Cognitive care Early Intervention of Alzheimer's disease

A project report

Submitted by

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1.INTRODUCTION

1.1 Project Overview

Alzheimer's disease (AD) is a progressive and irreversible neurological disorder that affects the brain, leading to memory loss, cognitive impairment, and changes in behavior and personality. It is the most common cause of dementia among older adults and is characterized by the buildup of abnormal protein deposits in the brain, including amyloid plaques and tau tangles. The exact cause of Alzheimer's disease is not yet fully understood, but it is believed to be influenced by a combination of genetic, environmental, and lifestyle factors. Age is also a significant risk factor, with the risk of developing the disease increasing significantly after the age of 65.The early symptoms of Alzheimer's disease may include mild memory loss, difficulty with problem-solving, and changes in mood or behavior. As the disease progresses, these symptoms become more severe, with individuals experiencing significant memory loss, difficulty communicating, and a loss of the ability to perform daily activities. By using deep learning models like Xception to analyze medical imaging data, it may be able to identify early signs of Alzheimer's disease before symptoms become severe. This can help healthcare providers to provide early treatment and support for patients and their families, ultimately leading to better outcomes for all involved.

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1.2 Purpose

By using deep learning models like Xception to analyze medical imaging data, it may be able to identify early signs of Alzheimer's disease before symptoms become severe. This can help healthcare providers to provide early treatment and support for patients and their families, ultimately leading to better outcomes for all involved.

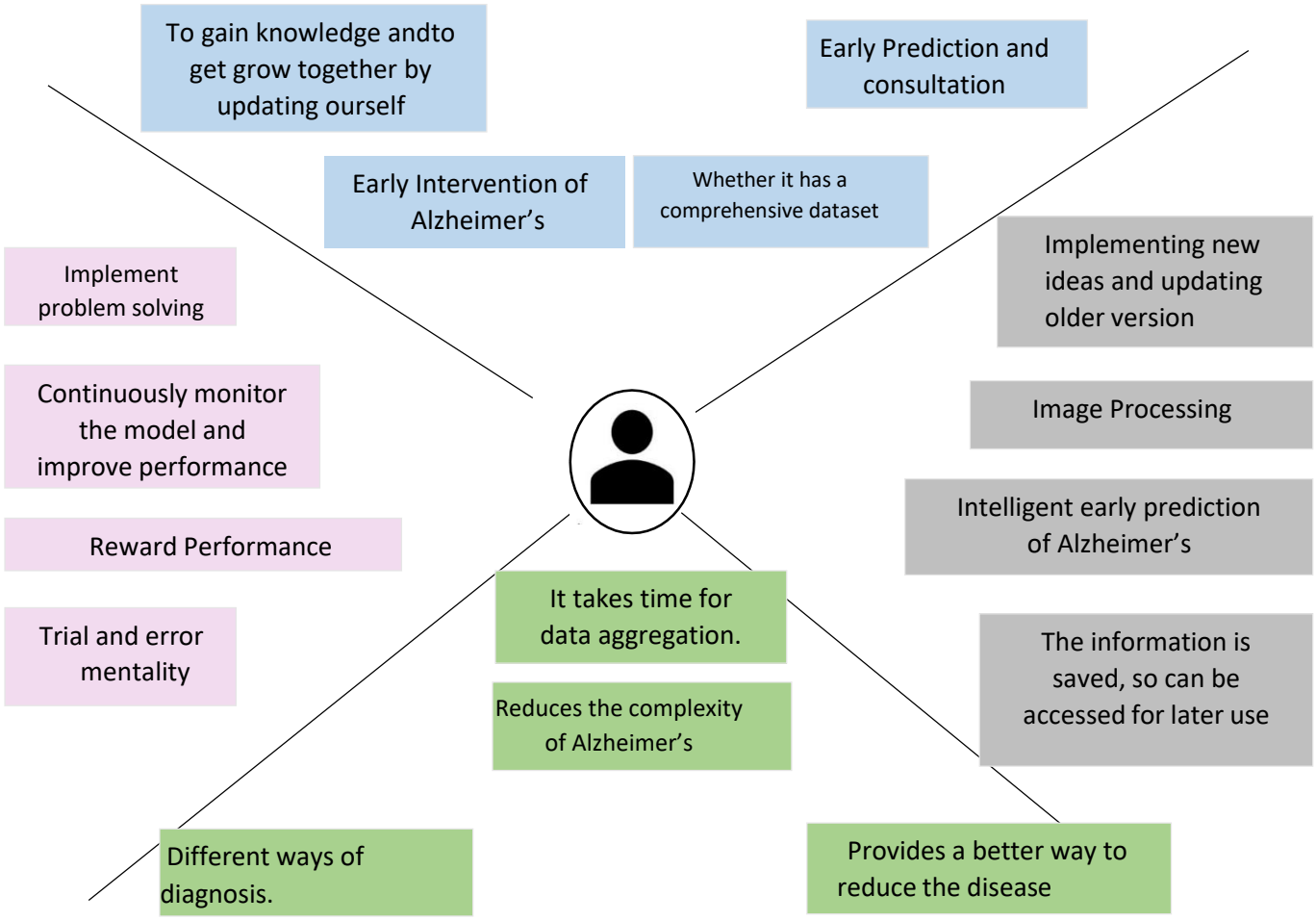
Alzheimer's Disease is predicted using ML algorithms by using a feature selection and extraction technique, and the classification is conducted based on the oasis longitudinal dataset. The different techniques (2) involved in analyzing brain images for diagnosing diseases of the brain to provide a brief overview.

2.1 PROBLEM STATEMENT DEFINITION

In the existing system it is difficult to identify if a person is suffering from Alzheimer's disease. It can be only done with the help of clinical history and by knowing if the person has some genetic disorder. Sometimes it is also possible that the doctor may not be able to detect the disease. Alzheimer's disease (AD), a type of dementia, is characterized by progressive problems with thinking and behavior that starts in the middle or old age. The symptoms usually develop slowly and get serious enough to interfere in daily life. Although the paramount risk factor is oldness but AD is not just an old age disease. In its early stages, the memory loss is mild while in the later stages, the patient's conversation and their ability to respond degrades dramatically. The current treatments cannot stop Alzheimer's disease (AD) from developing but early diagnosis can aid in precluding the severity of the disease and help the patients to improve the quality life. It has been reported that the number of individuals effected with AD will double in next 20 years, while in 2050, 1 out of 85 individuals will be effected. Thus the accurate diagnosis especially for the early stages of AD is very important.

2.2 EMPATHY MAP

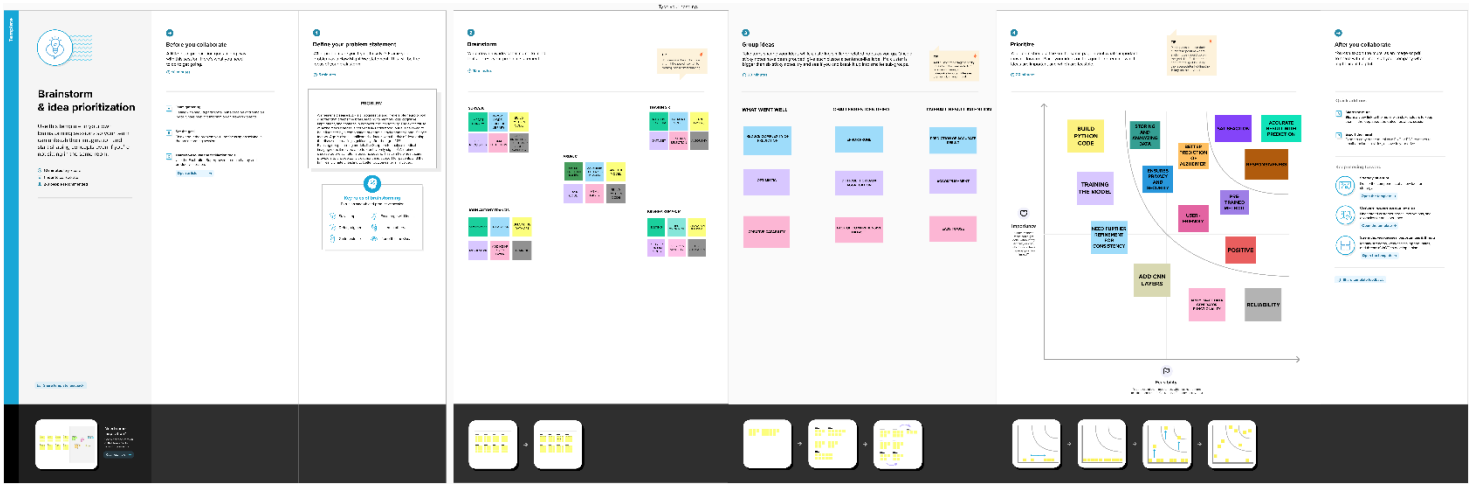
Empathy maps are useful tools for understanding the needs, thoughts, emotions and behaviors of users or stakeholders. In the case of a remote gas pipeline tel temperature monitoring system, the empathy map can help us gain insights into the experiences and perspectives of the people involved. Here's an example of an empathy map for this scenario



Pain		Gain		
Difficulties in data aggregation	It works based on a Probability from the given dataset, so that inaccurate dataset will give inaccurate outputs.	Easier intervention	Slow down the progression rate of the disease	Comfortable to use

2.3 IDEATION & BRAINSTROMING

Brainstorming is a creative problem-solving technique used to generate ideas and explore potential solutions for a specific topic or challenge. In the context of early intervention of Alzheimer's disease, brainstorming involves gathering a group of individuals with relevant expertise or knowledge and encouraging them to contribute ideas and suggestions for the system's design, functionality, and implementation. During a brainstorming session, participants are encouraged to think freely and express their ideas without judgment or criticism. The goal is to generate a large quantity of ideas, regardless of their feasibility or practicality at the initial stage. This allows for a wide range of perspectives and possibilities to be explored, which can later be refined and evaluated for their viability.



2.4 PURPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Early Intervention of Alzheimer's Disease using Machine Learning.
2.	Idea / Solution description	To create a web application that can be used to predict the occurrence of Alzheimer's.
3.	Novelty / Uniqueness	The Machine Learning techniques (26,27) were applied to Alzheimer's disease datasets to bring a new dimension to predict Disease at an early stage.
4.	Social Impact / Customer Satisfaction	It reduces the complexity of prediction and thus the stages can be simplified.
5.	Business Model (Revenue Model)	The achievement of deep learning is much more reliable when associated with other published results on diverse datasets using different classification algorithms for early intervention of Alzheimer's.
6.	Scalability of the Solution	It must be able to process the data of multiple users at a time and must provide accurate result.

3. REQUIREMENT ANALYSIS

3.1 FUNCTIONAL REQUIREMENT

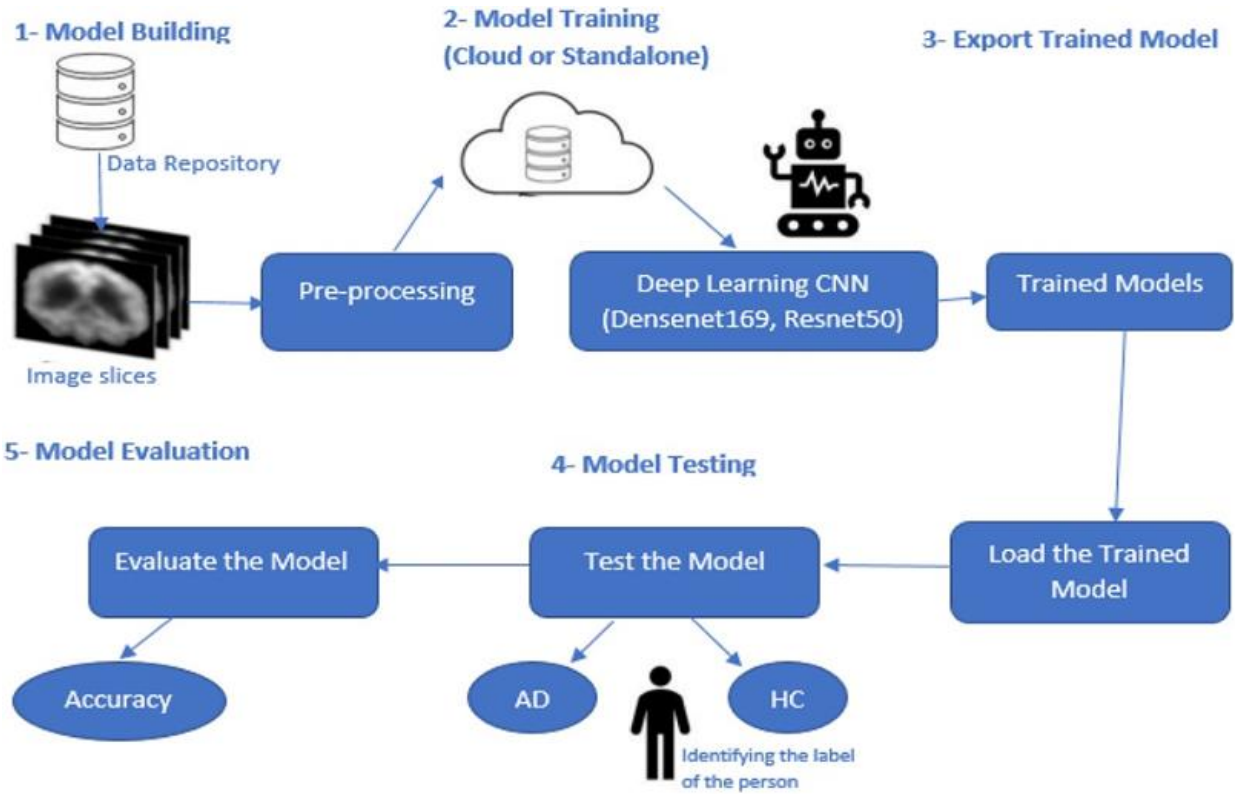
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
1	**User Registration**	Registration through Phone number Registration through Gmail
2	**User Confirmation**	Confirmation via Email Confirmation via OTP
3	**User Interface**	Create your profile and get sign in
4	**User Input**	Upload the dataset Upload the image as jpeg/png format
5	**Data Processing**	Evaluate the model using test dataset Train the dataset by DI algorithm Use Keras and Tensorflow for the accurate result of the trained CNN model
6	**Report Generation**	The final report of Alzheimer's disease for the given data set is displayed

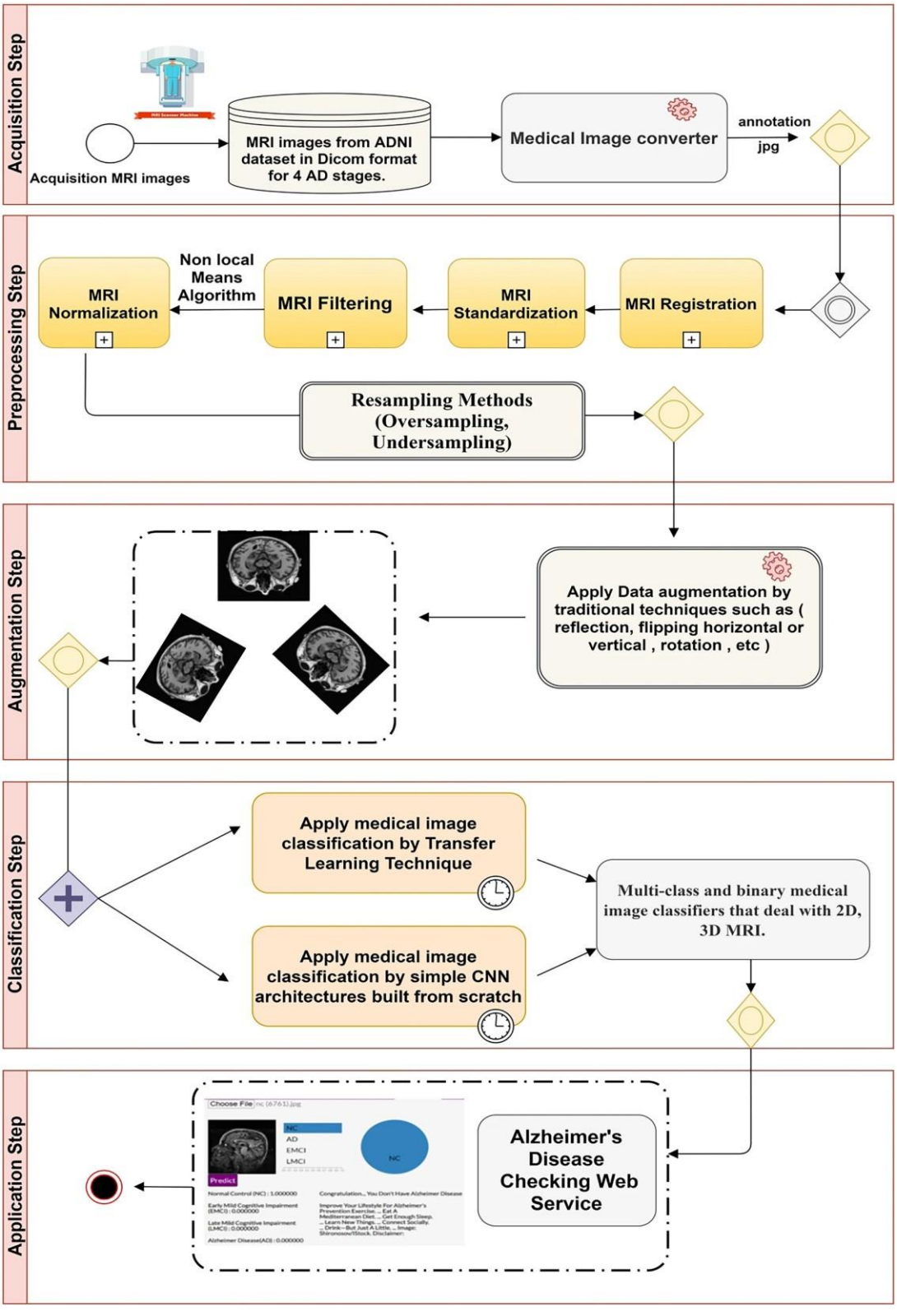
3.2 NON-FUNCTIONAL REQUIREMENT

FR No.	Non-Functional Requirement	Description
1	**Usability**	✓ Only authorized doctors could access the portal. ✓ The doctors could access a specific details of a patient by entering the patient serial number.
2	**Security**	✓ The data can be accessed only by authorized people .
3	**Reliability**	✓ By the usage of efficient algorithm, early intervention of Alzheimers disease in patient is displayed successfully.
4	**Performance**	✓ Greater accuracy in result.
5	**Availability**	✓ It only available for authorized doctors.

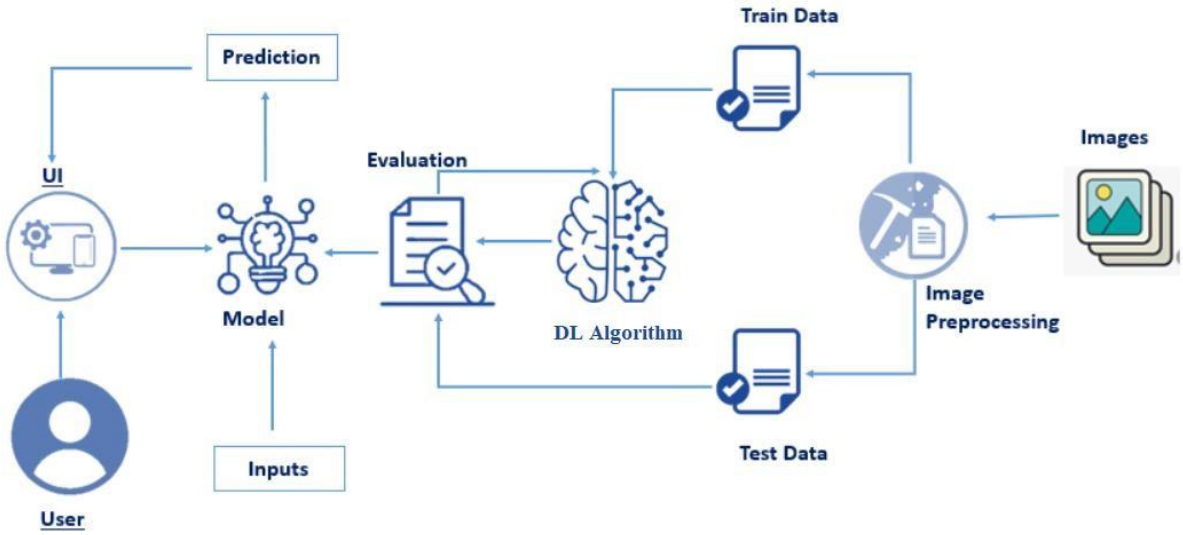
4.1 DATA FLOW DIAGRAM

A data flow diagram (DFD) for early intervention of Alzheimer's disease is a graphical representation that illustrates the flow of data and information within the system. It depicts the processes, data sources, data sinks, and data transformations involved in monitoring and managing the Alzheimer's disease.




Acquisition Step
Acquisition MRI images
MRI images from ADNI dataset in Dicom format for 4 AD stages.
Medical Image converter
annotation
jpg
Preprocessing Step
MRI Normalization
Non local Means Algorithm
MRI Filtering
MRI Standardization
MRI Registration
Resampling Methods (Oversampling, Undersampling)
Augmentation Step
Apply Data augmentation by traditional techniques such as (reflection, flipping horizontal or vertical , rotation , etc)
Classification Step
Apply medical image classification by Transfer Learning Technique
Apply medical image classification by simple CNN architectures built from scratch
Multi-class and binary medical image classifiers that deal with 2D, 3D MRI.
Application Step
Alzheimer's Disease Checking Web Service

4.2 SOLUTION &TECHNICAL ARCHITECTURE



The technical architecture for early in tervention of Alzheimer's disease that defines the structure and organization of the system's technological components and their interactions to enable the monitoring and management that predict and evaluate the process of Alzheimer's.

4.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
Customer (Web user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Surya. K
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Krishna Kumar. M
		USN-3	As a user, I can register for the application through Gmail		Medium	Tarun. SK

	Login	USN-4	As a user, I can log into the application by entering email & password		High	John Antony Fracis
	Dashboard	USN-5	As a user, the details of the patient are entered		High	Arun C
		USN-6	Page redirected to data collection phase		Medium	Surya. K
		USN-7	Patient MRI data set are uploaded		High	Krishna Kumar. M
		USN-8	The output of the processed data set is shown on the screen		High	Tarun SK
Database Administrator	Server	USN-1	The login credentials of the user are stored and managed		High	John Antony Francis
		USN-2	The patient details and the MRI datasets are saved		High	Surya. K
Administrator (Person-1)		USN-1	The collected dataset is verified and processed using deep learning		High	Arun. C
		USN-2	The output data is brought up to the web user		High	Krishna Kumar. M

5. CODING AND SOLUTIONING

5.1 FEATURE 1

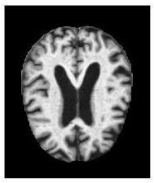
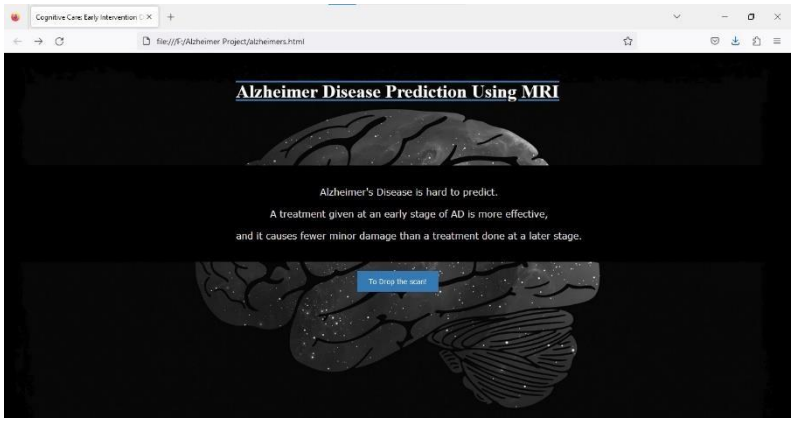
In this step we perform feature extraction and selection methods from sci-kit learn python libraries. For feature selection, we have used methods like simple bag-of-words and n-grams and then term frequency like TF-IDF(teamfrequency-inverse document frequency) weighting. Feature extraction can be done by finding the correlation among the dataset using heat map.

6. RESULTS

6.1 PERFORMANCE METRICS

The extracted features are fed into different classifiers. We have used Naive-Bayes, KNN (K-Nearest Neighbor), SVM(Support Vector Machine)and Random forest classifiers from sklearn. Each of the extracted features were used in all of the classifiers. Once fitting the model, we compared the f1 score and check the confusion matrix. With the help of the features extracted we would find the best classifier model for giving the result.

Our finally selected and best performing classifier algorithm is used. It takes a patient health record as input from user then model is used for final classification output that is shown to user along with probability of truth.

S.No.	Parameter	Values	Screenshot
1.	Model Summary	Early Intervention of Alzheimer's disease using deep learning Web Page	Out[4]:  *Path setting for Test and Train* In [5]: testPath=r"/content/Alzheimer_s Dataset/test" trainPath=r"/content/Alzheimer_s Dataset/train" *Importing the Libraries* In [6]: from tensorflow.keras.layers import Dense,Flatten,Input from tensorflow.keras.models import Model from tensorflow.keras.preprocessing import image from tensorflow.keras.preprocessing.image import ImageDataGenerator, load_img from tensorflow.keras.applications.xception import Xception, preprocess_input from glob import glob import numpy as np import matplotlib.pyplot as plt 

7. ADVANTAGES & DISADVANTAGES

The development of this work was motivated not only by medical purposes but also for the non-unified criteria regarding the usage of support vector machine and convolutional neural networks. Progressively, medicine and artificial intelligence tend to operate together and are proving to obtain outstanding results with respect to enhancing people's lives. The limits of this symbiosis are still uncertain, although it seems undeniable that, from such

combination, we are entering a new era in science, here, early in the 21st century. Considering our results, the following conclusions can be highlighted:

• It is possible to detect the early stages in Alzheimer's disease and this prediction can be as precise as the prediction of dementia itself. Significant memory concern (SMC) and early mild cognitive impairment (EMCI) have been proven to have an effect on the brain that can be detected and measured. Patients with early symptoms of dementia can be localized and preventive treatments can be applied.

• If the MRI images reach a high level of normalization and enough samples are accessible it is possible to build an SVM classifier able to predict Alzheimer's stages with an F1 score higher than 99.7%. As mention throughout the research, a key point of this investigation is the high quality of the dataset and the segmentation, bias correction and spatial normalisation applied by SPM12 [11,12] beforehand. The large number of samples (6,028) used it also relevant when compared with similar investigations [10]. The results show that our model has outperformed other modern experiments [5–7,14,24,25]. A more detailed comparison with some of the most promising investigations conducted to date is made in Table.

• In MRI images, some slices are more informative than others i.e., there are parts in the brain that contain more information and can be used more precisely to provide a diagnosis of the patient. Of the available slices in our dataset, slice 82 demonstrated the best results. This slice is located in the coronal plane, confirming the conclusions exposed by Luis Balderas in his thesis [9].

• In order to give a more accurate diagnosis, it is better to process all the information available in the brain rather than considering located regions only. Even if the disease has a more noticeable impact on specific regions, the information distributed throughout the brain's mass makes a difference when seeking optimal results.

• Both SVM and CNN approached competent performances. Nevertheless, SVM stands out above CNN. A possible explanation for this is the normalization and regularity of the data. Since the available images are already resized, and the classifier is built using delimited and localized variation of the imaged zones, the edge identification power of CNN does not beat the capacity of SVM

to allocate samples in Rn , n ∈ N and group them using the partitions generated by its trained hyperplane.

• The Mallat algorithm, revealed in [26], can be used to access the wavelet coefficients at deeper levels of the approximation image, LL. These coefficients are still very informative, exposing the power of the wavelet transform even in today's image classification tasks. Using the wavelet coefficients from the approximation image at level four gave an outstanding F1 score of 0.9979. This classifier, which used all the available coefficients from the set of slices, performed better than slice-isolated classifiers accessing wavelet coefficients at level three.

• PCA performs better than regular feature selection algorithms when facing image classification problems where data has certain continuity properties. Features are highly correlated with each other and present small variations. Applying feature selection could lead to missing wider anomalies that would otherwise be detected using a dimensionality reduction system. Disease's diagnosis using MRI is an open and extensive line of research. To continue and improve the steps followed in this investigation, I suggest these possible lines:

• It would be possible to access a higher level of detail either by using a machine with better specifications or performing mini-batch training techniques. This approach could lead to obtaining a more informative training dataset. Examples of this include using wavelet coefficients at lower levels or training a CNN classifier using all the available images as input.

• Investigate whether accessing different types of wavelet coefficients (diagonal, horizontal or vertical) can lead to a better outcome in F1 score or not.

• Research on the structure of CNN models to develop smarter and more suitable networks using different distribution and types of convolutional layers.

• Develop new paradigms of research to process 3D images and investigate the possible use and applications of the 3D wavelet transform.

8. CONCLUSION

This study is based on the comparison and evaluation of recent work done in the prognosis and prediction of Alzheimer's disease using machine learning

methods. Explicitly, the recent trends with respect to machine learning has been revealed including the types of data being used and the performance of machine learning methods in predicting early stages of Alzheimer's. It is obvious that machine learning tends to improve the prediction accuracy especially when compared to standard statistical tools. However, based on the review, the clinical diagnosis were not 100% accurate, as pathological verification was not provided which consequently introduce uncertainty in the predicted results.

9. FUTURE SCOPE

- It can be built into a proper user interface application so that it is easily accessible to everyone.
- It can be transferred as a tool in hospitals so that it helps the patients with Alzheimer's disease
- Alzheimer's Disease is predicted using ML algorithms by using a feature selection and extraction technique, and the classification is conducted based on the oasis longitudinal dataset. The different techniques (2) involved in analyzing brain images for diagnosing diseases of the brain to provide a brief overview.

10. APPENDIX

SOURCE CODE

Here some source code for early intervention of Alzheimer's disease

```
from google.colab import drive

drive.mount('/content/gdrive')

!unzip /content/gdrive/MyDrive/NM/Alzheimers.zip
```

```
import tensorflow as tf

img=tf.keras.preprocessing.image.load_img('Alzheimer_s Dataset/test/MildDemented/26 (19).jpg')

img

testPath=r"/content/Alzheimer_s Dataset/test"

trainPath=r"/content/Alzheimer_s Dataset/train"

from tensorflow.keras.layers import Dense,Flatten,Input

from tensorflow.keras.models import Model

from tensorflow.keras.preprocessing import image

from tensorflow.keras.preprocessing.image import ImageDataGenerator, load_img

from tensorflow.keras.applications.xception import Xception, preprocess_input

from glob import glob

import numpy as np

import matplotlib.pyplot as plt

from tensorflow.keras.preprocessing.image import ImageDataGenerator as IDG

IMG_SIZE=180

IMAGE_SIZE=[180,180]

DIM=(IMG_SIZE,IMG_SIZE)

ZOOM=[.99,1.01]

BRIGHT_RANGE=[0.8,1.2]

HORZ_FLIP= True

FILL_MODE="constant"
```

```
DATA_FORMAT="channels_last"

WORK_DIR="/content/Alzheimer_s Dataset/train"

work_dr=IDG(rescale=1./255, brightness_range=BRIGHT_RANGE,
zoom_range=ZOOM, data_format=DATA_FORMAT,
fill_mode=FILL_MODE, horizontal_flip=HORZ_FLIP)

train_data_gen=
work_dr.flow_from_directory(directory=WORK_DIR,
target_size=DIM, batch_size=6500, shuffle=False)

train_data, train_labels= train_data_gen.next()

print(train_data.shape, train_labels.shape) #before oversampling

from imblearn.over_sampling import SMOTE

sm= SMOTE(random_state=42)

train_data, train_labels= sm.fit_resample(train_data.reshape(-
1,IMG_SIZE*IMG_SIZE*3),train_labels)

train_data=train_data.reshape(-1,IMG_SIZE,IMG_SIZE,3)

print(train_data.shape,train_labels.shape)

#the output data gets doubled due to oversampling

from sklearn.model_selection import train_test_split

train_data, test_data, train_labels, test_labels=
train_test_split(train_data,train_labels,test_size=0.2,
random_state=42)

train_data, val_data, train_labels, val_labels=
train_test_split(train_data, train_labels, test_size=0.2,
random_state=42)

#splitting into train,test and validation sets
```

```
----------MODEL_BUILDING----------

IMAGE_SIZE=[180,180]

xcep_model= Xception(input_shape=IMAGE_SIZE+[3],
weights='imagenet',include_top=False)

for layer in xcep_model.layers:

    layer.trainable=False

from keras.layers import Dropout #import for Dropout

from keras.api._v2.keras import activations

from tensorflow.keras.models import Sequential

from tensorflow.keras.layers import SeparableConv2D,
BatchNormalization, GlobalAveragePooling2D

custom_inception_model= Sequential([

    xcep_model,

    Dropout(0.5),

    GlobalAveragePooling2D(),

    Flatten(),

    BatchNormalization(),

    Dense(512, activation='relu'),

    BatchNormalization(),

    Dropout(0.5),

    Dense(256, activation='relu'),

    BatchNormalization(),

    Dropout(0.5),

    Dense(128, activation='relu'),
```

```
    BatchNormalization(),
    Dropout(0.5),
    Dense(64, activation='relu'),
    Dropout(0.5),
    BatchNormalization(),
    Dense(4, activation='softmax'),
], name='inception_cnn_model')
import tensorflow
METRICS=[tensorflow.keras.metrics.CategoricalAccuracy(name='acc')
, tensorflow.keras.metrics.AUC(name='auc')]
custom_inception_model.compile(optimizer='rmsprop',
loss=tensorflow.losses.CategoricalCrossentropy(), metrics=METRICS)
history=custom_inception_model.fit(train_data,train_labels,
validation_data=(val_data, val_labels), epochs=30)
history=custom_inception_model.fit(train_data,train_labels,
validation_data=(val_data, val_labels), epochs=30)
custom_inception_model.save('adp.h5')
```

GITHUB & PROJECT VIDEO DEMO LINK

https://drive.google.com/file/d/1R0Tf99Q2goCaSgumTmMvsoCaNeKrh1MH/view?usp=drivesdk