IMPORT LIBRARIES

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import skimage.io
import os
import tqdm
import glob
import tensorflow

from tqdm import tqdm
from sklearn.utils import shuffle
from sklearn.model_selection import train_test_split

from skimage.io import imread, imshow
from skimage.transform import resize

from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import InputLayer, BatchNormalization,
Dropout, Flatten, Dense, Activation, MaxPool2D, Conv2D
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras.applications.densenet import DenseNet169
from tensorflow.keras.preprocessing.image import load_img,
img_to_array
```

IMPORT / VIEWING / PREPROCESSING DATASET

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

DATA AUGMENTATION

```
train_datagen = ImageDataGenerator(rescale = 1./255,
                                   rotation_range=30,
                                   zoom_range=0.2,
                                   horizontal_flip=True,
                                   vertical_flip=True,
                                   validation_split = 0.2)

valid_datagen = ImageDataGenerator(rescale = 1./255,
                                   validation_split = 0.2)

test_datagen  = ImageDataGenerator(rescale = 1./255)

train_dataset  = train_datagen.flow_from_directory(directory =
'drive/MyDrive/Alzheimer_s Dataset/train',
```

```
                                                 target_size =
(224,224),
                                                 class_mode =
'categorical',
                                                 subset =
'training',
                                                 batch_size = 128)
```

```
Found 4114 images belonging to 4 classes.
```

```
valid_dataset = valid_datagen.flow_from_directory(directory =
'drive/MyDrive/Alzheimer_s Dataset/train',
                                                  target_size =
(224,224),
                                                  class_mode =
'categorical',
                                                  subset =
'validation',
                                                  batch_size = 128)
```

```
Found 1027 images belonging to 4 classes.
```

MODEL BUILDING

```
# Model Initialization

base_model = DenseNet169(input_shape=(224,224,3),
                         include_top=False,
                         weights="imagenet")
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/densenet/
densenet169_weights_tf_dim_ordering_tf_kernels_notop.h5
51877672/51877672 [==============================] - 3s 0us/step
```

```
# Freezing Layers

for layer in base_model.layers:
    layer.trainable=False

# Building Model

model=Sequential()
model.add(base_model)
model.add(Dropout(0.5))
model.add(Flatten())
model.add(BatchNormalization())
model.add(Dense(2048,kernel_initializer='he_uniform'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(Dropout(0.5))
```

```
model.add(Dense(1024,kernel_initializer='he_uniform'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(4,activation='softmax'))

# Summary

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 densenet169 (Functional)    (None, 7, 7, 1664)        12642880

 dropout (Dropout)           (None, 7, 7, 1664)        0

 flatten (Flatten)           (None, 81536)             0

 batch_normalization (BatchN  (None, 81536)            326144
 ormalization)

 dense (Dense)               (None, 2048)              166987776

 batch_normalization_1 (Batc  (None, 2048)             8192
 hNormalization)

 activation (Activation)     (None, 2048)              0

 dropout_1 (Dropout)         (None, 2048)              0

 dense_1 (Dense)             (None, 1024)              2098176

 batch_normalization_2 (Batc  (None, 1024)             4096
 hNormalization)

 activation_1 (Activation)   (None, 1024)              0

 dropout_2 (Dropout)         (None, 1024)              0

 dense_2 (Dense)             (None, 4)                 4100

=================================================================
Total params: 182,071,364
Trainable params: 169,259,268
Non-trainable params: 12,812,096
_________________________________________________________________
```

```
# Model Compile

OPT    = tensorflow.keras.optimizers.Adam(lr=0.001)

model.compile(loss='categorical_crossentropy',
              metrics=[tensorflow.keras.metrics.AUC(name = 'auc')],
              optimizer=OPT)
```

```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use
`learning_rate` or use the legacy optimizer,
e.g.,tf.keras.optimizers.legacy.Adam.
```

```
# Defining Callbacks

filepath = './best_weights.hdf5'

earlystopping = EarlyStopping(monitor = 'val_auc',
                              mode = 'max' ,
                              patience = 15,
                              verbose = 1)

checkpoint    = ModelCheckpoint(filepath,
                                monitor = 'val_auc',
                                mode='max',
                                save_best_only=True,
                                verbose = 1)


callback_list = [earlystopping, checkpoint]

model_history=model.fit(train_dataset,
                        validation_data=valid_dataset,
                        epochs = 5,
                        callbacks = callback_list,
                        verbose = 1)
```

```
Epoch 1/5
33/33 [==============================] - ETA: 0s - loss: 1.3473 - auc:
0.7869
Epoch 1: val_auc improved from -inf to 0.69311, saving model to
./best_weights.hdf5
33/33 [==============================] - 3658s 110s/step - loss:
1.3473 - auc: 0.7869 - val_loss: 4.6611 - val_auc: 0.6931
Epoch 2/5
33/33 [==============================] - ETA: 0s - loss: 1.1044 - auc:
0.8280
Epoch 2: val_auc did not improve from 0.69311
33/33 [==============================] - 1446s 44s/step - loss: 1.1044
- auc: 0.8280 - val_loss: 3.6023 - val_auc: 0.6828
Epoch 3/5
33/33 [==============================] - ETA: 0s - loss: 0.9708 - auc:
```

```
0.8544
Epoch 3: val_auc did not improve from 0.69311
33/33 [==============================] - 1453s 44s/step - loss: 0.9708
- auc: 0.8544 - val_loss: 1.9630 - val_auc: 0.6772
Epoch 4/5
33/33 [==============================] - ETA: 0s - loss: 0.9087 - auc:
0.8625
Epoch 4: val_auc improved from 0.69311 to 0.75026, saving model to
./best_weights.hdf5
33/33 [==============================] - 1465s 45s/step - loss: 0.9087
- auc: 0.8625 - val_loss: 1.7690 - val_auc: 0.7503
Epoch 5/5
33/33 [==============================] - ETA: 0s - loss: 0.8784 - auc:
0.8698
Epoch 5: val_auc improved from 0.75026 to 0.78523, saving model to
./best_weights.hdf5
33/33 [==============================] - 1476s 45s/step - loss: 0.8784
- auc: 0.8698 - val_loss: 1.4338 - val_auc: 0.7852
```

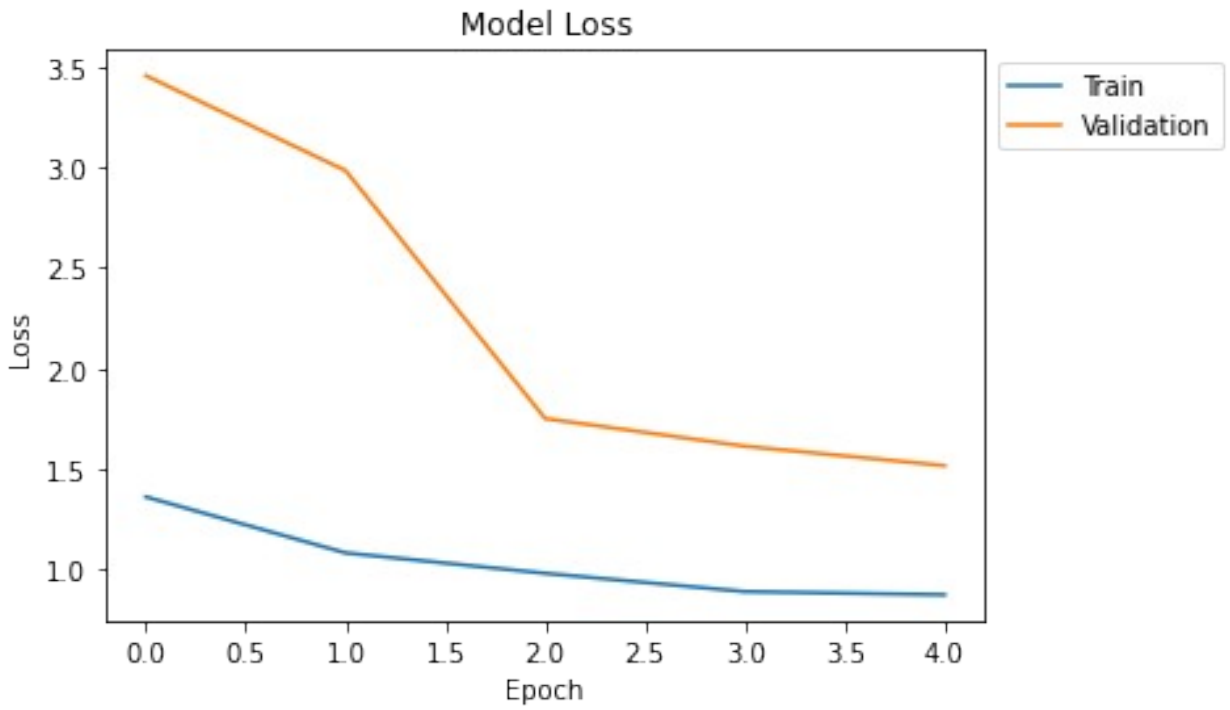
```
model.save('/content/drive/MyDrive/model')
```

```
WARNING:absl:Found untraced functions such as _update_step_xla,
_jit_compiled_convolution_op, _jit_compiled_convolution_op,
_jit_compiled_convolution_op, _jit_compiled_convolution_op while
saving (showing 5 of 169). These functions will not be directly
callable after loading.
```

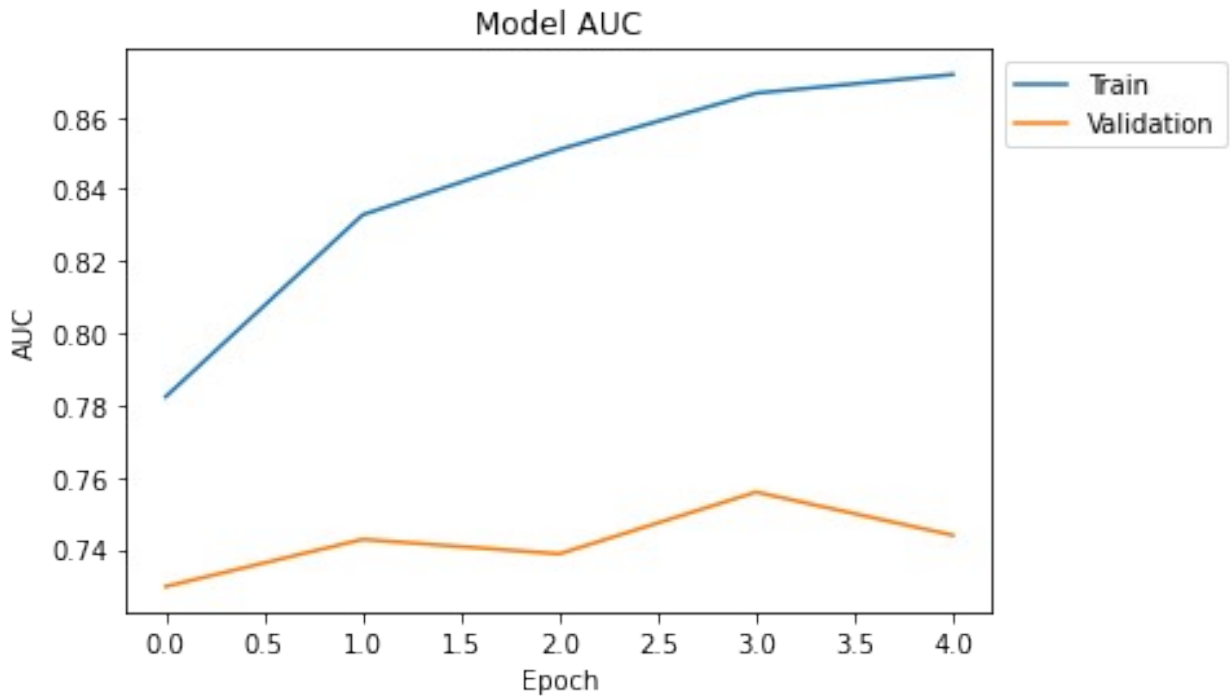
```
import tensorflow as tf
loaded_model =
tf.keras.models.load_model('/content/drive/MyDrive/model')
```

MODEL EVALUATION

```
# Summarize history for loss

plt.plot(model_history.history['loss'])
plt.plot(model_history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left',
bbox_to_anchor=(1,1))
plt.show()
```




```
# Summarize history for AUC

plt.plot(model_history.history['auc'])
plt.plot(model_history.history['val_auc'])
plt.title('Model AUC')
plt.ylabel('AUC')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validation'], loc='upper left',
bbox_to_anchor=(1,1))
plt.show()
```




```
# Test Data

test_dataset  = test_datagen.flow_from_directory(directory = 
'drive/MyDrive/Alzheimer_s Dataset/test',
                                                 target_size = 
(224,224),
                                                 class_mode = 
'categorical',
                                                 batch_size = 128)
```

```
Found 1279 images belonging to 4 classes.
```

```
# Evaluating Loss and AUC

loaded_model.evaluate(test_dataset)
```

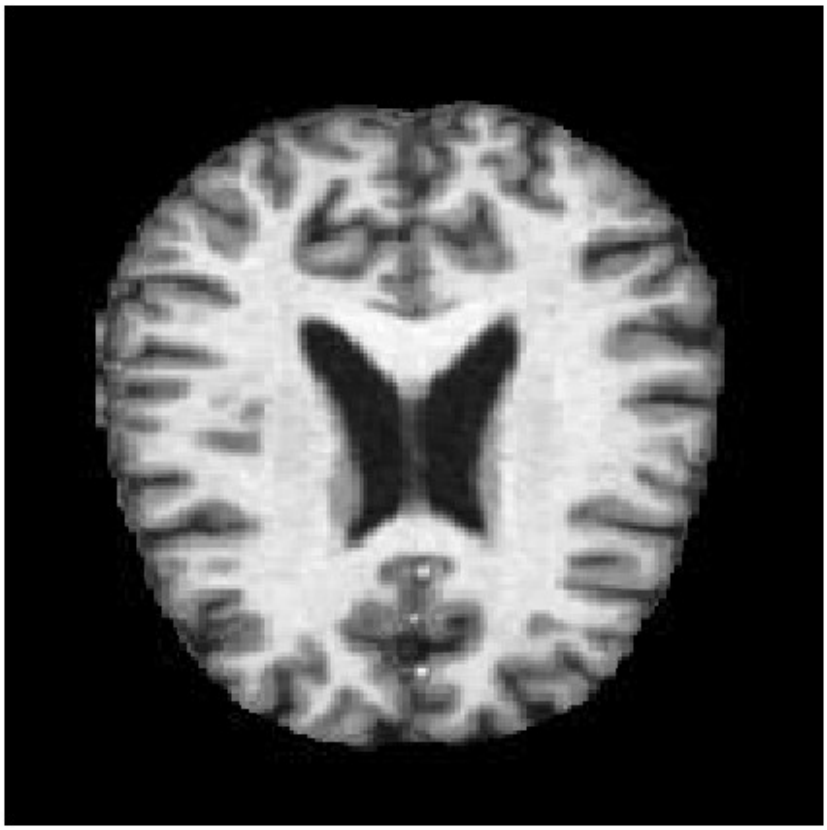
```
10/10 [==============================] - 302s 30s/step - loss: 0.9538
- auc: 0.8563
```

```
[0.9538397789001465, 0.8562548160552979]
```

```
# Test Case 1: Non-Dementia

dic = test_dataset.class_indices
idc = {k:v for v, k in dic.items()}

img = load_img('drive/MyDrive/Alzheimer_s Dataset/test/NonDemented/26
(100).jpg', target_size = (224,224,3))
img = img_to_array(img)
```

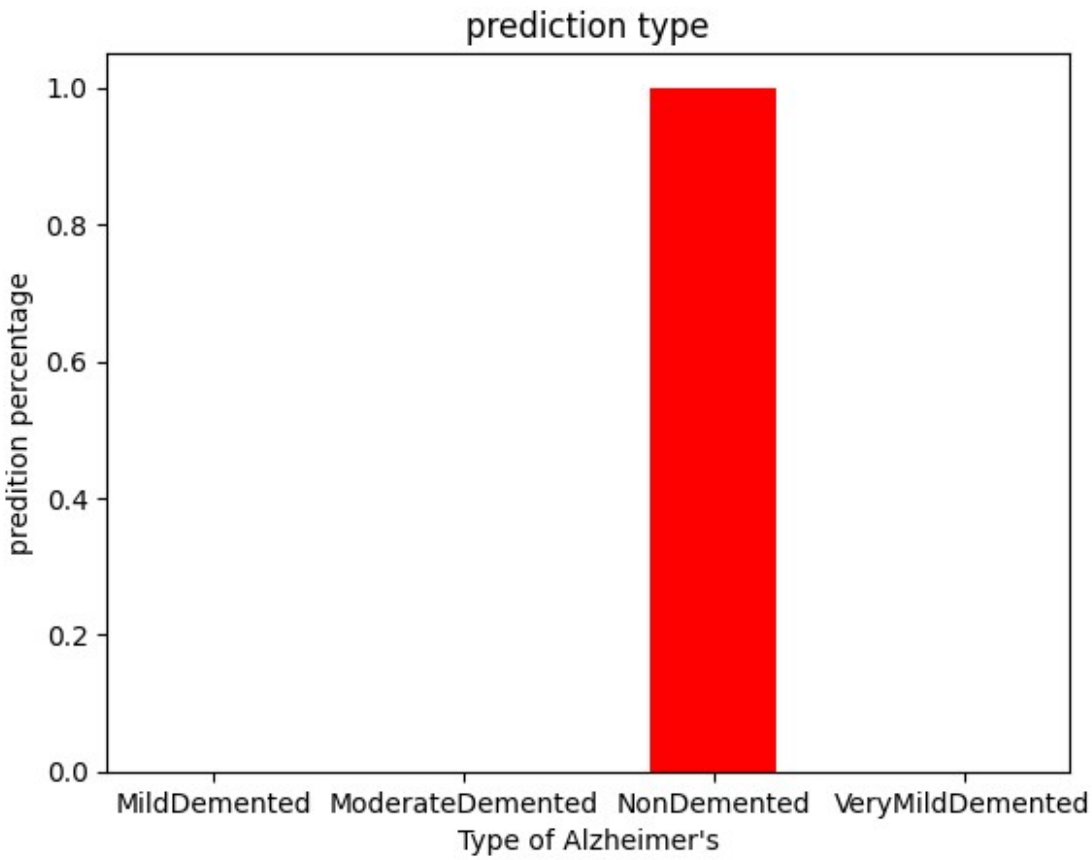
```
img = img/255
imshow(img)
plt.axis('off')
img = np.expand_dims(img,axis=0)
answer = (loaded_model.predict(img) > 0.5).astype("int32")
probability = round(np.max(loaded_model.predict(img)*100),2)


print(probability, '% chances are there that the image
is',idc[np.argmax(answer[0])])
```

```
1/1 [==============================] - 5s 5s/step
1/1 [==============================] - 0s 274ms/step
76.32 % chances are there that the image is NonDemented
```



The image has been classified as non-Demented type. The person does not have Alzheimer's disease.

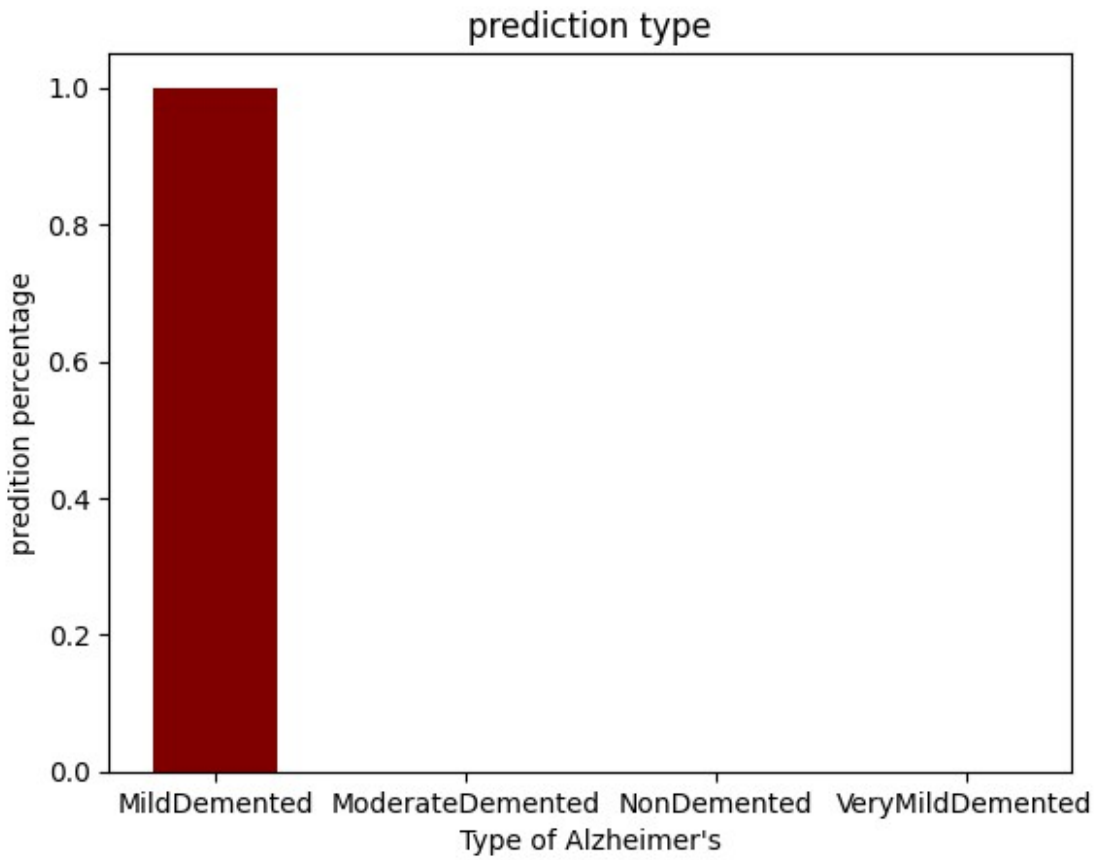
```
plt.bar(idc.values(), answer[0], width = 0.5, color = ['red'])
plt.xlabel("Type of Alzheimer's")
plt.ylabel("predition percentage")
plt.title("prediction type")
plt.show()
```




```
# Test Case 2: Mild Demented

dic = test_dataset.class_indices
idc = {k:v for v, k in dic.items()}

img = load_img('drive/MyDrive/Alzheimer_s Dataset/test/MildDemented/26
(24).jpg', target_size = (224,224,3))
img = img_to_array(img)
img = img/255
imshow(img)
plt.axis('off')
img = np.expand_dims(img,axis=0)
answer = (loaded_model.predict(img) > 0.5).astype("int32")
probability = round(np.max(loaded_model.predict(img)*100),2)

print(probability, '% chances are there that the image
is',idc[np.argmax(answer[0])])

1/1 [==============================] - 0s 395ms/step
1/1 [==============================] - 0s 299ms/step
65.59 % chances are there that the image is MildDemented
```

The image has been classified as Mild Demented type. The person has mild trace of Alzheimer's disease .

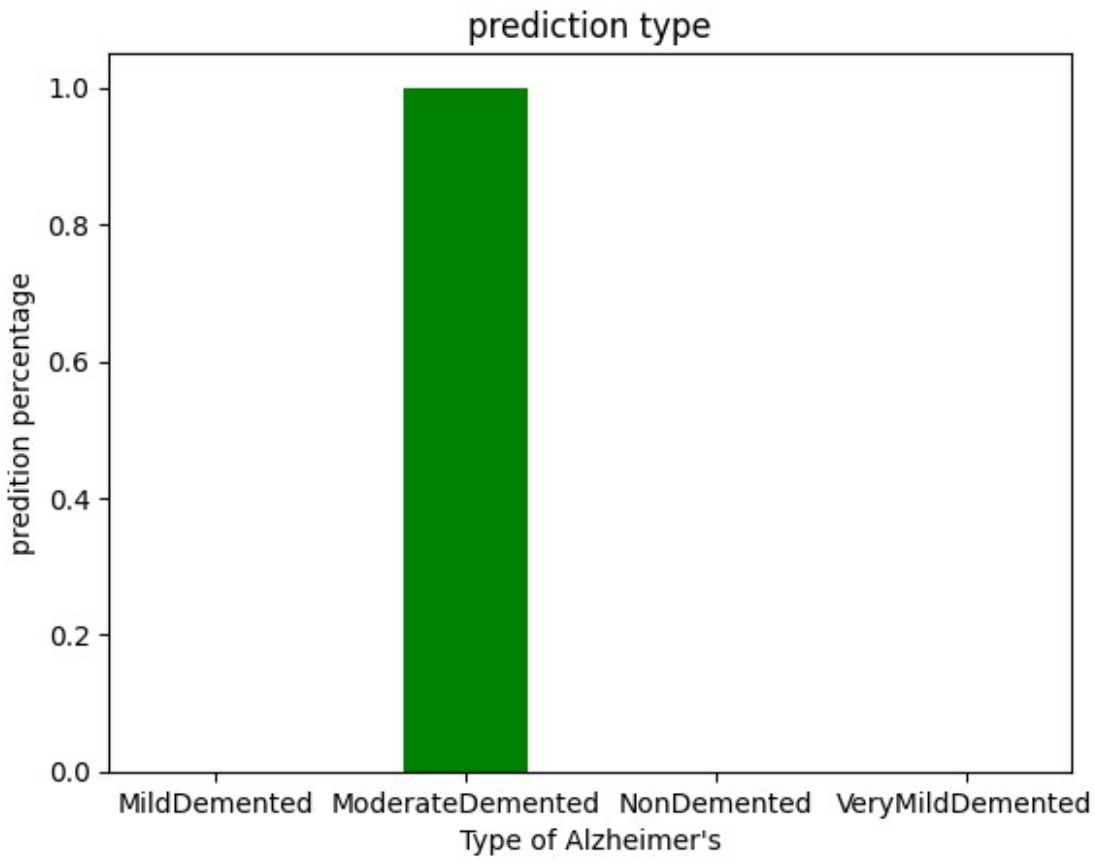
```
plt.bar(idc.values(), answer[0], width = 0.5, color = ['maroon'])
plt.xlabel("Type of Alzheimer's")
plt.ylabel("predition percentage")
plt.title("prediction type")
plt.show()
```



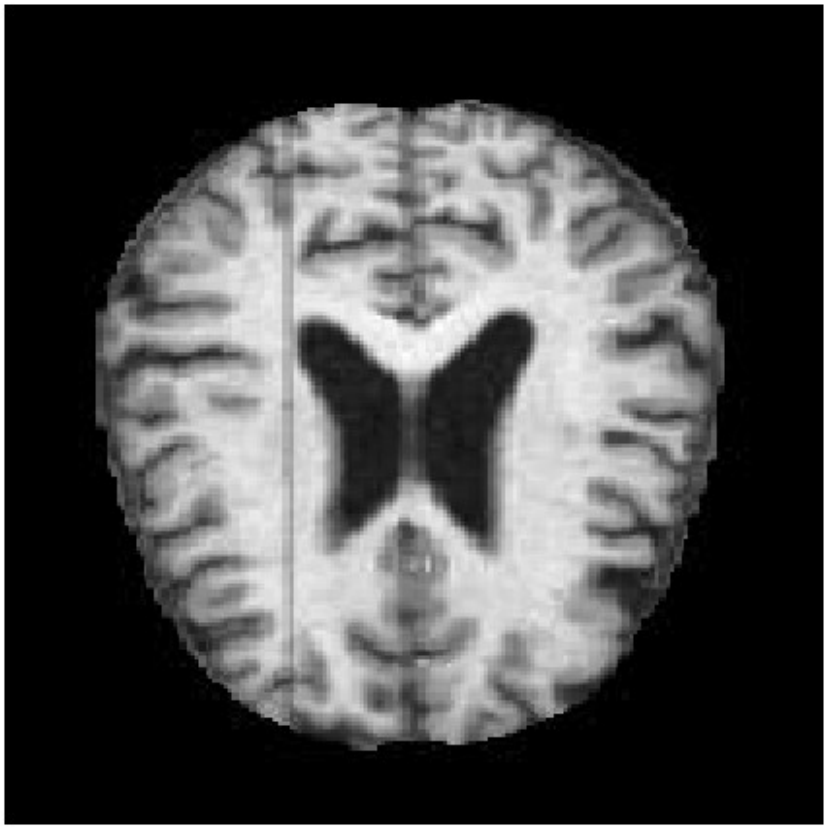

```
# Test Case 3: Moderate Demented

dic = test_dataset.class_indices
idc = {k:v for v, k in dic.items()}

img = load_img('drive/MyDrive/Alzheimer_s
Dataset/test/ModerateDemented/27 (2).jpg', target_size = (224,224,3))
img = img_to_array(img)
img = img/255
imshow(img)
plt.axis('off')
img = np.expand_dims(img,axis=0)
answer = (loaded_model.predict(img) > 0.5).astype("int32")
probability = round(np.max(loaded_model.predict(img)*100),2)

print(probability, '% chances are there that the image
is',idc[np.argmax(answer[0])])

1/1 [==============================] - 0s 281ms/step
1/1 [==============================] - 0s 271ms/step
74.34 % chances are there that the image is ModerateDemented
```

The image has been classified as Moderate Demented type. The person has moderate trace of Alzheimer's disease .

```
plt.bar(idc.values(), answer[0], width = 0.5, color = ['green'])
plt.xlabel("Type of Alzheimer's")
plt.ylabel("predition percentage")
plt.title("prediction type")
plt.show()
```

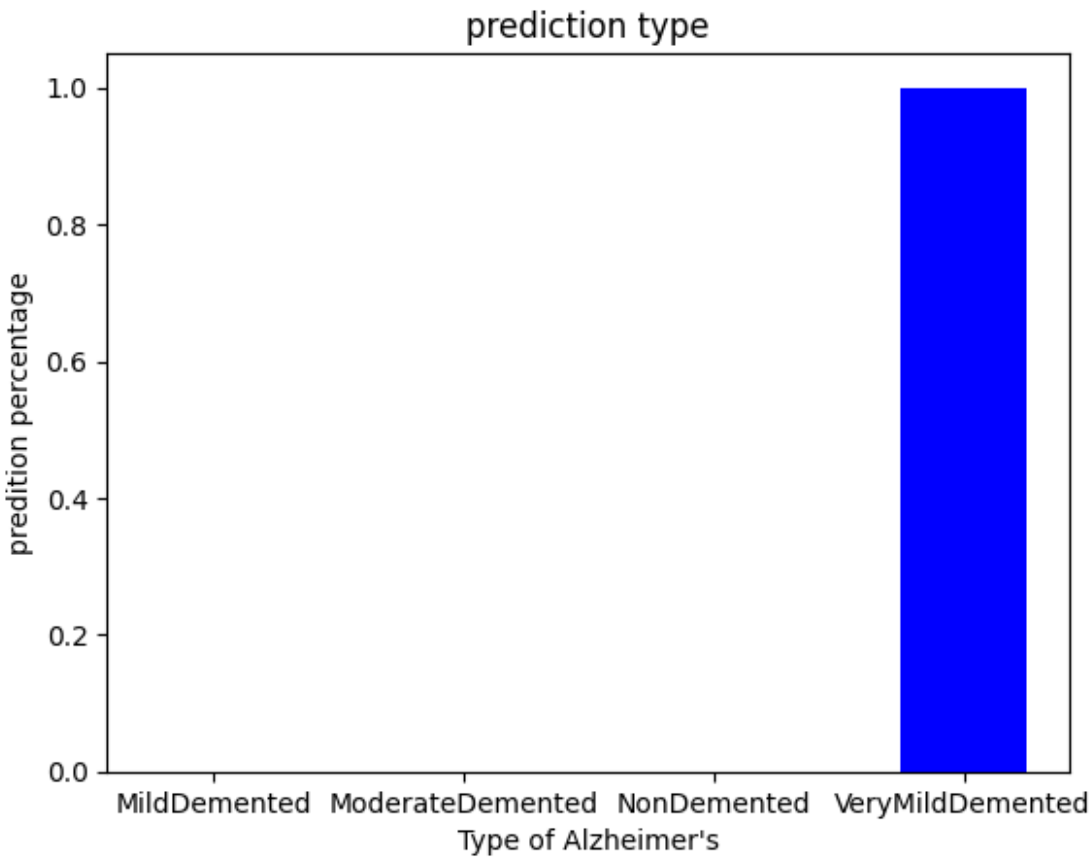



```
# Test Case 4: Very Mild Demented

dic = test_dataset.class_indices
idc = {k:v for v, k in dic.items()}

img = load_img('drive/MyDrive/Alzheimer_s
Dataset/test/VeryMildDemented/26 (54).jpg', target_size = (224,224,3))
img = img_to_array(img)
img = img/255
imshow(img)
plt.axis('off')
img = np.expand_dims(img,axis=0)
answer = (loaded_model.predict(img) > 0.5).astype("int32")
probability = round(np.max(loaded_model.predict(img)*100),2)

print(probability, '% chances are there that the image
is',idc[np.argmax(answer[0])])

1/1 [==============================] - 0s 276ms/step
1/1 [==============================] - 0s 268ms/step
79.31 % chances are there that the image is VeryMildDemented
```



The image has been classified as Very Mild Demented type. The person has a little trace of Alzheimer's disease.

```
plt.bar(idc.values(), answer[0], width = 0.5, color = ['blue'])
plt.xlabel("Type of Alzheimer's")
plt.ylabel("predition percentage")
plt.title("prediction type")
plt.show()
```

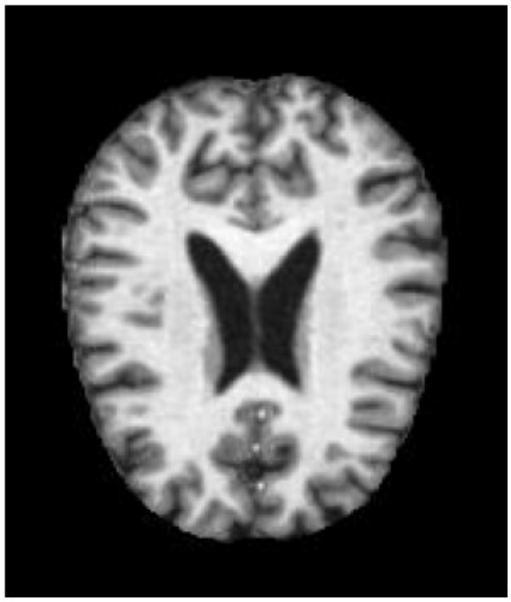



```
import cv2

fig = plt.figure(figsize=(10, 10))
rows = 2
columns = 2

Image1 = cv2.imread('drive/MyDrive/Alzheimer_s
Dataset/test/NonDemented/26 (100).jpg')
Image2 = cv2.imread('drive/MyDrive/Alzheimer_s
Dataset/test/MildDemented/26 (23).jpg')
Image3 = cv2.imread('drive/MyDrive/Alzheimer_s
Dataset/test/ModerateDemented/27 (2).jpg')
Image4 = cv2.imread('drive/MyDrive/Alzheimer_s
Dataset/test/VeryMildDemented/26 (54).jpg')

# NonDemented
fig.add_subplot(rows, columns, 1)
plt.imshow(Image1)
plt.axis('off')
plt.title("NonDemented")

# MildDemented
fig.add_subplot(rows, columns, 2)
```

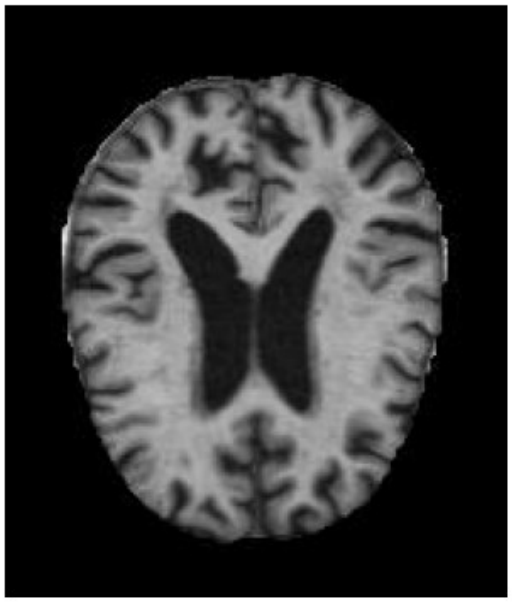
```
plt.imshow(Image2)
plt.axis('off')
plt.title("MildDemented")

# ModerateDemented
fig.add_subplot(rows, columns, 3)
plt.imshow(Image3)
plt.axis('off')
plt.title("ModerateDemented")

# VeryMildDemented
fig.add_subplot(rows, columns, 4)
plt.imshow(Image4)
plt.axis('off')
plt.title("VeryMildDemented")
```

```
Text(0.5, 1.0, 'VeryMildDemented')
```

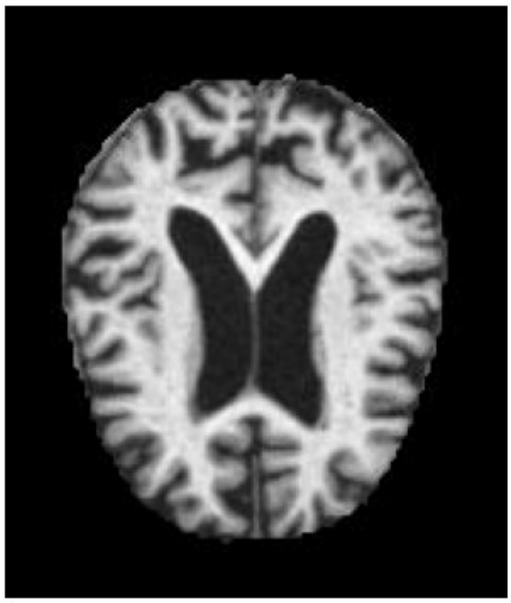
NonDemented



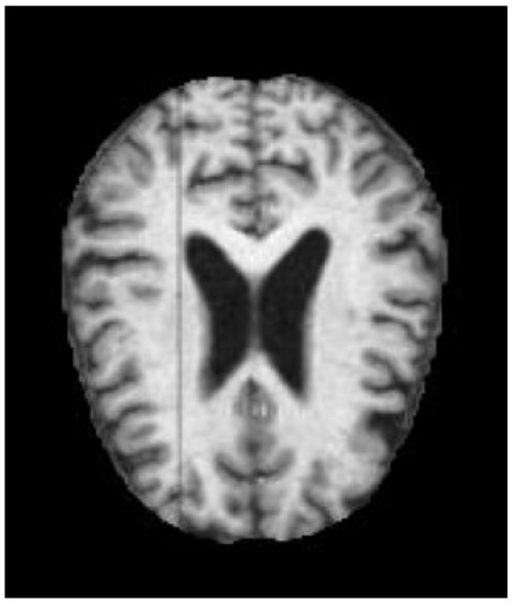
MildDemented



ModerateDemented



VeryMildDemented



Conclusion:

So, we have finally built are deep learning model using DenseNet169 transfer learning algorithm and achieved and AUC-90%.