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A Comparative Review of Detecting Alzheimer's Disease Using Various Methodologies

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ABSTRACT

The study discusses various methods suggested, replicated or performed by scientists, researchers which are mainly based on identification of Dementia which can lead to Alzheimer's Disease (AD). The study also provides various remarks or personal findings of particular specific methods provided by the authors of this paper, where methods are ranging from hardware based models to software based models.

1. INTRODUCTION

Alzheimer's disorder is a neurodegenerative disease that is the conventional state of dementia. In our cutting-edge society, it is the most high-priced disorder & it is characterized by means of cognitive, Mental and behavioral disruption. In other words, Alzheimer's sickness is the most common purpose of dementia, a most basic term for memory loss and other cognitive competencies that intervene with daily life.

2. HISTORY

As of Today, Approximately 60 to 80% of instances of dementia are due to Alzheimer's in Bangladesh. It most often starts in individuals over the age of 65, although Alzheimer's early onset is 4–5 percentage of instances. There are about 460,000 people struggling from dementia in our country, according to Alzheimer's Disease International Asia Pacific Report-2015, which would be doubled in 2030 and tripled via 2050 (Farjana, S. et al: (2018). So Bangladesh is no longer unfamiliar to this disease and the influence of AD is now not negligible. Bangladesh has a noticeably young population, with 8% of the total population of one hundred sixty million being over 60, or 12 million people (Taha, Dr. S et al: 2014). One can think about that among 12 million older people there would be at least a few thousand struggling from some shape of dementia. Older humans who are struggling from reminiscence disturbances are often stigmatized or branded as "Foolish". Often they will no longer receive the help they need or deserve from their household or society. The state of affairs can be even worse in rural villages than in towns, as there is frequently greater social taboo associated, more migration of youthful people to cities or overseas and a lack of perfect scientific and community-based guide services.

According to Professor Dr. Md Rezaul Karim Khan (Professor of Neurology Department Bangabandhu Sheikh Mujib Medical University), Elderly people,

specifically humans after the age of 65 years are primarily affected. (Farjana, S. et al: (2018).

A. CURRENT SITUATION OF ALZHEIMER'S DISEASE IN BANGLADESH

Some facts on the amount of AD patients in Bangladesh are accessible. In this nation, there are no correct epidemiological records of AD (R. Sneddon et al: 2005). The understanding of AD is now at the predominant level here. Consequently,

The impacted patient and their household participants are constantly facing quite a number issues. There is restricted funding for project AD studies. A lesser middle-income nation such as Bangladesh is now not but geared up for AD's leadership. Currently, most of the country's persons are in the younger group. However, there will be sizeable aged folks in this kingdom within 20–30 years. Therefore, AD incidents will be extra likely to occur. It is excessive time, therefore, to agree with proactively about the sickness and its administration and to take needed motion in this respect. The coverage makers, health professional and allied businesses need to come ahead to make countrywide precedence for AD in Bangladesh.

3. SYMPTOMS

Alzheimer's progresses progressively over the years, but the disorder has some most important symptoms. These signs are greater persistent than occasional memory lapse and become worse in Alzheimer's patients over time, in accordance to Mayo Clinic. The other signs and symptoms include:

i. Repeat statements and questions over and over, failing to realize that the query was requested earlier.
ii. Forget about conversations, appointments or occasions and can't remember them later.
iii. Routinely misplace property, regularly in illogical places.
iv. Get lost in areas that are recognized to the patient.
v. Ultimately overlook the household individuals ' names and everyday items.
vi. Finding the correct phrases to define items, specific thoughts or take part in discussions will become difficult.
vii. Changes in personality such as mistrust of others, irritability and aggression, adjustments in drowsing habits.
viii. Walking, loss of prohibitions, illusions such as wondering something was robbed, dumps, absence of devotion, temper swings and social withdrawal.

4. STAGES OF AD

The phases are divided into three classifications: Moderate Alzheimer's (early stage), Alzheimer's average sickness (middle stage), and Alzheimer's Terminal stage (last stage). Be conscious that putting an individual with Alzheimer's disease in a specific section may be challenging as phases may also overlap. The stages are stated as follows:

i. Early Stage: A character can operate separately in the early section of Alzheimer's. He or she can also still be driving, working, and participating in social activities. Nevertheless, the person may also experience like memory lapses, such as forgetting familiar phrases or putting everyday items.

ii. Middle Stage: Typically the longest section is average Alzheimer's and can remaining for many years. A character with Alzheimer's will require a greater quantity of care as the disease advances. The symptoms of dementia are more said in the course of the mild phase of Alzheimer's. A person can also locate it greater difficult to perform duties, such as paying bills, however they can also nevertheless take note essential facts about their lives.

iii. Last Stage: Dementia symptoms are severe in the final stage of this disease. Individuals lose the capacity to react to their surroundings, habits a discussion, and sooner or later modify motion. They can nevertheless inform phrases or sentences, but it turns into hard to communicate. As reminiscence and cognitive capabilities continue to deteriorate, vital adjustments in persona might also occur and people want complete help with day by day activities.

5. RISK FACTOR

i. Age

Age is the most necessary chance element for AD where there is a robust extend in the incidence of AD in men and women with age. (Evans DA et al: 1989, Vest RS et al: 2013). The International Alzheimer's Disease Report estimates that forty seven million folks globally will be dwelling with AD in2015, an estimated upward shove of 131 million through 2050 (Baumgart M et al: 2015). After era 65, the lifetime chance of AD for girls is one in six (16.7%), whereas for males it is one in eleven (9.1%) (Alzheimer's Association et al 2013).

ii. Obesity/Metabolic Syndrome

Relationship between AD and obesity in some research suggests an more desirable hazard for obese people of up

to 40%, (Fitzpatrick AL et al: 2009, Gustafson D et al: 2004, Gustafson D et al: 2003, Gustafson DR et al: 2009) in others no correlation has been observed (Profenno LA et al: 2010, Wilson RS et al: 2002, Plassman BL et al: 2000). Loss of weight and low body mass index are substantially associated with increased hazard of AD in aged adults, whereas a larger physique mass index may additionally be shielding at superior ages (Fitzpatrick AL et al: 2009, Besser LM et al: 2014, Emmerzaal TL et al: 2015, Hughes TF et al 2009).

iii. ***Family records of Alzheimer's disease***

AD's family records may play an essential part in AD's development and occurrence. Individuals whose mother and father or siblings are AD sufferers are greater susceptible to AD than individuals who have no AD household history (Green RC et al 2002, Barnard ND et al 2014, Papon MA et al: 2011). The genuine relationship between the expanded hazard of AD and household records of AD is now not completely diagnosed thru current research.

iv. Smoking

Early onset of AD is associated with smoking, viewed a modifiable risk element for AD estimating 4.7 million AD instances globally. Numerous studies have found that smoking is associated with each superior and decrease danger of AD. But lifetime smoking is associated with at least 1.7 instances (70%) greater threat of AD, and the danger increases drastically with higher cumulative exposure to smoking (Durazzo TC et al: 2014).

v. General anesthesia and AD

The preclinical manifestation of the viable role of everyday anesthesia in advancing AD processes in cellphone way of life or animal fashions has been recorded in a number of research. Current evidence suggests a correlation between exposure to volatile conventional anesthesia and AD pathogenesis in transgenic mouse fashions (Papon MA et al: 2011, Seitz DP et al: 2013), whereas Tauopathy evolution and AD-related methods in animals exposed to generic aesthesia have also been identified. (Papon MA et al: 2011)

vi. Diet

Numerous research have proven that dietary factors can play a quintessential role in the development of human and animal risk observation. Cognitive impairment in animals, excessive concentrations of AD and Taupathology in rodents predicting AD pathogenesis are associated with high concentrations of sucrose and fructose in Western diets (François B. Vialatte et al: 2006, Moreira PI et al: 2013), whereas trans and saturated fatty acids are associated with extended threat of AD and mild cognitive impairment (Barnard ND et al: 2014, Morris MC et al: 2014). Another rodent test (Grimm MO et al: 2012, Oksman M et al: 2006 shows that trans and saturated fatty acids have accelerated concentrations of AD. Again, in transgenic mice, eating regimen with oleic acid precipitated and decreased fat has been located to limit AD concentrations and pathology (Amtul Z et al: 2001). Various observations have been advised that AD levels decreases appreciably with diets containing excessive omega 3 polyunsaturated fatty acids (Hjorth E et al: 2013, Julien C et al: 2010, Lebbadi M et al:2011, Zerbi V et al:2014).

vii. Others

Also suspected as risk factors for AD are cardiovascular illness, social and cognitive involvement, aggravating talent injury, down syndrome, etc., however no important learn about has been performed to show their connection with AD. (Wang HX et al: 2012, Karp A et al: 2006, Di Marco LY et al: 2014, Sharp ES et al: 2010, Lehman EJ et al: 2012)

6. WHY AD DETECTION IS IMPORTANT

The early analysis of the ailment is consequently integral as it enables patients and his household to take precautionary steps as well. A clear prognosis will allow the household and the closest social community of sufferers to higher recognize the signs that appear and in session with the affected person to count on the future. Early detection of the disorder allows faster motion and precious time to be saved; accurate analysis to avoid problems and fast deterioration. A unique analysis helps deciding on the most useful administration of the patient: all dementia issues do not evolve in the same way. The coexistence of special motives that can affect cognitive capabilities is frequent, a proper differential prognosis is essential. (Farjana, S. et al: 2018). So there is no point exaggerating on the point that identifying Alzheimer's at an early stage is very crucial for the patient's well-being.

7. METHODOLOGIES

i. Neuroimaging(Nilesh Kulkarni et al 2014):

Based on EEG, Neuroimaging is one of the most-frequent methods for definitive prognosis of dementia. Various Neuro-imaging techniques are used for the diagnosis of the Alzheimer disorder. Numerous strategies along with single-photon emission computerized tomography (SPECT), positron emission tomography (PET), and magnetic resonance imaging (MRI) were proven effective for recognizing AD at an early level. This introduces MCI (mild Cognitive Impairment), the primary symptoms of AD. This technique can also decide whether the affected person is at the primary stage (MCI) or is already been suffering from Alzheimer's disease.

ii. Independent Component Analysis (ICA) (Co Melissant et al:2005):

This method uses automatic pattern recognition methods to discover EEG patterns indicative of Alzheimer's disease. This manner of detecting Alzheimer's sickness includes an ICA-based totally section of elimination of artifacts before automatic classification. The technique was implemented on group of eight peoples in duration from two patient groups, in which one group became at an original point of the illness (28 patients), the opposite group (15 patients) turned into at an extra advanced factor. Each configurations included a control group to be labeled as normal (10 and 21, respectively). It is essentially a statistical and computational approach for revealing hidden elements that underlie sets of random variables, measurements, or indicators. ICA defines a generative version for the observed multivariate records, which is typically given as a massive database of samples.

iii. Integrative EEG Biomarkers To Predict The Diagnosis (Simon-Shlomo Poil et al:2013):

Prediction of conversion to Alzheimer's disease (AD) at an early stage might enable an earlier, potentially more effective, treatment of AD. Electroencephalography (EEG) biomarkers might offer a non-invasive and comparatively reasonably-priced screening device to predict conversion to ad. This technique includes combining multiple data from multiple neurophisical biomarkers and use those data as a category index with a view to enhancing the accuracy of predicting the conversion of a patient's MCI state to Alzheimer's state inside the time period of two years.

The studies started with a total of 86 patients who were initially diagnosed with MCI for two years throughout which 25 sufferers had been converted to AD. We suggest that numerous EEG biomarkers can expect transformation from MCI to advert more often than not related to activity inside the beta-frequency variety (thirteen–30 Hz). With the aid of incorporating six EEG biomarkers into the diagnostic index the use of logistical regression, the forecast stronger in comparison to the classification using person biomarkers with a sensitivity of 88% and a specificity of 82%, compared to a sensitivity of 64%.

iv. False-Discovery-Rate Correction(Storey J. et al 2002):

The false discovery rate (FDR) is a way of conceptualizing the rate of type I errors in null speculation testing whilst engaging in more than one comparisons.

For a single-hypothesis test, this approach generally controls the type I error rate, a compound errors rate is regulated for multiple-speculation checking out. As an instance, traditionally controlling the false discovery rate FDR entails intricate techniques of sequential "p"-value rejection based totally on the statistics found. The FDR traditionally consists of complex sequential techniques of "p"-value refusal based at the information located. Even as a sequential "p"-value procedure fixes the error rate and "estimates" its respective region of rejection, we suggest the reverse approach-we" repair "the area of rejection and then estimate its respective error rate.

v. State-Of-The-Art Aar Algorithm (R. Cassani et al:2014):

The historical development brand new computational procedures and duality idea in GP has, for the maximum part, taken place outdoor brand new the common approaches in nonlinear programming (NLP).

As EEG signals are cutting-edge multiple artifacts, consisting of eye, muscle, motion, and environment. existing diagnostic structures commonly rely upon professional clinicians to manually choose artifact-free epochs from the amassed EEG multi-channel statistics to overcome this limitation and manually choosing is a tedious and time-consuming method that semi-automates the diagnostic scheme. To overcome this downside AAR Algorithms (Automated Artifact Removal) are used on this method. This article includes three automated Artifact removal Algorithms along with Statistical Artifact Rejection (SAR), Blind Source Separation Based on Second Order Blind Identification and Canonical Correlation Analysis (BSS-SOBI-CCA), and Wavelet Greater Independent Component Analysis (wICA).

vi. Wavelet Enhanced Independent Component Analysis (N. Castellanos et al:2006):

Recovering EEG brain signals: artifact suppression with this which entails separation of measured signals into statistically independent components or sources, accompanied with the aid of rejection of those deemed artificial. This approach is primarily based on making use of the wavelet threshold as an intermediate step no longer to the raw EEG observed however to the de-mixed autonomous parts. It enables the neural activity in "artificial" components to be recovered. This entails quantifying the distortions of the cerebral portion of EEGs added through the ICA and wICA artifact suppressions in time and freely using semi-simulated and actual EEG recordings. Independent thing analysis (ICA) has been shown to be beneficial in EEG recordings to suppress artifacts. It consists of isolating measured signals into components or sources which might be statistically autonomous, observed through rejecting those considered artificial. The thing confirmed that a "leak" of interesting cerebral activity into artificially categorized parts implies that one will lose that interest. To overcome this hassle, but it was advised that A brand

new wavelet-enhanced ICA (wICA) technique that applies the wavelet threshold as an intermediate step not to the observed raw EEG but to the independent de-mixed components. It permits the neural interest in "artificial" components to be recovered. Using semi-simulated and real EEG recordings, we quantify the distortions of the EEG cerebral element supplied in time and frequency domains through the ICA and wICA artifact suppressions.

vii. Higuchi's Fractal Dimension (HFD)(Tyler Staudinger et al: 2011):

HFD as a nonlinear approach, has occupied a critical location in the analysis of biological signals. Using HFD has evolved from EEG and single neuron activity analysis to the most recent application in automated assessments of various medical situations. The objective is to offer an up to date overview of the HFD approach applied in simple and clinical neurophysiological studies. P-values had been calculated between the two groups to detect EEG channels that have a considerable association with AD. K-K-means neighbor algorithm was used to compute the distance among AD patients and normal subjects in the category (Al-Nuaimi AH et al: 2017).

In particular HFD (Higuchi's Fractal measurement) is a quantitative degree of time collection complexity derived from fractal theory. The outcomes show that the HFD seems to comprise applicable records, commonly within the parietal and temporal areas. The AD institution had decreased HFD values, indicating much less complex signals are generated by means of AD topics. The life of neurofibrillary plaques and tangles can be ascribed to this reduced complexity.

viii. Symbolic Sequence Decomposition (S. Tong et al :2004):

It's a technique which can be used to transform a raw series right into a symbolic series. This approach offers the advantage to create more numerical computations seeing that these discrete symbolic time collection are represented in binary codes (R. Sneddon et al: 2005). Every region is associated with a unique symbol and these symbols are involved in creating another series of facts, called the symbol series, out of the original collection depending at the place which the original value falls into (C. S. Daw et al:2003).

ix. Multiscale Entropy (MSE)(Tomoyuki Mizunoa et al: 2010):

Multiscale entropy extends sample entropy to multiple time scales or signal resolutions to provide an extra perspective whilst the time scale of relevance is unknown. Like any entropy measure, the aim is to make an assessment of the complexity of a time collection.

Multiscale entropy (MSE) is a lately suggested physiological complexity index based on entropy, which evaluates signals at various time scales. To test this technique as an assistance in elucidating Alzheimer's disease pathophysiology (AD), in comparison with traditional EEG assessment, the research examined MSE in resting EEG status activity.

x. Nonlinear Analysis Of EEG Via Tsallis Entropy (Taha, Dr. S et al:2014):

Tsallis entropy is a nonlinear measure for quantifying EEG data by using analyzing the variance of the signal in both a slow and rapid way. The research includes data gathering from Electroencephalograms (EEG) that become registered on every subject matter the use of Neuroscan devices from 64 scalp electrodes with a sampling charge of 500 Hz. The association of electrodes is the regular 10-20 scheme, in keeping with the American Clinical Neurophysiology Society guidelines.

Multiple areas have been studied for the ORNL protocol to find out the finest viable combos of electrodes to differentiate the subjects efficiently. There was no important difference within the qEEG ratios between every day and MCI sufferers using prefrontal versus posterior parietal areas ($p>0.14$) advised statistical evaluation of the consequences. The occipital ratio reached an extensive p-value, so the occipital ratio for the ORNL protocol appears to be prime.

xi. Bump Modeling (François B. Vialatte et al:2006):

Preprocessing, including artifacts removal and dimensionality reduction based on Blind Source Separation (BSS) or Independent component analysis (ICA).

The bump modeling method is a two-dimensional generalization of the Gaussian mesa function modeling method originally intended for ECG one-dimensional (electrocardiogram analysis) signals. It has been used to extract data from time-frequency maps in the current research.

The primary concept of this technique is to approximate a time-frequency map with a set of predefined basic parameterized features called bumps (non-overlapping or overlapping) ; thus, the map is represented by the set of bumps parameters, which is a very scarce map encoding, resulting in data compression rates ranging from one hundred to one thousand.

xii. Blind Source Separation For Signal Filtering (François Vialatte et al:2005):

A signal can be modeled as a linear combination of a finite amount of brain sources, with additive noise, according to the presently prevalent perspective of EEG signal processing. Blind source separation methods can therefore be used to decompose raw EEG information to subspace for brain signals and subspace for noise.

This technique uses the AMUSE algorithm (Algorithm for Multiple Unknown Signals Extraction) which is proved to be faster than vast majority of ICA (Independent Component Analysis) algorithms because of its ease of use as no parameters are needed.

In the research conducted in this method, PCA showed much worse results than AMUSE algorithm, which demonstrates the significance of AMUSE (or more generally, BSS/ICA algorithms with suitable ranking and clustering) for EEG filtering/enhancement. Furthermore, sparse bump modeling appeared to be a valuable tool for compressing information contained in EEG time-frequency maps.

xiii. EEG Window Length Evaluation (Katerina D. Tzimourta et al:2019):

A set of statistical and spectral characteristics calculated for each EEG rhythm is obtained, forming the characteristic vector that trained and tested the random forest classification. Six classification issues are discussed, which include discrimination on the basis of whole brain dynamics and independently from particular brain segments to highlight any changes in cortical areas.

xiv. Epoch-based entropy measure (Nesma Houmani et al:2018):

Epoch-based entropy measure for early testing of Alzheimer's disease was implemented in these researches (Hughes TF et al:2009, Julien C et al:2010) .This measure's reliability arises from the reality that it estimates the complexity of EEG signals not only locally over time (as do classical complexity measurements), but also spatially by estimating the complexity of the inter-channel. First method to distinguish SCI from AD of automatic classification.

8. COMPARATIVE REVIEW

Table1: Methods Overview

Methods	Results/Remarks
Neuroimaging (Nilesh Kulkarni et al: 2014)	Utilizes SPECT/MRI/PET. Used for Early Stages mostly but also effective for other stages of AD. Accuracy can be up to 95% according to results. Can be quiet expensive.
Independent Component analysis (ICA) (Co Melissant et al:2005)	Uses Automatic pattern recognition. Gathers Data from MRI. Performance is purely dependent on Data Sets.
Integrative EEG biomarkers to predict the diagnosis (Simon-Shlomo Poil et al:2013)	Predicts about Dementia Transforming into AD. The more Biomarkers are there the better the results are.
False-discovery-rate correction (Storey J. et al 2002)	Can lessen the number of false discovered patients, which makes it precise.
State-of-the-art AAR Algorithm (R. Cassani et al:2014)	Automated system with better precision. Useful for both early & disease's progressive stages. Combination of three algorithms.
Wavelet enhanced independent component analysis (N. Castellanos et al:2006)	Enables neural activities and the artificial parts to be redeemed. Separates signals into statistical autonomous parts. An improvement over previous iteration called wICA.
Higuchi's fractal dimension (HFD) (Tyler Staudinger et al: 2011)	Non-Linear Method, uses K-Means Algorithm for clustering patients from healthy ones. Automated & can be used in different Stages.
Symbolic Sequence Decomposition (S. Tong et al :2004)	Doesn't provide improvement over other methods but can perform best as a diagnostic tool as it is relatively faster.
Multiscale entropy (MSE) (Tomoyuki Mizunoa et al: 2010)	Extends sample entropy to multiple time scales or signal when time scale is unknown.
Nonlinear Analysis of EEG via Tsallis Entropy (Taha, Dr. S et	Used for reducing the complexity of EEG signals, reaching 82% of accuracy. Quantifies EEG data by variance.

Methods	Results/Remarks
al:2014)	
Bump Modeling (François B. Vialatte et al:2006)	Used multi-channel EEG sonification, Extracts "TF" components & transforming while keeping the original signal consistent. Efficient in the early stages of AD.
Blind Source Separation for Signal Filtering. (François Vialatte et al:2005)	Cheaper than SPECT/MRI/PET as only requires 21-channel EEG components. Prioritizes using AMUSE Algorithm over PCA or ICA.
EEG Window Length Evaluation (Katerina D. Tzimourta et al:2019)	High precision for the whole-brain classification ranging from 88.79-96.78%. Has six classifications. Limitation is no additional EEG pre-processing for artifacts removal was employed to minimize EMG or other interferences.
Epoch-based entropy measure (Nesma Houmani et al:2018)	Obtained highly accurate percentage for classifying SCI (Subjective Cognitive Disorder) and Alzheimer's affected individuals which is 91.6%.

9. CONCLUSIONS & FUTURE SCOPE

From this article, we tried to discuss about some of the most frequent methods of detecting Alzheimer's disease on researches published by numerous scientist & authors. From the knowledge we gathered from these various articles, we have discussed about the upsides, drawbacks and a general glimpse of the methods in brief. Numerous methods can be used to detect the disease at different stages like various types of Component Analysis/ EEG analysis/ signal analysis/ algorithms. For the future scope of this article, we would very much like to utilize our knowledge to concentrate research into one specific way of detecting Alzheimer's disease using new methodologies and also working on specific methods to improve upon the previous works that has been published already.

We are also eager to use EEG in our research as it seems to be inexpensive and convenient tool for detection of Alzheimer's in the early stages. Because inexpensiveness is a very important criteria for a developing country like Bangladesh to utilize it to detect Alzheimer's. In future it can be made portable which have motivated the authors to develop & work with this particular sector.

Lastly we hope that this comparative study of these well-established methods will help any interested beginner individual who wants to perform research in the field of Alzheimer's detection.

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