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Detection of Dementia Disease using Machine Learning Techniques: A Survey

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Abstract: ***Dementia is a cognitive and neurological disease that affects millions of numbers of people whole around the world. In this paper, different machine-learning algorithms are discussed to analyse dementia disease. The main objective of this paper is to study dementia using various machine learning algorithms to inspect their causes and how to decrease the high-risk group of people. A structured literature review has been presented which includes 15 research papers that take a view of different techniques implementing machine learning used for dementia.***
Keywords: Dementia, Alzheimer's Disease, Machine Learning, Convolution Neural Network, K-Nearest Neighbor.

I. INTRODUCTION

Dementia is a neuropsychological condition brought on by brain disease or damage that impairs one's capacity for rational thought, memory, and normal behaviour. According to the report of 2022, there are almost 55 million people who are elder persons (aged 60 and above) who have dementia and this number is on an increasing scale which is a very serious and important topic for the whole nation. So, with a changing environment and in a world of new technologies, we can solve our problems on our own. We can also see the types of dementia like Alzheimer's Disease, Frontotemporal Dementia, and Dementia with Vascular and Lewy's Bodies. And out of all their variations, Alzheimer's Disease accounts for between 75% and 80% of all cases. Dementia can cause a variety of symptoms, such as cognitive problems like memory loss, trouble speaking and finding the right words, confusion, and disorientation. The second one is psychological changes like depression, anxiety, agitation, hallucinations, etc. Dementia is caused by the loss or damage of brain connections and nerve cells. Depending on whatever area of the brain is affected, dementia can have a variety of impacts on different people and cause specific symptoms. Other disorders linked to dementia is Parkinson's Disease, Huntington's Disease, Traumatic Brain Injury, Cruetzfeldt-Jakob Disease.

II. LITERATURE SURVEY

A thorough literature review of machine learning methods for dementia detection is presented in this section. Author Mathotaarachchi classifies the dementia category of AD using the technique of RUSRF for MRI image modularity with 84% accuracy, sensitivity of 70.8%, and 86.5% specificity in 2017.[1]. In the second paper Hazarika, R.A. Kandar dementia category of AD which uses the technique of DNN, DenseNet and uses MRI as an image modularity with an accuracy of 90.22% in 2021. [2].
S. AlzVNet uses MRI as an image modularity with a dementia category of AD which uses the technique of CNN and an accuracy of 98.3%, sensitivity of 97% in 2022.[3]. In the fourth paper Dolezel, D uses the technique of ResNet-50, GBM and uses MRI as an image modularity with an accuracy of 99% in 2019 [4]. Kang, M.J. Kim, S.Y. uses a dementia category of MCI, Dementia which uses the technique of ANN and uses NPT data as an image modularity with an accuracy of 96.66%, sensitivity of 96.8%, specificity of 96.6% in 2019.[5]. In the sixth paper authors uses the dementia category of AD which uses the technique of CNN and uses MRI as an image modularity with an accuracy of 97%, sensitivity of 95% in 2021. [6].
Pan, D. Zeng, A. Jia uses the technique of CNN and has a dementia category of AD, using MRI as an image modularity with an accuracy of 84% in 2020. Authors Herzog, N.J.; Magoulas use MRI as an image modularity which uses the technique of SVM and KNN and with an accuracy of 77%, sensitivity of 72.5%, specificity of 67% in 2021.[7]. E.E. Steketee, R.M.E. Houston uses the technique of Linear SVM and uses MRI, PET as an image modularity with an accuracy of 89%, sensitivity of 83%, specificity of 79% [8]. In 2017, J. Mattila, J. Soininen uses the technique of SVM and uses MRI/CT as an image modularity with an accuracy of 95%, sensitivity of 93%, specificity of 99% [9]. N. Amenta have successfully achieved the accuracy of 90.1%, sensitivity of 68.4%and has a dementia category of PD which uses the technique of SVM, KNN, LDA, LR and uses Clinical data as image modularity with an accuracy of 90.1%, sensitivity of 68.4% in 2022.[10]. In 2021, authors use a dementia category of AD and Frontotemporal Dementia which uses the technique of DT, RF, ANN, SVM, Naïve Bayes, and KNN and uses EEG as an image modularity with an accuracy of 80%, sensitivity of 94%, specificity of 58%. [11].

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With an accuracy of 77% and a sensitivity of 72.5 in 2021, Herzog, N.J. Magoulas, G.D. utilises a dementia category of AD that employs the method of Linear SVM and uses MRI as an image modularity. [12]. An accuracy of 74.1%, sensitivity of 70.6%, and specificity of 79.2% in 2020, authors utilise a dementia category of PD that employs the techniques Classification tree, Gaussian Kernel, LDA, Ensemble, KNN, Naive Bayes, SVM, RF, and uses Clinical data as a picture modularity. [13]. Using the techniques of gradient boosting, SVM, LR, RF, and using MRI as an image modularity with 2020, Battineni, Chintalapudi, and Amenta were able to reach an accuracy of 95.96% and a sensitivity of 95%. [14]

Table 1 Summary of dataset of previous research papers

Ref	Year	Dementia Category	Validation Methods	Technique	Image Modality	Accur -ac y	Specifi -city	Sensiti -vity
[1]	2014	AD	Cross-validation	Linear SVM	MRI, PET	89%	79%	83%
[2]	2017	AD	Independent test set	RUSRF	PET, MRI	84%	86.50%	70.86%
[3]	2017	Dementia	5-fold cross-validation	SVM	MRI/CT, clinical data	95%	99%	93%
[4]	2019	AD	10-fold cross-validation	ResNet-50, GBM	MRI	N/A	N/A	99%
[5]	2019	MCI, Dementia	10-fold cross-validation	ANN	NPT data	96%	96.8%	96.66%
[6]	2020	AD	5-fold cross-validation	CNN	MRI	84%	N/A	N/A
[7]	2020	PD	Leave-one-subjectout cross-validation	Classificati on tree, Naïve Bayes, SVM, RF, Gaussian Kernel, LDA, Ensemble, KNN	Clinical data	74.1 % (SVM)– 84.5 % (KNN)	79.2% (SVM) –84.6% (LR)	70.6% (SVM) –88.5% (KNN)
[8]	2020	AD	Cross-validation	Gradient Boosting	MRI	95.96 % (NB)	N/A	95%-96%
[9]	2021	AD	Independent test set	Residual Networks,	MRI	90.22%	N/A	N/A

				DNN,				
				Inception-				
				V1, V2, V3,				
				And				
				DenseNet				
[10	2021	AD	10-fold	CNN	MRI	97%	N/A	95%
]			cross-					
			validation					
[11]	2021	Dementia	10-fold cross-validation	NB, LD, SVM, and KNN	MRI	77% (NB)-93% (C-SVM)	67% (KNN) -95% (SVM)	72.5% (CNN) -99% (KNN)
[12]	2021	AD and Frontotemporal Dementia	10-fold cross-validation with one patient left out.	DT, RF, ANN, SVM, Naïve Bayes, and KNN	EEG	94% (NB)– 98.6% (RF)	58% (NB)– 99% (RF)	80% (DT)– 99.1% (RF)
[13]	2021	Dementia	10-fold cross-validation	Linear SVM	MRI	72.5% (CNN)– 99% (KNN)	67% (KNN) –95% (SVM)	77% (NB)– 93% (C-SVM)
[14]	2022	AD	Independent test set	CNN	MRI	98.30%	N/A	97%
[15]	2022	PD	10-fold cross-validation	SVM, KNN, LDA, LR	Clinical data	68.4% (SVM)	N/A	95.96% (NB)– 97.58% (GB)

III. PROPOSED METHODOLOGY

The dataset for the proposed investigation was obtained from OASIS-Brains.org [16]. The age range of the 150 individuals in this longitudinal cohort is 60 to 96. Each patient underwent a total of 373 imaging sessions, with at least two visits spaced by at least a year. For each patient, three or four different T1-weighted MRI images from one scan session are displayed. All individuals, including both sexes, are right-handed. 72 of the patients were categorised as non-demented throughout the whole research. Among the 64 patients, 51 had mild to severe Alzheimer's disease at the time of the first diagnosis and remained demented throughout the course of the scans.

The steps involved in the suggested work are as follows:

A. Data Collection

The dataset is collected from the oasis-brains[16].org including 150 subjects in cross-sectional data aged from 60 to 96. All throughout the study, 72 of the participants were classified as nondemented. 51 people with mild to moderate Alzheimer's disease were among the 64 subjects who were initially diagnosed as demented and remained so throughout the course of the scans. At the time of their second visit, 14 additional subjects who had previously been classified as nondemented were found to be suffering from dementia.

B. Data Pre-processing

Because real-world data is inconsistent and incomplete, data pre-processing is becoming an increasingly crucial issue for data mining. The column mean and median values are used to fill in the gaps left by the missing entries.

C. Classification

Specifically, the four classifiers are used namely, Random Forest, Decision Tree, Voting Classifier, SVM.

1) *Random Forest Classifier*: On various samples, the Random Forest classifier constructs decision trees and uses their majority vote for classification and average for regression[17].
2) *Decision Tree Classifier*: Decision Tree Classifier develop a model that forecasts the value of a target variable by learning straightforward decision rules derived from the attributes of the data[18].
3) *Voting Classifier*: Voting classifiers learn from a variety of models and predict an output (a class) based on how likely it is that the result will fall into the category that was selected during training. It simply takes the results of each classifier that is given into the voting classifier and arithmetically averages them to anticipate the output class based on the vote with the largest majority [19].
4) *SVM:* For both classification and regression, the Support Vector Machine (SVM), a method of supervised machine learning, is used. The best fit is classification, even if we additionally take into account regression problems. Finding a hyperplane in an N-dimensional space that categorizes the data points unambiguously is the objective of the SVM method [20].

D. Performance Evaluation

Finally, the classification accuracy is determined and examined. The percentage of successfully categorized samples over all samples obtained is known as the classification accuracy.

IV. EXPERIMENTAL ANALYSIS

As shown in Table 1 we can conclude that Random Forest Classifier is showing the best classification accuracy of 83.9% which is the highest amongst all. And the lowest accuracy percentage is given by SVM classifier which is 77%.

V. CONCLUSION

As of now after studying all the previous research papers, it will conclude that dementia is a major health problem, and we must focus on risk reduction instead of its cure. According to the literature review, a lot of effort has been made to use different machine-learning algorithms for diagnosing dementia in subjects early. Determining the crucial traits that might spot dementia at a very early stage is still necessary, though. Future research's primary objective will be to identify unique features that are more sensitive for the early diagnosis of dementia. Eliminating pointless and superfluous characteristics from the feature sets currently in use is crucial for enhancing the efficacy of dementia diagnosis algorithms.

The extraction of novel traits that are more sensitive for the early identification of dementia is a task for the future. In order to improve the effectiveness of dementia detection algorithms, it is also important to remove unnecessary and redundant features from existing feature sets.

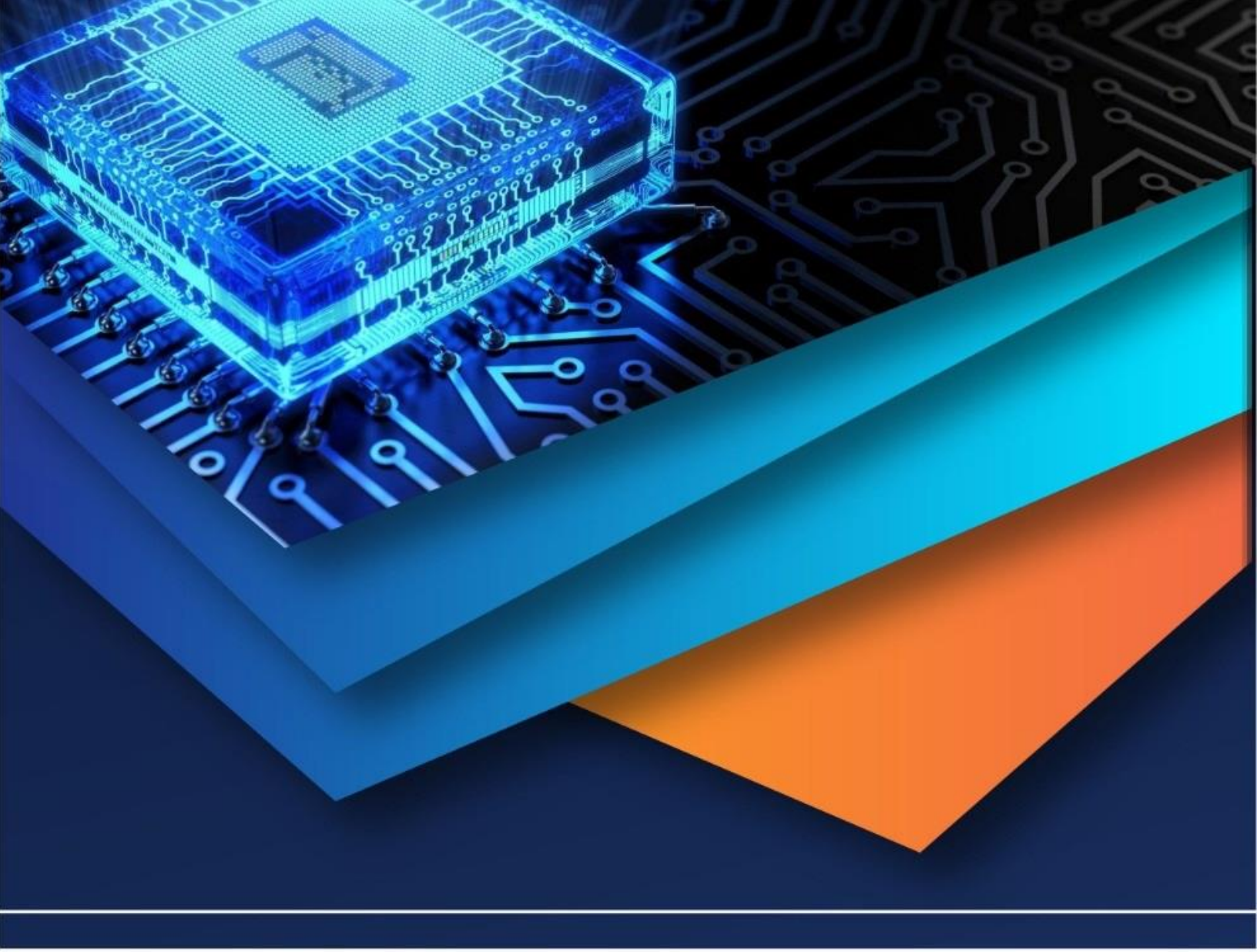
Table 1: Classification accuracy for Oasis Data

Classifier	Classification Accuracy
Random Forest	83.92%
Decision Tree	79.62%
Voting Classifier	83.03%
SVM	77.43%

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