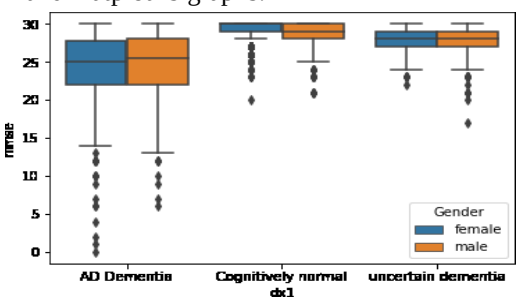

Fig. 1 Box plot distribution of output class

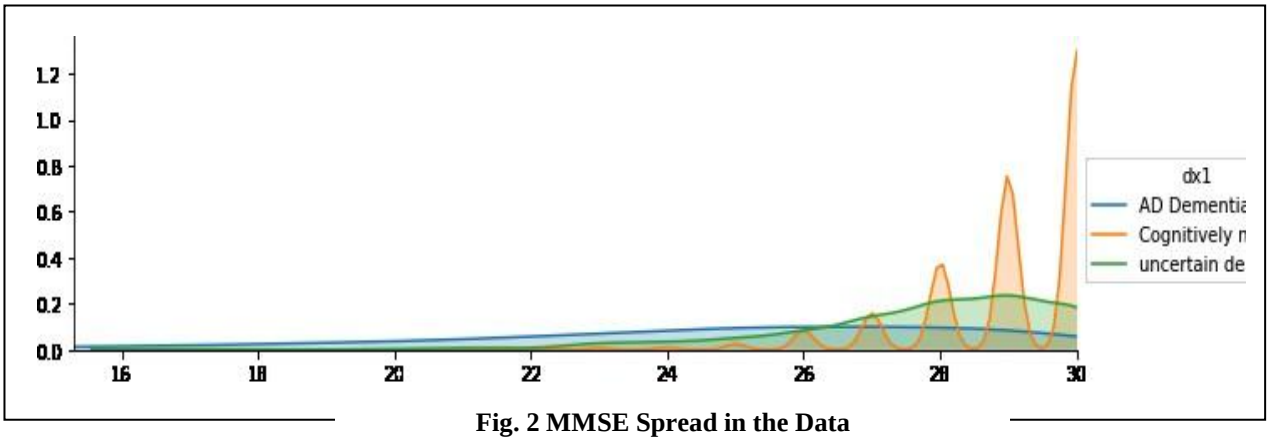

Fig. 2 MMSE Spread in the Data

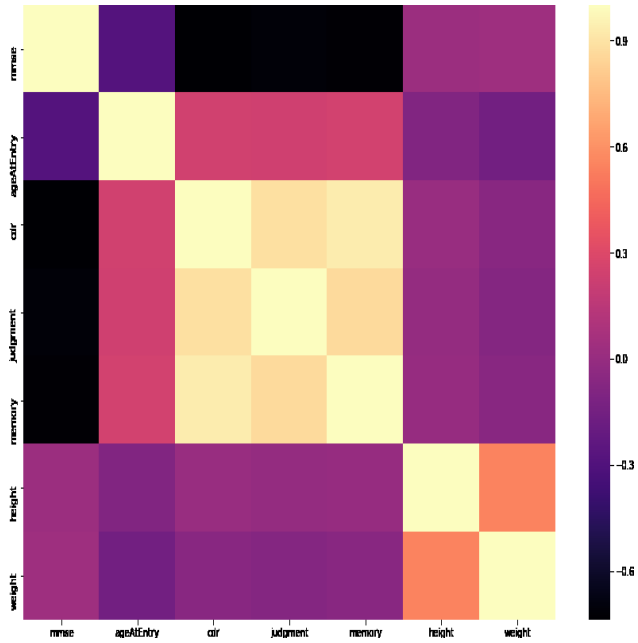

Fig. 3 Heatmap depicting correlation of features

C. NAÏVE BAYES

Naive Bayes classifiers is a collection of classification algorithms based on Bayes' Theorem. It is not single algorithm rather collection of algorithms where they share a standard principle, i.e. every pair of features being classified is independent of every other. The assumption made by Naive Bayes is that every feature is independent and equal.

D. SVM

SVM is one of the types of supervised learning algorithm that is used for both classification or regression but commonly used for classification purpose only. In this algorithm we have two different set of categories of data set. When an input is given to this algorithm the out given by SVM is the data set

To answer this question, we have to learn the concept of margin. For a given hyperplane choose a data from one data set which is closet to other data set and vice versa. Now draw a line just touching the two chosen data from the data set and calculate the distance between them. This is known as margin. Repeat this process for different hyperplane and choose the hyperplane which has the largest value of the margin.

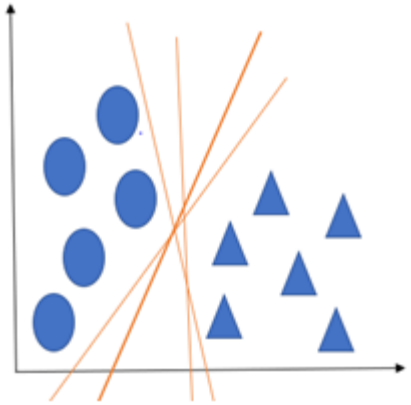

Fig. 4 SVM working mechanism

E. Artificial Neural Networks

ANNs also known as connectionist systems are developed on the basis of biological neural networks. These systems learn how to do the given tasks by mainly learning through the experiences. An ANN is simply based on perceptron or neuron model. Perceptron Mathematical Model is given by:

$$(x) = a_0 + \sum_{n=0}^{n} (a_i * b_i)$$

to which the given input belongs.
it's assumed that we have two types of data sets named as triangle and circle and we have two types of features viz x and y. Now we to find for the input pair (x, y), whether the input belongs to triangle or circle. Before processing further,

Where,

a_o = bias a_i = input b_i = weight

we have to separate the two types of data sets. For this we draw a hyperplane. We can see that we can have more than one hyperplane so now the question arises, which hyperplane should we choose?

Activation Function: In ANN, an activation function of a node defines the output for that node foe a given set of inputs. Sigmoid function: In general, we don't have only two outputs
i.e. 0 or 1. So avoid this problem we use this function which is more dynamic in nature.

F. *MMSE (Mini – Mental State Examination)*

The MMSE (also known as Folstein test) is a test which tells about the disease dementia. It consists of 30-point or score in which the health professional asks the patient several questions. The questions can be framed in various ways such as – memorizing the names of certain things and repeating the names of few things after some period of time, few simple calculations, check whether the patient is following the orders or not etc. It can also be used for checking the seriousness of the disease so that necessary action can be taken in time to avoid further damage.

In the following table, the MMSE score value depicts different stages or rather different levels of the disease dementia: -

III. RESULT AND DISCUSSION

A. *Naïve Bayes*

Table 1 Depicts MMSE test range

MMSE Score	Level of Dementia
20 – 24	Mild Dementia
13 – 20	Moderate Dementia
Less than 12	Severe Dementia

G. *CDR (Clinical Dementia Rating)*

The CDR consists of 5-point scale which is used to characterize six different fields for the disease dementia. The six different fields are -Orientation, Memory, Judgment, Problem Solving, Personal Care, Community Affairs, Home & Hobbies. The following table shows the CDR values along with the level of dementia:

Table 2 Depicts CDR Range

CDR Value	Level of Dementia
0	Normal
0.5	Very Mild Dementia
1	Mild Dementia
2	Moderate Dementia
3	Severe Dementia

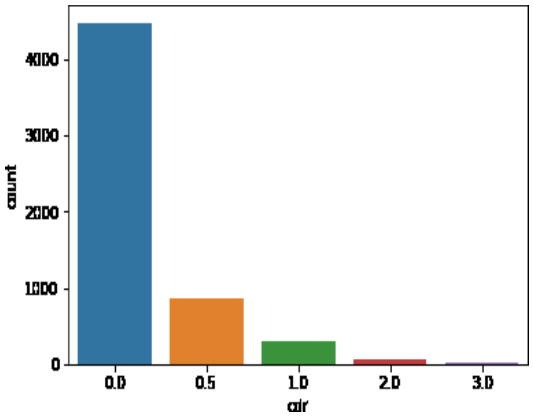

Fig.5 CDR spread in the Data Set

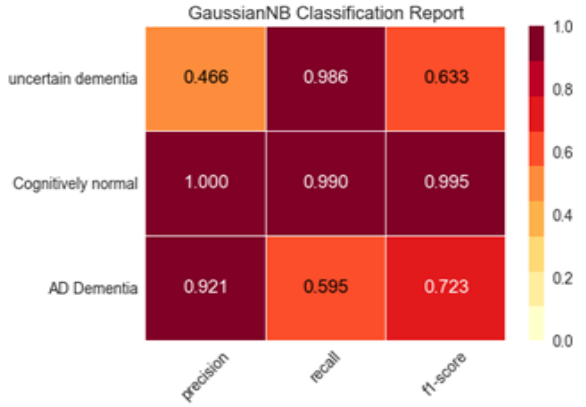

Fig. 6 Classification report for Naïve Bayes

The Naïve Bayes classifier provides 93% F1 score, 92% precision and 92% recall. The Naïve Bayes classifier is fast and simple with little to no customization needed and works on big data set comfortably.

B. *SVM*

0-Uncertain Dementia 1-Cognitively normal 2-AD Dementia

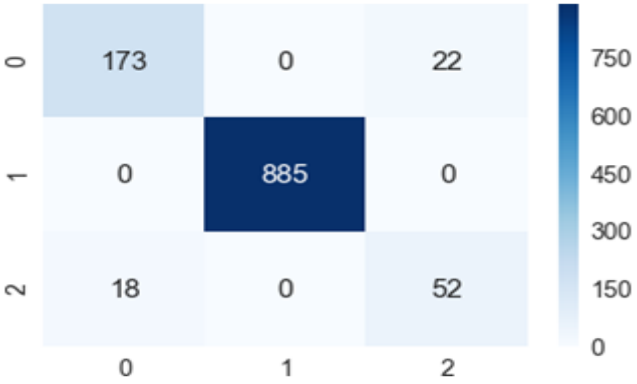

Fig.7 SVM Confusion Matrix

The SVM classifier provides The Naïve Bayes classifier provides 97% F1 score, 97% precision and 97% recall. The SVM classifier is effective but requires a lot of customization and it is not suitable for big data set.

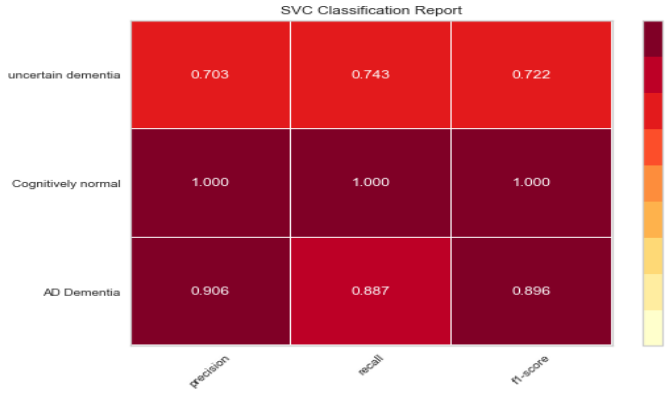

Fig-8 SVC or SVM classifier

C. Neural Network

The neural Network also provides 97% accuracy in all of the metrics but it has more wrong predictions than the SVM data set. It is highly customizable and effective.

	precision	recall	f1-score	support
0	0.93	0.89	0.91	254
1	1.00	1.00	1.00	1169
2	0.74	0.81	0.77	95
avg / total	0.97	0.97	0.97	1518

Fig. 10 Classification Report for Neural Network

0-Uncertain Dementia 1-Cognitively normal
2-AD Dementia

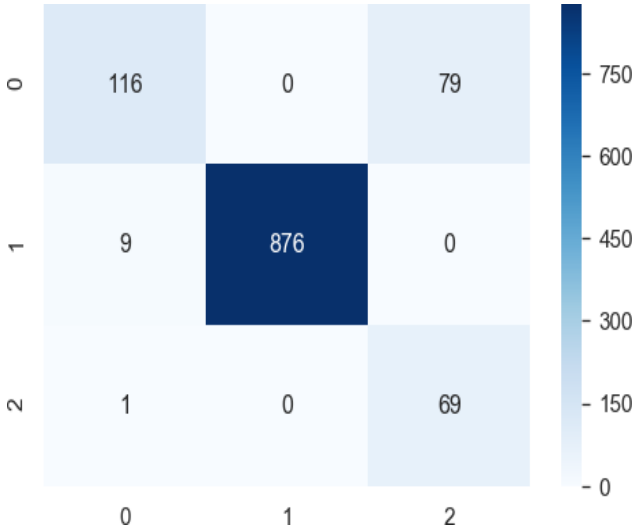

Fig. 9 Neural Network Confusion Matrix

IV. CONCLUSION

It is concluded that Neural Network is the most customizable and is fast and efficient on big data. SVM is highly effective but mostly useless for big data set as it requires a lot of time to execute. While Naïve bayes is lower in efficiency it is simple and fast.

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