

Detection and Categorization of Patients Having Alzheimer's Disease: Machine Learning Algorithms

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Abstract. Alzheimer's illness is a condition that gradually impairs memory and other important brain functions. The reason for this is because the connections between brain cells and the cells themselves deteriorate and die, producing memory loss. There is no cure in the world for this disease, but medication and some other strategies, activities, games, etc. may help in improving the symptoms. This research Alzem-cure will help in detecting, predicting, and analyzing the AD. Logistic Regression is implemented in order to achieve the aforementioned tasks. A front-end where patients can submit their attributes' regarding Alzheimer's is made which will result in predicting whether the patient is demented or non-demented. Furthermore, in the front-end various activities, games and tasks are mentioned which significantly results in improving the symptoms of the patient and keep them calm and positive all day long.

INTRODUCTION

Alzheimer's illness is among the most prevalent forms of dementia. Memory, language, and thought are all controlled by the areas of the brain implicated in Alzheimer's disease. The people who are beyond age 65 are more prone to have this disease. It is much less common for younger people to get AD, although the cause for why younger people gets affected with this disease is not limpid. Beyond age 65 the number of people having AD doubles every 5 years.

The prime known risk factor for AD is age. Although it's not clearly understood what causes AD. There are distinct factors which can affect different persons differently. Also, the development of neuronal connections and cortical patterns inside of a patient's brain are corelated with the geometric measures as well [1].

Due to AD, there is a chance of mental symptoms like aggression, anxiety or depression which can make the conditions worse. Hence, in these conditions necessary care of the patient is taken. The patient is always kept busy and involved in some or the other things so that the patient is always calm and there is no mental stress on the patient.

This is done by making the patient play some mind games like puzzles, chess, bingo sudoku, solving cross words etc.

The patients are made as social as possible by making them participate in dancing, singing etc. competitions.

The patients are motivated to do things they are good at and always kept happy as much as possible.

AD can be cured by such therapies over drug-based cure prescribed by doctors as there are also side effects of drugs on some people and it is always better to implement methods which would keep the patient away from side effects.

In this paper we have discussed on a website Alzem-cure which consist of games, puzzles, motivational quotes, and mind engaging activities which will keep the AD patients involved in some mind engaging activities.

LITERATURE REVIEW

Random Forest is used for detecting and predicting AD with a good cohort robustness, this paper was published in August 2014. Two significantly large databases have been used. Here they have trained the AD and healthy control classifiers. Tuning and performance assessment was done in training. They were successful to produce accurate and robust models across different cohorts. Random Forest model performed with higher accuracy as compared to linear support vector machine.

They have used high-dimensional inputs for their classification and prediction work. Those algorithms also resulted in equivalent performance. The MCI to Alzheimer's disease conversion amid two years before the inception of Alzheimer's disease was also predicted by the classifiers trained. In this study they got the best accuracy.

They were successful to show that geometric measures are interconnected with the development of cortical connectivity patterns and neuronal connections [1].

Alzheimer's disease (AD) is most common cause of age-relative disorder, it is one of the cause of deaths all over the world. That's why detecting AD has turn out to be an important task. Many current techniques for diagnosing Alzheimer's are costly or encroaching.

So, this paper investigated the usage of indices to identify Alzheimer's patient in a sample of few Alzheimer's patients and Control Subjects. And based on MMSE outcome, patients were divided into Three groups, Mild, moderate, and severe.

BPW short for Blood pressure waveform and PPG short for Photoplethysmography were non-invasively measured in AD patients, and the Heart rate was also measured.

After that, they did the analysis in 2 parts using,

1) Signal processing by determining the pulse wave forms and it is performed in MATLAB.

2)The second part consisted of Information processing, from the results of first part the features of pulse signals were collected, it is performed using python and MLP short for machine learning platform to categorize the statistics.

This study indicates significant differences between Alzheimer's patients and control subjects. Therefore, this paper proves that these indices can be used to identify Alzheimer's illness [2].

In order to effectively treat patients with Alzheimer's disease, especially in the initial stages of the condition, accurate diagnosis is essential. This is due to risk awareness, which enables patients to take protective measures before permanent brain damage develops. Deep learning (dl) has established itself as the gold standard for the earliest diagnosis of Alzheimer's disease. In this work, related studies using MRI data, ML, and DL methods, and datasets related to Alzheimer's disease were examined. Section III of the paper details the shifts between machine learning (ml) to deep learning (dl) in the AD sector. In this study they have reviewed few of the detection and diagnosis techniques and some AD datasets as well. The approach they specify is suitable for the neuroimaging research [3].

M. Tanveer et al. has reported a paper in April 2020 in which they have done a detailed study of the efficient automation technology necessary for early detection of Alzheimer's illness. It uses a variety of feature extraction and machine learning algorithms to provide reviews of 165 papers from 2005 to 2019. They have surveyed the machine learning algorithms in three major categories: vector machine (SVM's), Deep Learning (DL) and Artificial Neural Networks (ANN) [4].

Diagnosis of Alzheimer's illness is very significant in treating patients at an early stage because it can help patients take some precautions before irreparable brain damage. The need of variety of medical tests and vast amounts of multivariate heterogeneous data makes manual comparisons, visualizations, and analysis extremely hard.

There are some Brain imaging techniques Like MRI short for Magnetic Resonance Imaging for Alzheimer's illness. MRI uses magnetic fields and radio waves to capture high-quality, high-resolution 2D and 3D pictures of the cerebrum that are further used to detect AD.

The second technique is PET short for Positron Emission Tomography. It uses radiotracers and brain activity is being studied as a radio sphere.

Third Technique is the MRI biomarker of AD, regarded as the medical signs on a patient or we can say as the external exemplification of the patient's medical condition. There are three types of biomarkers OF AD - Biochemical, Genetic and Neuroimaging.

Machine learning was used in past to determine and predict MRI biomarkers. Deep learning involves two levels of abstraction and expression for understanding text, audio, and images. Deep neural networking can also be used for bioimage dataset here, but requires a huge amount of data, and for this issue, data augmentation is used. CNN which is short for Convolutional Neural Network is also used with fine-tuned pre-trained DL model, CNN uses layers for training and testing.

Different datasets can be used such as ADNI which is drawn from more than 40 radiology centers, Harvard medical school dataset, OASIS (Open Access Series of Imaging Studies, etc. [5].

Rafi U. Haque et al. published an article in which they discussed the clinical viewpoint and research potential. A degenerative neurological condition called Alzheimer's disease is the primary cause of insanity and the sixth highest cause of death worldwide. Work on the molecular processes underpinning amyloid- and alphabetic character disease has made significant advances in our knowledge of AD during the last two decades. Despite this advancement, there are no disease-modifying medicines for Alzheimer's illness, a dilemma that may be exacerbated by the disorder's growing costs and prevalence. Additionally, comprehensive counselling to address the crippling psychological and behavioral issues is critical.

In order to fully understand the inherited and environmental/lifestyle components that help to the pathology of Alzheimer's disease, this point of view emphasizes use of such anthropoid primate (NHP) paradigms to connect the molecular, circuits, and behavioral levels of study. These inquiries are still underway [6].

Deep learning (DL) is an approach which has been exceptionally good. Its performance has been better than traditional machine learning, mainly in the area of computer vision. Using deep learning to detect initial symptoms and instinctively classifying Alzheimer's illness is gaining awareness, due to advancement of neuroimaging data has become multivariate

In order to diagnose and categorize Alzheimer's illness, a thorough analysis of published reviews utilizing deep learning methods and neuroimaging data was conducted. The results of these research were collated, evaluated, and categorized according to the kind of neuroimaging they employed. Four of the 16 review meetings that held full integration criteria employed both deep learning (DL) and traditional machine learning (ML), whereas the other 12 used solely deep learning.

Orthodox Machine Learning in order to classify and for feature selection's combination gave accuracies of up to 98.8% for Alzheimer's illness categorization. For the classification of Alzheimer's disease (AD), convolutional neural networks or recurrent neural networks, which use neuroimaging data for selecting features, have accuracy rates of up to 95%. The combination of multimodal neuroimaging and fluid biomarkers proves to give the best performance for classification. Approaches of DL pursue to better the performances and seem to have encouraging outcomes for diagnostic categorization of Alzheimer's Detection by using multivariate neuroimaging data. Alzheimer's Detection research that uses deep learning methods are still in works, improvement in performances by using further hybrid data types is still in development [7].

As we know nowadays people are working so hard, they develop anxiety, pressure, tension, and stress. This could trigger Aggression, agitation in the demented people. There are various things which can calm people with dementia, things like exercising, meditating, taking brain challenges, and changing diets. There are also many dementias friendly activities that help those people to calm down and release their stress. But before actually starting with the activities we should keep some points in mind which could trigger them, first we should avoid pointing out what they can no longer do, we should also develop a support circle for the demented person (family and friends), we should let them socialize.

We should also keep in mind the about the ability and skills of the person, focusing on the enjoyment and be aware of the physical limitations of the demented person.

There are various stimulating activities for dementia patients, including as

1. Playing chess, card games, solving cross words, jigsaw puzzles, Sudoku, Bingo, these are some mind games that helps the demented person to relieve their stress and they also boost confidence.

2. Dancing, chair exercise, yoga, meditation, nature walks, play with a pet, these are some physical activities which helps to relieve the demented physically and it also keep them happy.

3. Listening to music, singing, reading books, and listening to different stories, drawing, and painting, jokes, these are some activities which we can do with the loved ones, and this can bring up some special memories with loved ones and help in staying calm and reduces agitation and aggression [8].

This blog provides information on the most effective ways to control dementia-related agitation. It reveals that psychological and behavioral symptoms are prevalent in dementia, and it affects many people suffering from dementia. Due to dementia those people can also suffer from agitation. Aggression, anxiety, and depression. Due to this behavioral changes people become aggressive and for this doctor prescribe medication to manage behavior but

these medications can have many side effects as well. It can cause other medical problems too. According to a recent survey (Competitive Efficacy of Treatments for Violent and Flustered Behavior patterns in Dementia), non-drug therapy is more successful, <https://doi.org/10.7326/M19-0993>) looking at more than 160 articles researcher found that non-therapies are more effective. For physical aggression outdoor activities helpful, for verbal aggression different therapies reading, singing like activities are helpful. For mental state, different mind games are considerate. This Article also have tips for caregivers to decrease agitation and aggression in demented person. These tips include giving different types of relaxing therapies, going for walk, reading books, listening to music, getting creative [9].

METHODOLOGY

The prime objective of this research is to detect and predict if the patient has dementia or not. For this the data used in the research is of **Oasis**. The data contains **374 rows** and **15 columns**.

Tools for implementation of reading and operating on data are NumPy, pandas. The data frame's structure allows for the patient's classification into two classifications with dependency of 10 parameters. For visualization, matplotlib, seaborn, cufflinks and plotly is implemented.

Analysis started with cleaning of data. The dataset had three categories under the group column namely, '**demented**', '**non-demented**', and '**converted**'. Before implementing anything further, the '**converted**' data points were replaced with '**demented**'.

The class count of 0 i.e., non-demented **exceeds 175** and class count of 1 i.e., demented is **less than 155** as shown in the count plot.

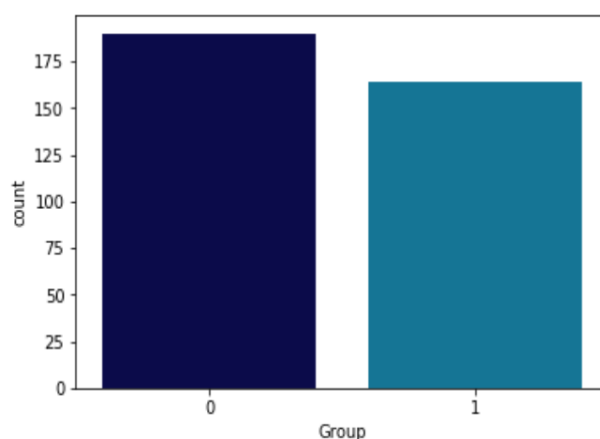


FIGURE 1. Count Plot

Dividing the data into training and testing, separating the characteristics and target columns (class), and keeping the test size at **0.3**.

For classification Logistic regression is implemented. The accuracy score tends to differ according to the testing data therefore, cross validating the accuracy score of 10 data samples was significant.

Next Decision Tree Classifier was implemented. Performed Grid Search CV. Hyperparameters were tuned, the model was fitted again giving the endmost accuracy score for the Decision Tree Classifier.

Checking for feature importance in order to get the insight on which feature holds the utmost importance. The features are then broken down into components and variance using Principal Component Analysis. Predictions and the actual class that provided the final report were compared.

In front-end the languages used are namely Python, HTML, CSS. Django is used for making the form in which patients will be able to submit their parameters which was then integrated with the back end i.e., the Logistic Regression model using pickle module.

FIGURE 2. Overview of the form

Then further when the patient submits the data, they are redirected to another page based on the prediction the model gives. For instance, if they are categorized into demented category, they will be redirected to the high-level dementia page similarly if they're categorized into non-demented category, they'll be redirected to the low-level dementia page. Both the pages contain activities, games accordingly for the patient, to keep them happening and positive all day long.

RESULTS AND DISCUSSION

The study's findings include an analysis of incorrectly classifying dementia and non-dementia as dementia and the classification of data related to Alzheimer's disease using machine learning. The accuracy score following cross validation in the Logistic Regression Algorithm implementation is **0.95**. Below is a heat-map of the confusion matrix with relatively few miss-classified values.

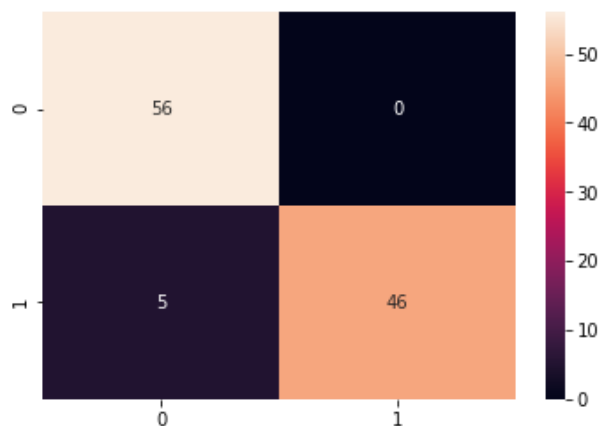


FIGURE 3. Heat map of confusion matrix showing classification logistic

For classification using decision tree, criterion Gini gives the best accuracy score for decision tree classifier. Accuracy score after implementing decision tree classifier is 0.906. After tuning hyper parameters of decision tree, accuracy score we got is 0.91. Importance of the parameters using decision tree states that the parameter CDR has highest importance i.e., 0.42.

[[32 1]
[7 31]]

In this study the importance of features in the dataset was checked. The results of which showed that the features CDR and MMSE i.e., mini-mental state examination was more than the rest of the features.

The low-level and high-level dementia pages includes games and a couple of activities which will help the patient with improving their memory, also help them stay calm and positive.

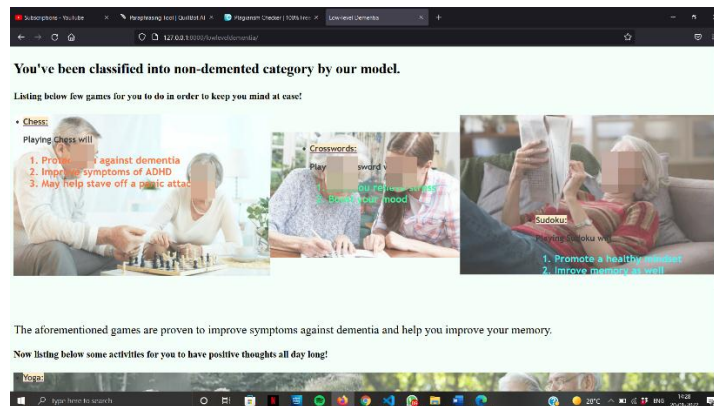


FIGURE 4. Low-level dementia page

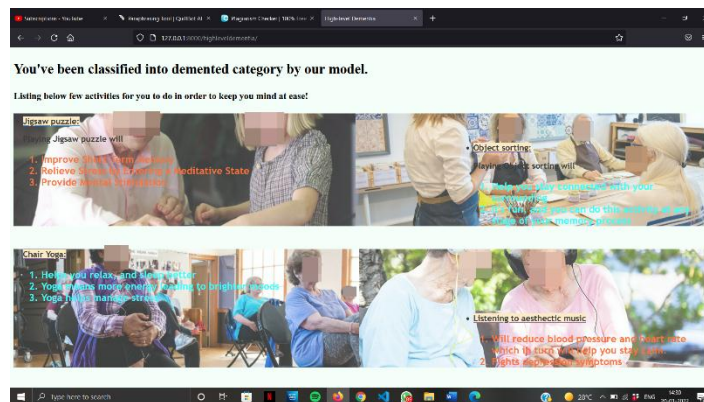


FIGURE 5. High-level dementia page

The activities mentioned in both the pages are considerate of the patient's mental state to not put the patient in more stress but to help keep them calm, stress-free, and relieved. When the patient will click on any of the activity or game's name they'll be redirected to the specific website which will help them perform the activity and play the particular game.

CONCLUSION

Tumor categorization is carried out using a machine learning technique, and the Decision Tree Classifier tested with a 91 percent accuracy rate while the Logistic Regression tested with a 95 percent accuracy rate. After predicting the data with TensorFlow, the development of Deep Learning (dl) algorithms would be the next step. This method can be used for implementation on MRI pictures and categorization.

The front-end designed for this study includes activities which are proven to help the AD patients. These are the activities and games which the patient can play daily and stay calm, improve their memory, and prolong the more difficult stages of Alzheimer's.

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