What Kills Our Mind? Unveiling the Mysteries with Longitudinal Insights from the Oasis Dataset Study

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Overview

Overview

Introduction

Random Coefficients Model:

- Handles data grouped at multiple levels (e.g., students in schools).
- Allows for individual variability in changes over time.
- Can manage both within-group and between-group differences.

Mean Response Model:

- Focuses on estimating the average change over time.
- Useful for examining overall trends and patterns.
- Ideal for data with a clear trajectory or growth pattern.

Fixed Effects Models, Time-Series Cross-Sectional (TSCS) Models...

MRI and Alzheimer's

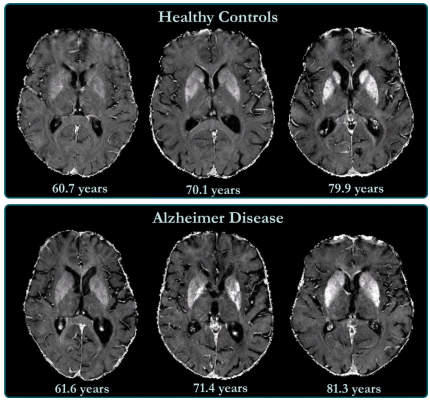

Figure 1: Evolution of a person's brain suffering from Alzheimer's disease.

Source: https://healthimaging.com/topics/medical-imaging/neuroimaging/imaging-monitor-effects-new-alzheimers-drug

Dataset Overview

The Open Access Series of Imaging Studies (OASIS) is a project aimed at making neuroimaging data sets of the brain freely available to the scientific community.

Subj ID	MRI ID	Group	Visit	MR Delay	M/F	Hand	Age	EDUC	SES	MMSE	CDR	eTIV	nWBV	ASF
OAS2_0001	OAS2_0001_MR1	Nondemented	1	0	M	R	87	14	2.0	27.0	0.0	1987	0.696	0.883
OAS2_0001	OAS2_0001_MR2	Nondemented	2	457	M	R	88	14	2.0	30.0	0.0	2004	0.681	0.876
OAS2_0002	OAS2_0002_MR1	Demented	1	0	M	R	75	12	NaN	23.0	0.5	1678	0.736	1.046
OAS2_0002	OAS2_0002_MR2	Demented	2	560	M	R	76	12	NaN	28.0	0.5	1738	0.713	1.010
OAS2_0002	OAS2_0002_MR3	Demented	3	1895	M	R	80	12	NaN	22.0	0.5	1698	0.701	1.034

Table 1: Sample Data from the Dataset

Variable Definitions

Demographics Info

- **Subject.ID**: Subject Identifier
- **MRI.ID**: MRI Identifier
- **Group**: Dementia Group
- **Visit**: Visit Number
- **MR.Delay**: MRI Delay
- **M/F**: Gender
- **Hand**: Handedness
- **Age**: Age

Clinical Info

- **EDUC**: Education
- **SES**: Socioeconomic Status
- **MMSE**: Mental State Score
- **CDR**: Dementia Rating

Anatomic Volumes

- **eTIV**: Intracranial Volume
- **nWBV**: Brain Volume (Normalized)
- **ASF**: Scaling Factor

Overview

Literature Review

Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 8, 5616-5634

Alzheimer's Diseases Detection By Using MRI Brain Images: A Survey:

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Abstract:

Alzheimer's disease (AD) is one of the most common public health issues the world is facing today. This disease has a high prevalence primarily in the elderly accompanying memory loss and cognitive decline. At present, there is no specific treatment for this disease. Early and accurate diagnosis of AD become a challenging task which many authors have developed numerous computerized automatic diagnosis systems utilizing neuroimaging and other clinical data. These studies have identified the importance of structural differences in brain regions such as the entorhinal cortex, hippocampi, and other brain areas between Alzheimer-affected brain and a healthy brain. Magnetic Resonance Imaging (MRI) scanners have proven the potentiality to study AD-related brain structural variations, consequently, structural MR imaging techniques have been exploited as a significant diagnostic tool when reporting a cognitive decline. The researchers showed promising results not only for excluding non-neurodegeneration causes, but rather to accurately identify AD neurodegenerations. Machine Learning (ML) and subfield deep learning (DL) has become prominent techniques for detecting AD at their early stages. Here, brief literature of the previously adopted AD diagnosis techniques will be reviewed, including traditional diagnosis methods, and advancing to the relevant modern employment of DL in AD diagnosis.

INDEX TERMS: Alzheimer's disease, Beta Amyloids (Aβ), neuroimaging, Structural MRI, Deep Learning, convolution neural network.

I INTRODUCTION:

Dementia is a broader term of brain disease that causes a decline in the person's ability to think, remember, and affects his behavioral abilities in his daily life. Dementia ranges in severity from the mildest stage, when it just begins to affect a person's ability to function, to the most severe stage, when the person is completely reliant on others for his most basic daily activities [1] .

The most common type of dementia is Alzheimer's disease (AD), an age-related neurodegenerative disorder that affects the brain, resulting in cells' death and overall brain volume loss. This leads to cognitive mental problems such as memory loss and confusion; which is one of the most prominent characteristics in Alzheimer's patients [2].

Beta amyloids and tau tangles, abnormal protein deposits in the brain, cause AD by damaging brain cells in the memory and mental functions areas. When more neurons die, entire brain areas shrink, resulting in cognitive function issues, which are the primary symptoms of AD [3]. As the disease

(a) Alzheimer's and MRI

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Article

Explainable AI-based Alzheimer's Prediction and Management Using Multimodal Data

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Abstract: According to the World Health Organization (WHO), dementia is the seventh leading reason of death among all illnesses and one of the leading causes of disability among the world's elderly people. Day by day the number of Alzheimer's patients is raising. Considering the increasing rate and the dangers, Alzheimer's disease should be diagnosed carefully. Machine learning is a potential technique for Alzheimer's diagnosis but general users do not trust machine learning models due to the black-box nature. Even, some of those models do not provide the best performance because of using only neuroimaging data. To solve these issues, this paper proposes a novel explainable Alzheimer's disease prediction model using a multimodal dataset. This approach performs a data-level fusion using clinical data, Freesurfer MRI segmentation data, and psychological data. For Alzheimer's disease vs cognitively normal prediction, the random forest classifier provides 100% accuracy. Furthermore, Alzheimer's disease and non-Alzheimer's dementia should be classified properly because their symptoms are similar. To the best of our knowledge, we are the first to present a three-class classification on Alzheimer's disease vs cognitively normal vs non-Alzheimer's dementia and achieved 99.86% accuracy using an ensemble model. Besides, a novel Alzheimer's patient management architecture is also proposed in this work..

Keywords: Machine learning; Dementia; Data-level fusion

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1. Introduction

Alzheimer's disease (AD) is a chronic, progressive neurodegenerative disease that gradually deteriorates memory and cognitive abilities, and it is the most common cause of dementia in older people. Currently, more than 55 million people live with dementia around the globe. Forgetting recently acquired information, important dates or events, difficulty in performing simple daily works, and repeatedly asking the same questions are all classic early symptoms of Alzheimer's disease. In the final stage, patients' behavioral changes are also observed. The disease strikes the majority of people in their mid-60s. Scientists agree that the root cause of this neurological disease is a combination of genetics, long-term environmental conditions, and lifestyle [1]. Though some medications are available, AD is not curable, and the damage it causes is permanent. The most common cause of death of Alzheimer's patients is aspiration pneumonia [2].

Even though Alzheimer's disease is incurable, predicting Alzheimer's can help to identify patients who are at risk of this disorder. As dementia is a common symptom for AD and non-AD patients, proper diagnosis is important. Here, non-AD dementia means

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(b) XAI and Alzheimer's

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Classification and Development of Tool for Heart Diseases (MRI Images) Using Machine Learning

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Abstract— **Heart diseases are one of the major killers worldwide. Early detection of heart disease such as Global Hypokinesia can reduce this global burden. Computational method has potential to predict disease in early stages automatically and especially helpful in resources limited countries. Computational method to predict global hypokinesia based on confirms cases of global hypokinesia through MRI was developed. Almost all feature extraction method was used on MRI images and model was generated on merged and different images separately. High accuracy of model independent test set justified our approaches and reliability of model. The newly developed was implemented in python and available for open use.**

Keywords—cp-charm; cellprofiler; Global hypokenesia; feature extraction; MRI; prediction.

I. INTRODUCTION

Nearly half of all African-American adults have some form of cardiovascular disease, 48 percent of women and 46 percent of men. Heart disease is the No. 1 cause of death in the worldwide and the leading cause of death in the United States, killing over 375,000 Americans a year [5]. So automate detection for such a disease is important. Global Hypokinesia is a disease in which heart is weak which serves blockage of coronary arteries. The various portions of the heart such as ventricles, walls, membranes and arteries etc. are deteriorated and work abnormally in Global hypokinesia. Global hypokinesia can be a reason of heart failure due to low output of heart. Symptoms of global hypokinesia are water and fluid retention, irregular or fast heartbeat, pulmonary congestion, fatigue, dizziness and weakness [2]. The test used to detect Global Hypokinesia is MRI test. The image is described as homogeneous areas according to one or several a priori attributes [7].

MRI is popular and reliable method for testing Global hypokinesia so computational method developed by using MRI images Magnetic resonance imaging (MRI) is noninvasive test that used to recognize medical conditions. MRI procedures a commanding magnetic field, radio frequency pulses and a computer system to yield thorough images of organs, soft tissues, bone and almost all other internal body parts. MRI does not work with harmful ionizing radiation which means x-rays. MRI makes physicians to diagnose various parts of body and define occurrence of definite diseases. The images output of machine can be used to inspected on a printed form or in a CD and transmitted electronically. To produce whole images of the structures inside the heart in cardiac MRI uses a powerful magnetic field, radio waves and a computer system. MRI is used to diagnose cardiac disease and to estimate the heart's structure and role in patients through congenital heart disease.

The threat of having heart disease is worldwide so there is need of a tool which can predict disease on the bases of MRI images. So the tool is developed to predict global hypokinesia on bases of MRI images. The data is collected from IGMC Shimla. The method used in tool was segmentation free. The output can be taken directly by software and will predict disease automatically. Pre-processing of MRI pictures is a step in image analysis which achieve image enhancement and noise reduction methods which are taken to increase image quality, then some morphological operations are applied to detect the Global hypokinesia in the patients through images [4] [1]. The MRI image is shown in Fig 1

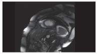

Fig 1: MRI test image

The morphological operations are basically applied on some assumptions about the size and shape of the heart and in the end the heart is mapped onto the actual gray scale image with 255 intensities to create noticeable heart in the image [3].

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(c) Heart Diseases and ML

Baglat et al. (2020), Jahan et al. (2023), Marcus et al. (2010), Sharma et al. (2016), Sh et al. (2022)

Overview

Exploratory Analysis

Table 1: Summary of the OASIS Longitudinal Dataset

Variable	Description	Value Range or Unique Values
Subject.ID	Unique identifier for each subject	150 unique IDs
MRI.ID	Identifier for each MRI scan	373 unique IDs
Group	Classification of subject	Nondemented, Demented, Converted
Visit	Number indicating the visit sequence	1 to 5
MR.Delay	Time delay between MRI scans	0 to 2639 days
M.F	Gender of the subject	Male (M), Female (F)
Hand	Handedness (all right-handed)	Right (R)
Age	Age of the subject	60 to 98 years
EDUC	Years of education	6 to 23 years
SES	Socioeconomic status	1 (highest) to 5 (lowest)
MMSE	Mini-Mental State Examination score	0 to 30
CDR	Clinical Dementia Rating	0 to 2
eTIV	Estimated total intracranial volume in mm^3	1106 to 2004 mm^3
nWBV	Normalized whole-brain volume	64.4% to 83.7%
ASF	Atlas scaling factor	0.876 to 1.587

Figure 3: Closer look into the features of the dataset. Handedness, for example was excluded.

Feature importance

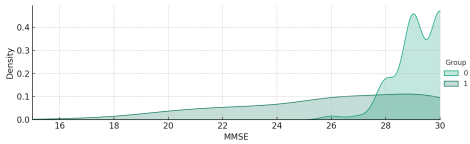

Figure 4: MMSE Distribution. The chart shows that the Nondemented group has higher scores than the Demented group.

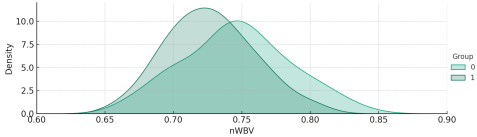

Figure 5: nWBV Distribution. The chart indicates that the Nondemented group has a higher brain volume ratio than the Demented group.

MMSE - Mini-Mental State Examination score
nWBV - Normalized whole-brain volume

Choosing the features for Longitudinal Analysis

Coefficients Model, represented as:

$$\text{CDR} \sim \text{MMSE} + \text{nWBV} + \text{Age} + \text{Visit} + (1|\text{SubjectID})$$

The Mean Response Model, formulated as:

$$\text{CDR} \sim \text{MMSE} + \text{nWBV} + \text{Age} + \text{Visit}$$

$1|\text{SubjectID}-$ represents a random intercept for each unique subject. It accounts for individual differences in the baseline value of the dependent variable and acknowledges the correlation between multiple measurements from the same subject.
CDR - Clinical Dementia Rating. Is it also the dependent variable.

Longitudinal Analysis

Model	AIC	BIC
Random Coefficients Model	372.69	403.64
Mean Response Model	458.94	486.03
RC Model (Converted Group)	36.39	46.05
MR Model (Converted Group)	34.39	42.44
RC Model (Converted Progression)	36.39	46.05
MR Model (Converted Progression)	34.39	42.44

Table 2: AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) results. Two different forms of measuring how well the models fit the data.

Plotting the sad truth of Alzheimer's data analytics

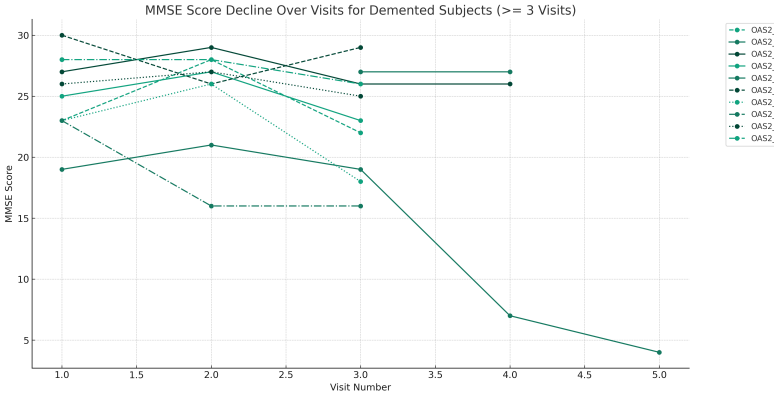

Figure 6: Evolution of the Mini-Mental State Examination score. In all cases, the end results is a lower value compared to the starting one, indicating a decline in mental capacity.

Conclusion

- Random Coefficients Model: Found a significant negative relationship between Alzheimer's disease progression (Clinical Dementia Rating) and MMSE scores, nWBV, and age. Positive relationship with visit number indicates increasing dementia severity over time.
- Mean Response Model: Showed similar negative correlations between MMSE, nWBV, age, and dementia progression across the dataset.
- 'Converted' Group Analysis: Different disease progression pattern observed, suggesting specific factors influencing Alzheimer's disease progression in initially nondemented individuals.
- Longitudinal Analysis: Highlighted progressive cognitive decline in Alzheimer's disease, especially in subjects with three or more visits, showing consistent MMSE score decrease.

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Questions

Questions, feedback, discussion