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An Investigation on Current Approaches for Classification of Alzheimer's Disease Using Image Processing and Neural Network Techniques

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Abstract

Alzheimer's Disease (AD) is an untreatable, dynamic neurological encephalopathy. Prior recognition and stage categorization of AD can assist with correct treatment also evade brain tissue destroy. A few 'statistical' & Artificial Intelligence (AI) systems are developed by researchers for AD analysis. MRI (Magnetic Resonance Imaging) might be a typical observes for AD determination in medical investigation. Recognition of AD is finding the equivalence in 'AD-MRI' records and usual 'MRI' records of elder group. As of late, advanced artificial neural network system has effectively shown human level completing in various fields including medicinal data investigation. This research reviews an image processing and neural network methods for AD recognition also stage categorization utilizing brain MRIs. While the majority of the current methodologies performs binary classification yet distinguishes various stages of AD is exceptionally imperative part right now.

Keywords: *Alzheimer's disease, Stage Classification, MRI, Image Processing, Neural Network*

1. Introduction

AD is the most common sort of 'dementia'. The occurrence of AD is evaluated to be approximately '5%' following '65' years of age also is amazing '30%' for over '85' years of age in many countries. It is assessed that by '2050', around '0.64' Billion individuals will be determined to have AD. It wrecks brain cells then making individuals to drop their remembrance, mind functions and capability to proceed with day by day actions. At first, AD influences the portion of the brain which controls language also memory. Accordingly, AD patients experience the ill effects of amnesia, uncertainty and trouble in talking, reading/writing. They frequently disregard their life and may not perceive their relatives. They battle to perform every day actions like brushing hair/brushing tooth. At last, AD decimates the portion of the brain that control breathing also heart functionality which cause demise. Thus, auspicious analysis of this disease for fitting and immediate treatment is essential to prevent/ as a minimum impediment its growth [1].

For accurate AD detection, numerous researchers have built up a numerous computer-aided diagnostic frameworks. From medical images, feature vectors are extracted to coach organized classifications which need human specialists that consistently require huge amounts of time, cash also vitality. With the development of artificial neural systems, features are extracted legitimately from the input medical data without the commitment of human specialists. So scientists are concentrating on building up those systems for exact disease analysis. This innovation has arrived at most significant triumph used for various medicinal data analysis activities, for example, 'MRI',

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'microscopy', 'CT', 'ultrasound', 'X-ray' also 'mammography'. The computer-aided diagnostic frameworks demonstrated noticeable outcomes for organ and substructure division, a few disease detection plus classification in territories of bone, taxonomy, cerebrum, guts, heart, bosom, lung, retina, and so forth [2]. This work centers on investigating MRI dataset utilizing image processing and neural network approaches for Ad detection. The topic in this ground is to extract the input image as well as classify the extracted features into the connected sample then recognizes the brain image which is suffered by the 'AD' from image feature classification outcome. Additionally, this system has three main steps that can be illustrates in following figure,

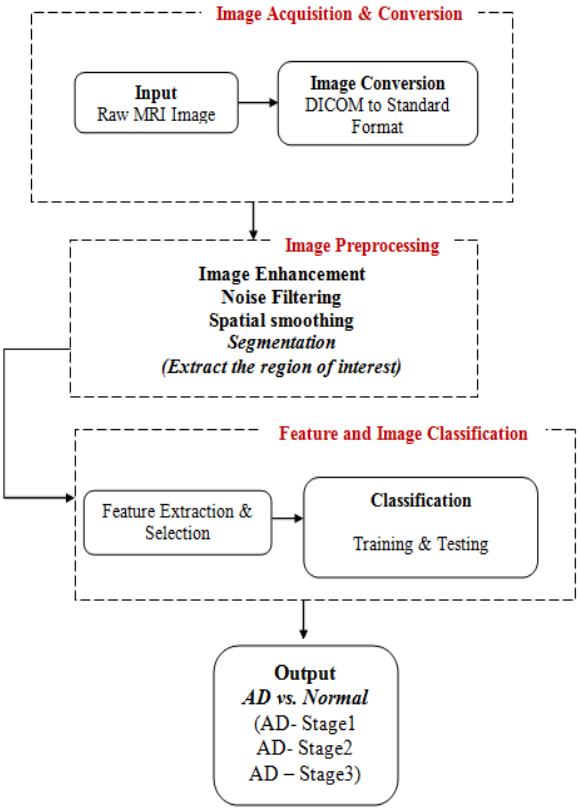

Figure 1: Phases of Image Classification Process for AD

After preprocessing stage, it involves to filtering the noise and segments the region of interest from input image. After that, features are extracted from the segmented part for additional examination. The motive of the image 'classification' method is to connect the input variables (image features) happen to the output variables (to characterize one definite set which is disease or else no disease class).

2. AD: Alzheimer's Disease

'AD' is a developing disease which annihilates memory just as other significant mind operations. Initially, somebody with AD may see mellow perplexity alongside unpredictability in recalling. Finally, individuals with the illness may even now overlook indispensable individuals in their lives and endure sensational character changes. AD is the most well-known reason for lot of Brian issue which causes the loss of scholarly & social skills [2]. In AD, In Alzheimer's disease, the brain cells relapse and expire, causing a delicate decrease in memory and mental capacity.

i. Symptoms

Memory problems are usually the first symptoms of AD. It is a brain syndrome which makes a slow refuse in 'memory', 'thinking', 'reasoning skills' and 'remembering things' that have been recently learned is especially difficult [3]. Some other symptoms are:

AD doesn't influence everybody with the above mentioned way, so people may meet signs at various occasions.

ii. Reason for AD

The specific explanation of Alzheimer's isn't clear, yet there are various hereditary, ecological, and way of life aspects which can add. In any case, what is recognized is that Alzheimer's harms the cerebrum and its cells [3]. This prompts the brain attenuation. The brain of someone with Alzheimer's generally has '2' sorts of variations from the norm: plaques plus tangles.

Table 1: Types of AD

Plaques	Tangles
Plaques are clumps of protein that get in the way of communication between brain cells. This causes damage and possibly even the death of these brain cells. These protein clumps are called amyloid plaques.	The system that carries nutrients through the brain is a protein called Tau. In the brain of someone with Alzheimer's, threads of this protein (better known as neurofibrillary tangles) collect in the brain cells. These tangles prevent nutrients from being carried through the brain.

iii. Risk factors connected with 'AD'

There are various effects that can be viewed as risk factors for 'AD'. The most well-known of these is aging, generally happen in individuals beyond 60 years old [4]. Some other normal factors are listed in following table:

Table 2: Risk factors of AD

S.NO	Reasons
1	Genetics
2	Diabetes
3	Mild cognitive impairment
4	Severe head trauma
5	Heart disease
6	High blood cholesterol
7	Smoking
8	Poor diet
9	Individuals with Down syndrome

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iv. Stages of AD

The AD stage is very significant factors in choosing treatment options. The 'AD' stage is depends on the outcomes of the some physical tests, medical imaging tests/other test. During the ultimate stages, the patient is totally dependent upon caregivers. Persons with AD will eventually not be able to carry out even the simplest tasks separately; muscle mass plus mobility decline to the point where they are laid up also incapable to feed themselves. The stage of AD shows how severe it is and how far it's increase [5]. It helps the physician to decide, which treatment is required for the patient. Different Stages of 'AD' can be described as follows,

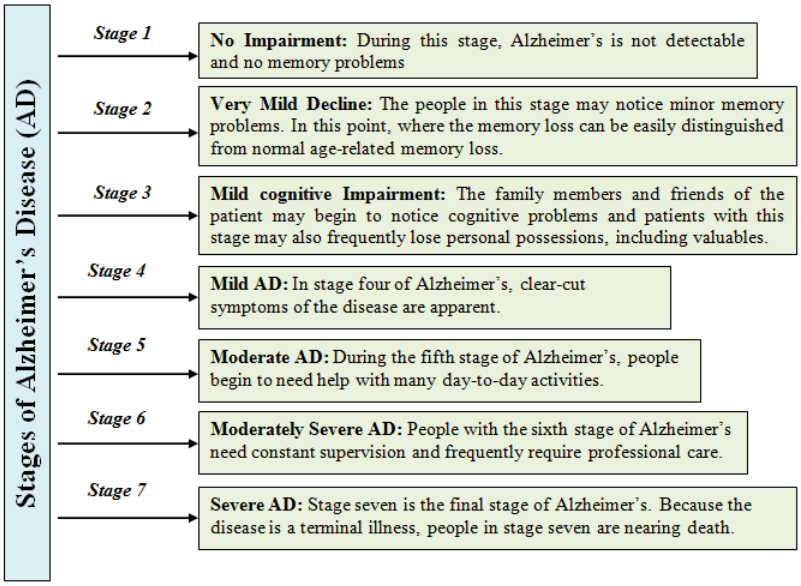

Figure 2: Stages of AD

To better recognize how 'AD' influences the hypothalamus also other regions of the brain; it's helpful to first have an understanding of the primary stages of this progressive disease [6]. The following figure comprises the three main stages in image Alzheimer's disease (AD),

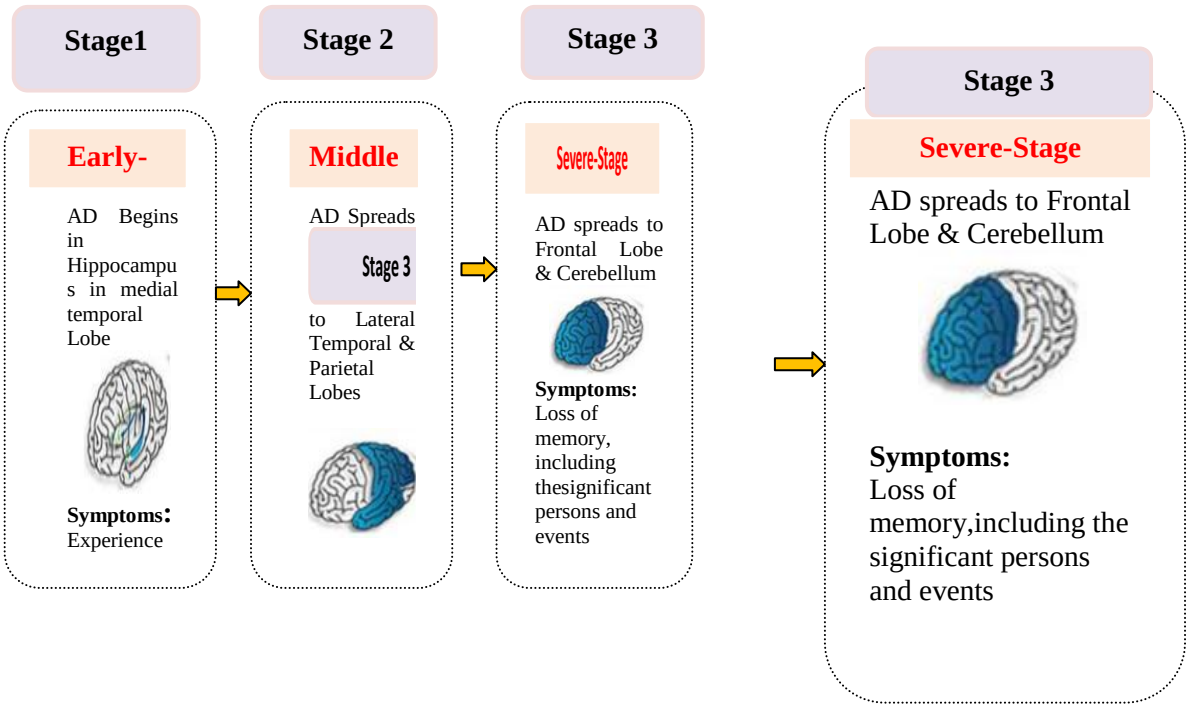

Figure 3: Main Stages of 'AD'

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One of every nine individuals '65' and more aged has 'AD', and around 30% of Americans beyond 85 years old has the AD. 81% of individuals with Alzheimer's are 75 years of age or more aged.

3. Computer Aided System for 'AD' Detection in 'MRI'

i. Preprocessing methods

Currently, a fast development in engineering science and Medical Instrumentation has assisted the improvement of digital medical imaging. Noise removal is the most important challenging preprocessing in the medical image processing system. Impulse noise is often introduced into images during acquisition and transmission, has undesirable effects on different image processing purposes. Here the incidence of 'impulse noise', linear denoising filters are reasonably unsuccessful. Nonlinear denoising filtering methods are effectively preserved edges as well as features of input images, when techniques using linear denoising filters lead to blur also deform them. Accidentally, deserting of ultrasound to attempt to recognize interior organs came while new radiological innovations for brain imaging, for example, magnetic resonance imaging (MRI) were emerging [7].

ii. Segmentation Techniques

The brain matters are mainly classified as grey matter, white matter, cerebrospinal fluid (CF). CF protein level changes associated to the neurological diseases. Cerebrospinal is a colorless liquid. CSF surrounds and fills the spinal cord and brain. 'CF' protein level variations are found in any stages AD of individuals. The intracranial pressure to the traditional level is maintained by the traditional flow of CF. The disorder is diagnosed by the simulation of CF and to assist for the treatment. Clustering [8] is that the essential technique in image segmentation in that big amount of samples are converted into a small amount of equivalent clusters. This method mentions to the categorization of pixels into clusters depends on definite criteria of the input objects. A variety of clustering algorithms are introduced to build the segmentation efficient.

iii. Feature Extraction in Images

Features are an important measurement for image understanding, especially the feature representation of the segmented region that used for object classification and analysis [9]. The common techniques of Feature extraction are:

Features are a significant estimation for object recognition, particularly the features in the segmented area that utilized for 'object' classification [9]. The normal strategies of 'Feature extraction' are:

i. PLS: 'Partial Least Squares' algorithm

PLS feature extraction is progressively compelling for extricating the precisely right features from the segmented objects. It for demonstrating associations among the groups of observed factors significance of inactive factors. It involves classification responsibilities, regression and dimension decline strategies. It reached out to regression issues normally. The indicator and anticipated factors are each considered as a chunk of factors. 'PLS' function a replacement indicator portrayal and furthermore relapses the reaction factors on these new indicators by removes the score vectors. The proper classifiers are regularly applied when the important inactive vectors are removed [10].

ii. NMF: 'Non-Negative Matrix Factorization' algorithm

'NMF' algorithm is used for feature extraction task which transformed a set of images into decreased number of features. So as to decrease the scourge of dimensionality, the all out quantities of 'voxels' are down examined by a factor of '0.5' also the majority optimal features are chosen, with utilization of the 'Fisher discriminate ratio'. 'NMF' algorithm is a newly formed method for detecting diminished linear representations of non negative information being a valuable deterioration tools for multivariate features [11].

a. Feature Selection

This process utilized to select the numerous features which are suitable for the classification system. Determination of related features for magnitude shrinking in the classification system can build up computational competence effectiveness. The ultimate collections of features are frequently decided during, 'clustering', 'data correlation' also 'analysis algorithms' to obtain likeness samples inside the training feature. It has the accompanying strategies,

i. LDA('Linear Discriminant Analysis') algorithm

The motive of 'LDA' system is to recognition a linear arrangement of features which ready to provide the finest plausible partition among various classes of input data in the extracted feature sets. This can diminish magnitude gap for classification also provide improved classification exactness.

ii. PCA: 'Principal Component Analysis' algorithm

This is an adept method of 'Dimensionality Reduction' of an extracted feature set by a larger number of organized factors. Still, for feature data with light allocation along with artifacts, 'PCA' technique can't select the best set of features [12].

iii. Genetic Algorithms Based Optimization

This is a powerful strategy for analysis optimal features that utilizes regular selection standards. It uses earlier aspects of data and utilizing selection for endurance and can adjust to the particular parameter concerns. They are fixed as twofold strings which are related with the fitness estimation [12].

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iv. Classification system

They chose features of object which are created from 'feature extraction/selection' are utilized in object 'classification'. In the MRI examination, input image features estimations can be utilized for translate the outcome by utilizing knowledge-based & classification model [12]. Some related methods are described in this section:

i. 'Statistical Classification (SC)' techniques:

The types of 'SC' techniques are 'Un-supervised' & 'Supervised' frameworks. In the 'Un-supervised' strategies, it clusters the selected features and separates them in component space such as incorporate 'K-means' and 'fuzzy' clustering. Then again, a 'supervised' methodology requires 'training' data along with 'test' data also 'class label' to classify the input features, some related methods are 'K Nearest Neighbor (KNN)' and 'Bayesian' classifier.

ii. 'Rule-Based Systems' (RBS):

This framework examines the feature vector that utilizing various rules which are intended to test explicit states in the feature subsets for further process that rules includes of 2 parts: 'Condition Premises' & 'Activities' that are produced dependent on specialist facts to conclude the activity when the conditions are fulfilled. The activity is an element of the 'rules' specified in the system that could modify the feature set state of an element factor upheld a chose condition of analysis. Typically, a 'RBS' comprises of 3 types of rules: 'Supervisory' rules, a 'Focus of Attention' rules, also 'Knowledge' rules.

iii. 'Artificial Neural Network (ANN)' Classifiers:

The 'ANN' system does 'Feature Classification', 'Image Interpretation' and 'Object Recognition'. Some examples are Back Propagation Neural Network (BPNN), Associative Memories (AM), Radial Basis Function (RBF) and Self-Organizing Maps (SOM) feature. By then 'fuzzy system-based' methodologies are applied in ANN for better classification outcome.

iv. 'Relevance Vector Machine (RVM)' Classification:

The RVM includes 'Bayesian probabilistic principle', 'Classification' also 'Regression'. The additional methods for model classification utilizing speculative systems comprise 'Kernel based Classifier' and 'Linear Programming Perturbation based' approaches [14].

Table 3: Benefits and Limitations of Existing classification Algorithms

Year	Author	Method & Focus	Benefits	Limitation
2013	T. Brosch et al.,	Deep Belief Networks(DBNs) for Classification	High classification accuracy Correlations shown with demographic information	Lack of clinical explanation
2015	AdrienPayan et al.,	Sparse auto encoders and Convolutional neural networks for pattern classification	High classification accuracy Patch based approach	Lack of clinical explanation Bias in data
2015	W. H. Kim et al.,	Multi-resolution statistical analysis for Staging/ Connectivity analysis	Connectivity characterization Usage of DTI-MRI	Lack of demarcation of effects of AD from other physiological conditions
2013	Suk HI &Shen D	Multimodal data fusion Deep neural networks for Classification	Usage of Multimodal data fusion High classification accuracy	Lack of demarcation of effects of AD from other physiological conditions
2013	Tzyh-Chyang Chang	SOM and PSO-SVM for classify the AD and Mild stage of AD	Visualization of high dimensional data. It easy to understand.	Similar samples are not always near each other. SOM has higher learning rate and less iterative time

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4. Literature Survey

Recently, People are aware about 'AD'. In the research of early detection and staging of 'AD', image processing and machine learning techniques are playing an important role. At this point, 2 major perspectives being tackled by researchers, they are classification of imaging data into AD patients and staging of patients on the scale of 'AD' development.

Serra L et.al., have identified the structural differences within the regions like the hippocampus and entrorhinalcortext of healthy brain and brain with AD has been identified by Serra L etal. The variations of the behavior of AD Patients can be understood by the changes in cerebrospinal tissues. More than that the changes in brain tissues connectivity and behavior of AD patient are linked to each other strongly. The changes causing AD thanks to the degeneration of brain cells are noticeable on images from different imaging modalities, e.g., structural and functional resonance imaging (sMRI, fMRI), position emission tomography (PET), single photon emission computed tomography (SPECT) and diffusion tensor imaging (DTI) scans [13].

Ambastha AK. Extracted 3D brain region patches from 100 subject MRI images using a predefined anatomical atlas. They extracted the features in the brain, trained them and finally used the boosting algorithm and found the weightage of pair predictor in the classification step. Their classifier gave 81.79% a final accuracy [14].

AdrienPayan et al. [15] utilized 'deep convolutional neural networks' to classify the 'AD' Vs normal data. They utilized fix extraction also auto encoders to pre learn fix features. Patch based strategies use the disseminated idea of data in regards to AD inside the brain.

M. Liu, R. et al., [16] proposed 'multi-template based multi-view learning' for AD detection. A RIML (relationship-induced multi-template learning) technique is proposed in it. Also, it includes 3 primary phases, 'feature extraction', 'and feature selection ', 'ensemble classification'. Primarily, a multi-layout highlight extraction technique is used for template selection. For each selected number of templates a similar brain MRI features are selected and the tissue thickness map with grey values extricated. The RIML technique [6] is applied to diminish the features from unique features and chosen needed features. They chose features at that point experience classification dependent on Support Vector Machine (SVM) and recognize whether the patient is of 'AD' controlled otherwise typical controlled one with precision of 93.06%.

Mingxia Liu et al., proposed a natural structure based multi-see inclining (ISML) strategy with highlight portrayal produced from different formats for AD/MCI characterization. In particular, they initially select numerous layouts from information, and afterward separate multi-see highlight portrayal for subjects utilizing those formats, where every format is treated as a particular view. A while later, they bunch subjects inside each class into a few sub-classes in each view space, and encode those sub-classes with one of a kind codes by considering both their unique class data and their own conveyance data, trailed by a perform multiple tasks include determination method. At last, they become familiar with a view-explicit SVM classifier utilizing chosen includes in each view space, and circuit consequences of different SVMs together by a larger part casting a ballot technique. They assess the adequacy of the proposed technique on 459 subjects with MRI gauge information from the ADNI database, and gain the exactnesses of 93.83%, 89.09%, and 80.90% for AD versus NC, pMCI versus NC, and pMCI versus sMCI characterization errands, individually [17].

Suk et al. [18] developed an auto encoder organize based model for AD assurance and used a couple of complex SVM partitions for request. They have removed low-to mid-level features from appealing current imaging (MCI), MCI-converter essential MRI, and PET data and performed request using multi partition SVM.

Morra et al. [19] took a gander at a couple of model's displays for AD area including dynamic AdaBoost, SVM with manual component and SVM with modernized feature. For working up these classifiers, ordinarily predefined features are removed from the MRI data. Regardless, setting up a classifier self-sufficient from the part extraction procedure may bring about hazardous execution on account of the possible heterogeneous nature of the classifier and features.

Table 4: Performance analysis various classification methods

S.No	Focus	Methodology	Performance Measure (%)
			Accuracy
1	AD VS Normal	Meta classifier (MC)	81.79
2	AD VS Normal	Support Vector Machine (SVM)	93.06
3	AD VS Normal	Ensemble classification (EC)	93.80
4	Ad stage classification	Multi-kernel SVMs (MK-SVMs)	93.83
5	AD VS Normal	Pulse Coupled Neural Network (PCNN)	67.3
6	Ad stage classification	Dynamic Neuro-Fuzzy (DNF) Technique	85.65

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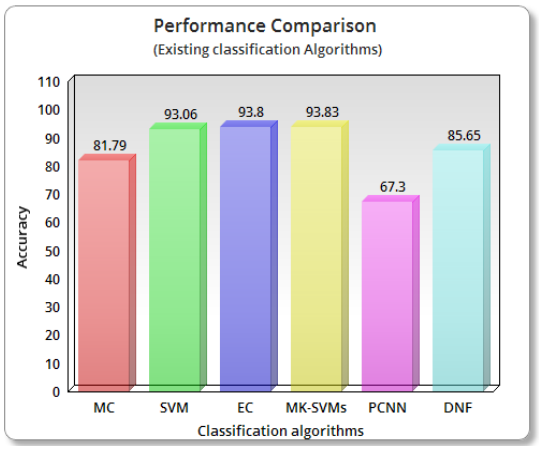

Figure 4: Performance comparison of existing classification algorithms

The above Table3 and figure demonstrates the performance analysis various existing AD classification methods. It shows machine learning has shown promising results by analyzing an existing models in the earlier researches but existing techniques are fails to obtain 100% accuracy in AD classification. So, the novel system is required to give a more effective outcome by combining machine learning with cognitive technologies to processing large volumes of data with minimal amount of time.

5. Proposed Model and Methodology

In existing classification systems, they are lacking to classify the various stages of AD disease. Our proposed research analyzes the most recently used methods in machine learning and deep learning from 2013 to 2019. To achieve higher classification accuracy, the structure of the proposed model is presented below,

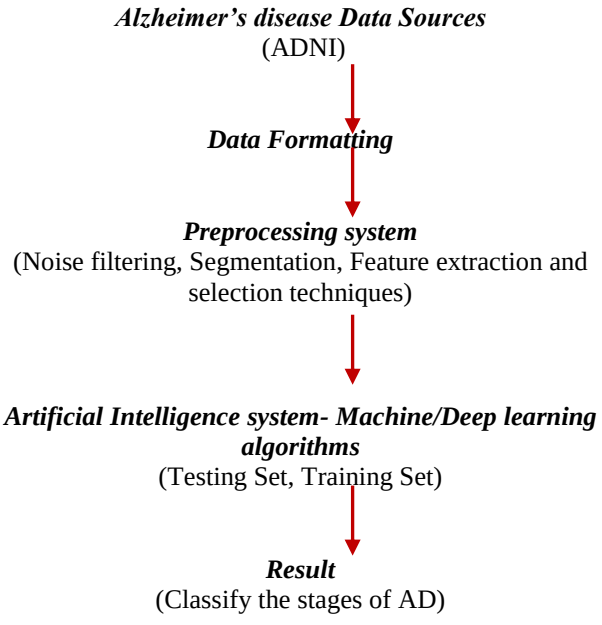

Figure 5: Stages of Proposed Model

The above figure describes the stages of proposed model. In proposed model, we will obtain the data from the 'Alzheimer's disease Neuroimaging Initiative (ADNI)' database. Firstly, all relevant data for analyzing is collected and formatted by the appropriate system. After formatting the data, it is preprocessed so that it can be suitable for subsequent process. To extract and select the optimized features for classification, it requires highly efficient techniques. The next step is to build models that can be classifying the stages of AD. This is done with training and testing datasets. Either machine learning or deep learning models are best used to build the intelligent classification system.

6. Conclusion

Classifying stages of Alzheimer's disease is challenging. Image processing and neural network methods are suitable for classifying AD stages that has been successfully applied in lot of existing approaches. This paper reviewed the recent classification systems that include many machine and deep learning techniques. This survey has explored almost all published AD classification studies from 2012 to 2019. This paper defines the AD, the nature of stages, and utilized techniques. A serious part of any innovative research system is the creation of a fine classification outline also the organization of a reference gathering from appropriate literature. Through this study, importance of existing techniques in the classification of AD has been recognized.

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