```
import zipfile
import os

# This assumes you uploaded a file named "AugmentedAlzheimerDataset.zip"
# If your mac named it "Archive.zip", change the name below.
zip_path = "AugmentedAlzheimerDataset.zip"

print("Unzipping the dataset... this might take a minute...")

with zipfile.ZipFile(zip_path, 'r') as zip_ref:
    zip_ref.extractall("./dataset") # We extract it to a folder named 'd

print("Done! Checking file counts...")

# Let's verify we have the right folders
base_path = "./dataset/AugmentedAlzheimerDataset"
categories = os.listdir(base_path)
print(f"Found categories: {categories}")

# Count images to make sure it matches the PDF claims
total_images = 0
for category in categories:
    if not category.startswith('.'): # Ignore hidden mac files like .DS_
        path = os.path.join(base_path, category)
        count = len(os.listdir(path))
        print(f" - {category}: {count} images")
        total_images += count

print(f"Total images found: {total_images}")
```

```
Unzipping the dataset... this might take a minute...
Done! Checking file counts...
Found categories: ['NonDemented', 'ModerateDemented', 'MildDemented', 'Ve
 - NonDemented: 9600 images
 - ModerateDemented: 6464 images
 - MildDemented: 8960 images
 - VeryMildDemented: 8960 images
Total images found: 33984
```

```
import torch
device = "cuda" if torch.cuda.is_available() else "cpu"
print(f"We are using: {device}")



# Tensor
x = torch.rand(3,3).to(device)
print("\nHere is a 3x3 Tensor living on the GPU:")
print(x)
```

```
We are using: cuda

Here is a 3x3 Tensor living on the GPU:
tensor([[0.7992, 0.9077, 0.9001],
        [0.2471, 0.0270, 0.3519],
        [0.8857, 0.3207, 0.1258]], device='cuda:0')
```

```
import pandas as pd
import os
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder

base_path = "./dataset/AugmentedAlzheimerDataset"

image_paths = []
labels = []


for category in os.listdir(base_path):
  category_path = os.path.join(base_path, category)

  # check if folder
  if os.path.isdir(category_path):
    for filename in os.listdir(category_path):
      # we only want image files
      image_paths.append(os.path.join(category_path, filename))
      labels.append(category)



# creating the dataframe
df = pd.DataFrame({
    "image_path": image_paths,
    "label": labels
})



# label encoder
le = LabelEncoder()
```

```
df["label_encoded"] = le.fit_transform(df["label"])


# split into train and test
train_df, test_df = train_test_split(df, test_size = 0.2, stratify=df["l


print(f"Total Images: {len(df)}")
print(f"Training on: {len(train_df)} images")
print(f"Testing on: {len(test_df)} images")

# Show the first few rows so we can see what the data looks like
print("\nExample Data:")
print(train_df.head())
```

```
Total Images: 33984
Training on: 27187 images
Testing on: 6797 images

Example Data:
                                              image_path               labe
431    ./dataset/AugmentedAlzheimerDataset/NonDemente...        NonDemente
4753   ./dataset/AugmentedAlzheimerDataset/NonDemente...        NonDemente
9725   ./dataset/AugmentedAlzheimerDataset/ModerateDe...  ModerateDemente
10854  ./dataset/AugmentedAlzheimerDataset/ModerateDe...  ModerateDemente
27874  ./dataset/AugmentedAlzheimerDataset/VeryMildDe...  VeryMildDemente

       label_encoded
431                2
4753               2
9725               1
10854              1
27874              3
```

```
# Data loader
```

```
from torch.utils.data import DataLoader, Dataset
from PIL import Image
from torchvision import transforms
import torch

# Define the transformations (copied from 0IKx6P4AED4z for self-containm
train_transforms = transforms.Compose([
    transforms.Resize((224, 224)),
    transforms.RandomHorizontalFlip(),
    transforms.RandomRotation(10),
    transforms.ToTensor(),
    transforms.Normalize([0.485, 0.456, 0.406], [0.229, 0.224, 0.225])
    ])

# For testing, we DON'T flip or rotate. We want to test on the "real" im
```

```
test_transforms = transforms.Compose([
    transforms.Resize((224,224)),
    transforms.ToTensor(),
    transforms.Normalize([0.485, 0.456, 0.406], [0.229, 0.224, 0.225])
])

# Custom dataset class (corrected __getitem__ method)
class MRIDataset(Dataset):
  def __init__(self, df, transform = None):
    self.df = df
    self.transform = transform

  def __len__(self):
    return len(self.df)

  def __getitem__(self, idx): # CORRECTED: changed __get_item to __getit
    # The model asks: "Give me the image at row number 'idx'"
    try:
      row = self.df.iloc[idx]
      img_path = row["image_path"]
      label = row["label_encoded"]
      # Open the image file
      image = Image.open(img_path).convert("RGB")
      # Apply transformations
      if self.transform:
        image = self.transform(image)
      return image, torch.tensor(label).long()
    except Exception as e:
      print(f"Error loading image at index {idx}: {e}")
      return None

train_ds = MRIDataset(train_df, transform=train_transforms)
test_ds = MRIDataset(test_df, transform=test_transforms)

# 4. Re-create DataLoaders
train_loader = DataLoader(train_ds, batch_size=32, shuffle=True, num_wor
test_loader = DataLoader(test_ds, batch_size=32, shuffle=False, num_work

print("Class re-defined and loaders ready.")

# 5. Test it immediately
images, labels = next(iter(train_loader))
print(f"Success! Batch shape: {images.shape}")
```

```
Class re-defined and loaders ready.
Success! Batch shape: torch.Size([32, 3, 224, 224])
```

```
# BRain(CNN)
import torch.nn as nn
from torchvision import models
```

```
class HybridModel(nn.Module):
  def __init__(self, num_classes = 4):
    super().__init__()

    # Using MobileNetV2, pretrained on ImageNet
    self.cnn = models.mobilenet_v2(weights="IMAGENET1K_V1").features


    # Just train transformer brain
    for param in self.cnn.parameters():
      param.requires_grad = True


    # The BRAIN(Transformer)
    encoder_layer = nn.TransformerEncoderLayer(
        d_model = 1280,
        nhead = 8, # model looks at 8 differentt perspecives at once
        dim_feedforward = 2048,
        dropout = 0.1,
        batch_first = True # ensures input format is [Batch, Sequence, F
    )
    self.transformer = nn.TransformerEncoder(encoder_layer, num_layers =


    # Mouth (Classifer)
    self.fc = nn.Linear(1280, num_classes) # turn 1280 features into 4 p

  def forward(self, x):
    # Look at image
    # Input [Batch, 3, 224, 224]
    x = self.cnn(x)
    # Output: [Batch, 1280, 7, 7]


    # Squash the image
    # We take the average of the 7x7 grid to get one single summary vect
    x = x.mean([-1, -2])
    # Output: [Batch, 1280]


    # Prepare for transformer
    x = x.unsqueeze(1)
    # Output: [Batch, 1, 1280]

    # Think
    x = self.transformer(x)


    # Remove the sequence dimension
    x = x.squeeze(1)
```

```
        # Output: [Batch, 1280]


        # Decide (Linear layer)
        x = self.fc(x)
        # Output: [Batch, 4]
        return x

# Instantiate the model and move it to the GPU
model = HybridModel(num_classes=4).to(device)

print("Hybrid Model Created Successfull!")
```

```
Downloading: "https://download.pytorch.org/models/mobilenet_v2-b0353104.p
100%|██████████| 13.6M/13.6M [00:00<00:00, 87.6MB/s]
Hybrid Model Created Successfull!
```

```
# Create a fake input tensor (Batch=32, RGB=3, Size=224x224)
dummy_input = torch.randn(32, 3, 224, 224).to(device)

# Pass it through the model
output = model(dummy_input)

print(f"Input shape: {dummy_input.shape}")
print(f"Output shape: {output.shape}")

# Expected Output shape: [32, 4]
# (32 images, 4 scores each)
```

```
Input shape: torch.Size([32, 3, 224, 224])
Output shape: torch.Size([32, 4])
```

```
# Training Loop
import torch.optim as optim
from tqdm.notebook import tqdm



criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr = 1e-4)

# training function
def train_one_epoch(epoch_index, train_loader):
  model.train()
  running_loss = 0.0
  correct_predictions = 0
  total_samples = 0

  progress_bar = tqdm(train_loader, desc=f"Epoch {epoch_index+1} Trainin
```

```
    for images, labels in progress_bar:
      images, labels = images.to(device), labels.to(device)

      # zero the gradients
      optimizer.zero_grad()

      # Forward pass, make ur first guess
      outputs = model(images)

      # Calc loss
      loss = criterion(outputs, labels)

      # Backward pass
      loss.backward()

      # Update weights
      optimizer.step()

      # track stats for progress bar
      running_loss += loss.item()
      _, predicted = torch.max(outputs, 1) # get the class with high prob
      correct_predictions += (predicted == labels).sum().item()
      total_samples += labels.size(0)

      # update the progress bar text
      current_acc = 100 * correct_predictions / total_samples
      progress_bar.set_postfix({'Loss': loss.item(), 'Acc': f"{current_acc

    epoch_loss = running_loss / len(train_loader)
    epoch_acc = 100 * correct_predictions / total_samples
    return epoch_loss, epoch_acc



  # validation function (praccitse function)
  def validate(test_loader):
    model.eval()
    running_loss = 0.0
    correct_predictions = 0
    total_samples = 0


    with torch.no_grad(): # Dont calc gradients to save time
      for images, labels in tqdm(test_loader, desc="Validating"):
        images, labels  = images.to(device), labels.to(device)

        outputs = model(images)
        loss = criterion(outputs, labels)
```

```
            running_loss += loss.item()
            _, predicted = torch.max(outputs, 1) # get the class with high pro
            correct_predictions += (predicted == labels).sum().item()
            total_samples += labels.size(0)

    epoch_loss = running_loss / len(test_loader)
    epoch_acc = 100 * correct_predictions / total_samples
    return epoch_loss, epoch_acc

print("Training functions defined.")
```

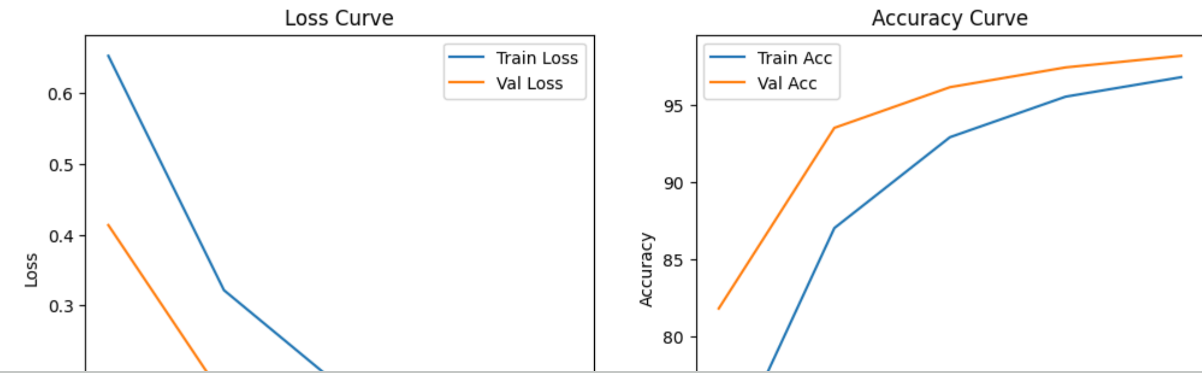
```
Training functions defined.
```

```
# START TRAINING
EPOCHS = 5
history = {'train_loss': [], 'train_acc': [], 'val_loss': [], 'val_acc':

for epoch in range(EPOCHS):
  print(f"\n--- EPOCH {epoch+1}/{EPOCHS} ---")


  # Train
  train_loss, train_acc = train_one_epoch(epoch, train_loader)

  # Validate
  val_loss, val_acc = validate(test_loader)

  # Store the history
  history['train_loss'].append(train_loss)
  history['train_acc'].append(train_acc)
  history['val_loss'].append(val_loss)
  history['val_acc'].append(val_acc)

  print(f"Train Loss: {train_loss:.4f} | Train Acc: {train_acc:.2f}%")
  print(f"Val Loss:   {val_loss:.4f} | Val Acc:   {val_acc:.2f}%")


print("\nTRAINING COMPLETE!")
```

```
--- EPOCH 1/5 ---
Epoch 1 Training: 100%   850/850 [02:05<00:00,  7.91it/s, Loss=0.149, Acc=70.86%]

Validating: 100%   213/213 [00:18<00:00, 13.42it/s]
Train Loss: 0.6528 | Train Acc: 70.86%
Val Loss:   0.4135 | Val Acc:   81.82%

--- EPOCH 2/5 ---
Epoch 2 Training: 100%   850/850 [02:04<00:00,  7.13it/s, Loss=0.1, Acc=87.02%]

Validating: 100%   213/213 [00:18<00:00, 13.31it/s]
Train Loss: 0.3214 | Train Acc: 87.02%
Val Loss:   0.1696 | Val Acc:   93.51%

--- EPOCH 3/5 ---
Epoch 3 Training: 100%   850/850 [02:05<00:00,  6.61it/s, Loss=0.705, Acc=92.91%]

Validating: 100%   213/213 [00:17<00:00, 13.44it/s]
Train Loss: 0.1862 | Train Acc: 92.91%
Val Loss:   0.1013 | Val Acc:   96.15%

--- EPOCH 4/5 ---
Epoch 4 Training: 100%   850/850 [02:05<00:00,  7.26it/s, Loss=0.393, Acc=95.53%]

Validating: 100%   213/213 [00:17<00:00, 14.31it/s]
Train Loss: 0.1231 | Train Acc: 95.53%
Val Loss:   0.0716 | Val Acc:   97.43%

--- EPOCH 5/5 ---
Epoch 5 Training: 100%   850/850 [02:05<00:00,  7.28it/s, Loss=0.0132, Acc=96.79%]

Validating: 100%   213/213 [00:17<00:00, 13.40it/s]
Train Loss: 0.0949 | Train Acc: 96.79%
Val Loss:   0.0563 | Val Acc:   98.18%

TRAINING COMPLETE!
```

```
# Visulisation
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix, classification_report
import numpy as np



plt.figure(figsize=(12,5))

# Plot Loss
plt.subplot(1, 2, 1)
```

```
plt.plot(history['train_loss'], label='Train Loss')
plt.plot(history['val_loss'], label='Val Loss')
plt.title('Loss Curve')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

# Plot Accuracy
plt.subplot(1, 2, 2)
plt.plot(history['train_acc'], label='Train Acc')
plt.plot(history['val_acc'], label='Val Acc')
plt.title('Accuracy Curve')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()


plt.show()

all_preds = []
all_labels = []

model.eval()
with torch.no_grad():
  for images, labels in tqdm(test_loader, desc="Generating Predictions")
    images = images.to(device)
    outputs = model(images)
    _, preds = torch.max(outputs, 1)

    all_preds.extend(preds.cpu().numpy())
    all_labels.extend(labels.numpy())

cm = confusion_matrix(all_labels, all_preds)
class_names = le.classes_ # names we have saved earlier

plt.figure(figsize=(10,8))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=class_nam
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.title('Confusion Matrix')
plt.show()


# 4. Print the Detailed Report
print("\nClassification Report:\n")
print(classification_report(all_labels, all_preds, target_names=class_na
```




```
# predictor function
import torch.nn.functional as F
import numpy as np
import matplotlib.pyplot as plt

def predict_single_image(model, dataset, index=None):
  """
  pick an image, show it, and ask the model what it is.
  """
  model.eval() # set to eval mode

  if index is None:
    index = np.random.randint(0, len(dataset))

    # get image and label from dataset
    # we are using the dataset object beacusing it handles and resises/tra
    image_tensor, true_label_index = dataset[index]

    # Prepare image for model (adding the batch dimension)
    # The model expects [Batch, 3, 224, 224,] but we have [3, 224, 224]
    input_tensor = image_tensor.unsqueeze(0).to(device)


    # Make the prediction
    with torch.no_grad():
      output = model(input_tensor)

      # Calc probabilites
      probs = F.softmax(output, dim=1)
      confidence, predicted_class_index = torch.max(probs, 1)

    
    # Decode the answer
    predicted_label = le.classes_[predicted_class_index.item()]
    true_label = le.classes_[true_label_index.item()]
    conf_score = confidence.item() * 100



    # visualization
    inv_normalize = transforms.Normalize(
```

```
        mean = [-0.485/0.229, -0.456/0.224, -0.406/0.225],
        std = [1/0.229, 1/0.224, 1/0.225]
    )
    img_display = inv_normalize(image_tensor)


    # Rearrage the dimensions for matplotlib (C,H,W) -> (H,W,C)
    img_display = img_display.permute(1,2,0).numpy()

    # Clip values to be between 0 and 1 just in case
    img_display = np.clip(img_display, 0,1 )

    plt.figure(figsize=(6,6))
    plt.imshow(img_display)
    plt.axis('off')

    # Color code, green if correct, red if wrong
    color = 'green' if predicted_label == true_label else 'red'
    plt.title(f"True: {true_label}\nAI Pred: {predicted_label} ({conf_sco
    plt.show()

# Run this multiple times to see different patients!
print("Running diagnostic on a random patient...")
predict_single_image(model, test_ds)
```

```
Running diagnostic on a random patient...
```

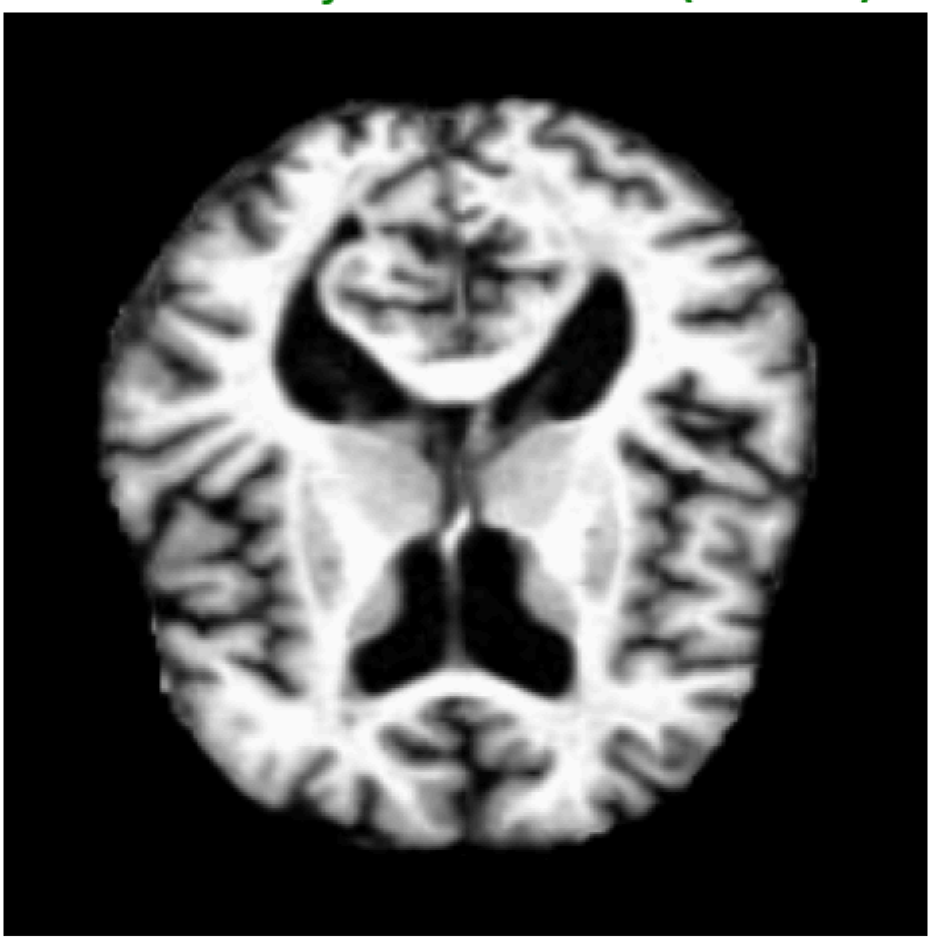
True: MildDemented

```
# predictor function
import torch.nn.functional as F
import numpy as np
import matplotlib.pyplot as plt

def predict_single_image(model, dataset, index=None):
  """
  pick an image, show it, and ask the model what it is.
  """
  model.eval() # set to eval mode

  if index is None:
    index = np.random.randint(0, len(dataset))

    # get image and label from dataset
    # we are using the dataset object beacusing it handles and resises/t
    image_tensor, true_label_index = dataset[index]

    # Prepare image for model (adding the batch dimension)
    # The model expects [Batch, 3, 224, 224,] but we have [3, 224, 224]
    input_tensor = image_tensor.unsqueeze(0).to(device)


    # Make the prediction
    with torch.no_grad():
      output = model(input_tensor)

      # Calc probabilites
      probs = F.softmax(output, dim=1)
      confidence, predicted_class_index = torch.max(probs, 1)


    # Decode the answer
    predicted_label = le.classes_[predicted_class_index.item()]
    true_label = le.classes_[true_label_index.item()]
    conf_score = confidence.item() * 100



    # visualization
    inv_normalize = transforms.Normalize(
        mean = [-0.485/0.229, -0.456/0.224, -0.406/0.225],
        std = [1/0.229, 1/0.224, 1/0.225]
    )
    img_display = inv_normalize(image_tensor)


    # Rearrage the dimensions for matplotlib (C,H,W) -> (H,W,C)
```

```
    img_display = img_display.permute(1,2,0).numpy()

    # Clip values to be between 0 and 1 just in case
    img_display = np.clip(img_display, 0,1 )

    plt.figure(figsize=(6,6))
    plt.imshow(img_display)
    plt.axis('off')

    # Color code, green if correct, red if wrong
    color = 'green' if predicted_label == true_label else 'red'
    plt.title(f"True: {true_label}\nAI Pred: {predicted_label} ({conf_sc
    plt.show()

# Run this multiple times to see different patients!
print("Running diagnostic on a random patient...")
predict_single_image(model, test_ds)
```

```
Running diagnostic on a random patient...
```

True: VeryMildDemented
AI Pred: VeryMildDemented (99.46%)

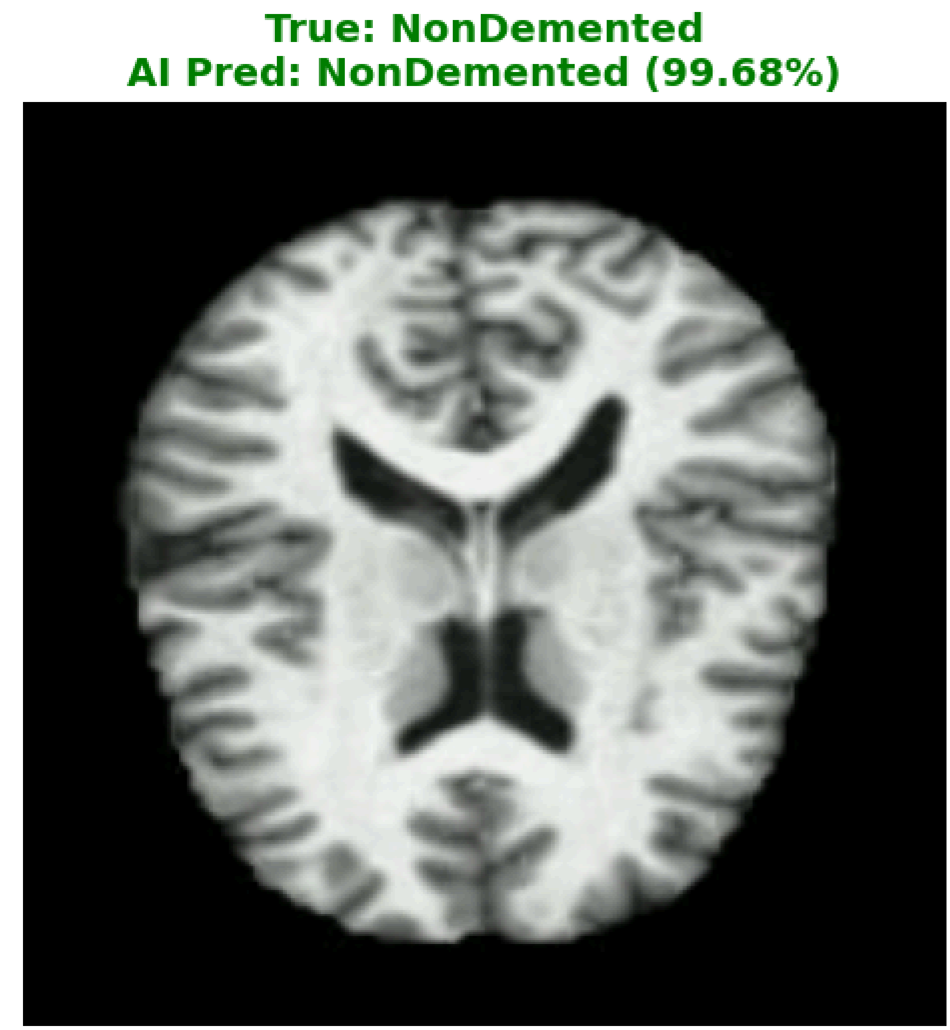


```
# predictor function
import torch.nn.functional as F
import numpy as np
```

```
import matplotlib.pyplot as plt

def predict_single_image(model, dataset, index=None):
  """
  pick an image, show it, and ask the model what it is.
  """
  model.eval() # set to eval mode

  if index is None:
    index = np.random.randint(0, len(dataset))

    # get image and label from dataset
    # we are using the dataset object beacusing it handles and resises/t
    image_tensor, true_label_index = dataset[index]

    # Prepare image for model (adding the batch dimension)
    # The model expects [Batch, 3, 224, 224,] but we have [3, 224, 224]
    input_tensor = image_tensor.unsqueeze(0).to(device)


    # Make the prediction
    with torch.no_grad():
      output = model(input_tensor)

      # Calc probabilites
      probs = F.softmax(output, dim=1)
      confidence, predicted_class_index = torch.max(probs, 1)


    # Decode the answer
    predicted_label = le.classes_[predicted_class_index.item()]
    true_label = le.classes_[true_label_index.item()]
    conf_score = confidence.item() * 100



    # visualization
    inv_normalize = transforms.Normalize(
        mean = [-0.485/0.229, -0.456/0.224, -0.406/0.225],
        std = [1/0.229, 1/0.224, 1/0.225]
    )
    img_display = inv_normalize(image_tensor)


    # Rearrage the dimensions for matplotlib (C,H,W) -> (H,W,C)
    img_display = img_display.permute(1,2,0).numpy()

    # Clip values to be between 0 and 1 just in case
    img_display = np.clip(img_display, 0,1 )

    plt.figure(figsize=(6,6))
```

```
    plt.imshow(img_display)
    plt.axis('off')

    # Color code, green if correct, red if wrong
    color = 'green' if predicted_label == true_label else 'red'
    plt.title(f"True: {true_label}\nAI Pred: {predicted_label} ({conf_sc
    plt.show()

# Run this multiple times to see different patients!
print("Running diagnostic on a random patient...")
predict_single_image(model, test_ds)
```

```
Running diagnostic on a random patient...
```




```
Grad-CAM
port cv2



ass GradCAM:
def __init__(self, model, target_layer):
  self.model = model
  self.target_layer = target_layer
  self.gradients = None
```

```
    self.activations = None
    self.target_layer.register_forward_hook(self.save_activation)
    self.target_layer.register_full_backward_hook(self.save_gradient)

  def save_activation(self, module, input, output):
    self.activations = output

  def save_gradient(self, module, grad_input, grad_output):
    self.gradients = grad_output[0]

  def __call__(self, x, class_idx=None):
    # Forward Pass
    self.model.eval()
    output = self.model(x)

    if class_idx is None:
      class_idx = output.argmax(dim=1).item()

    # Backward Pass
    self.model.zero_grad()
    class_score = output[0, class_idx]
    class_score.backward()

    # Heatmap
    # pool the gradients first
    pooled_gradients = torch.mean(self.gradients, dim=[0,2,3])

    # weight the activations by gradients
    activation = self.activations[0]
    for i in range(activation.shape[0]):
      activation[i, :, :] *= pooled_gradients[i]

      # average the channels to get a single 2d map
      heatmap = torch.mean(activation, dim=0).cpu().detach().numpy()

      # cleanup
      # apply ReLU
      heatmap = np.maximum(heatmap, 0)
      if np.max(heatmap) !=0:
        heatmap /= np.max(heatmap)

    return heatmap, class_idx


  f visualize_gradcam(model, dataset, index=None):
      # setup grad-cam on last layer of CNN
      grad_cam = GradCAM(model, model.cnn[-1])

      # get the image
      if index is None:
        index = np.random.randint(0, len(dataset))
```

```
        # get image and label from dataset
        # we are using the dataset object beacusing it handles and resises/
        img_tensor,label_idx = dataset[index]

        # Prepare image for model (adding the batch dimension)
        # The model expects [Batch, 3, 224, 224,] but we have [3, 224, 224]
        input_tensor = img_tensor.unsqueeze(0).to(device)

        # generate heatmap
        heatmap, pred_idx = grad_cam(input_tensor)

        # visualization logic
        # resie the heatmapt to match orgina image size
        heatmap = cv2.resize(heatmap, (224, 224))

        # convert heatmap to rgb colors
        heatmap = np.uint8(255 * heatmap)
        heatmap = cv2.applyColorMap(heatmap, cv2.COLORMAP_JET)

        # prepare original image
        inv_normalize = transforms.Normalize(
            mean = [-0.485/0.229, -0.456/0.224, -0.406/0.225],
            std = [1/0.229, 1/0.224, 1/0.225]
        )
        original_img = inv_normalize(img_tensor).permute(1,2,0).numpy()
        original_img = np.clip(original_img, 0, 1)
        original_img_uint8 = np.uint8(255 * original_img)
        original_img_uint8 =  cv2.cvtColor(original_img_uint8, cv2.COLOR_RG
        # overlay: 60% original image + 40% heatmap
        superimposed_img = cv2.addWeighted(original_img_uint8, 0.6, heatmap

        # show it
        plt.figure(figsize=(10,5))

        plt.subplot(1,2,1)
        plt.imshow(original_img)
        plt.title(f"Original: {le.classes_[label_idx]}")
        plt.axis('off')

        plt.subplot(1,2,2)
        plt.imshow(cv2.cvtColor(superimposed_img, cv2.COLOR_BGR2RGB))
        plt.title(f"AI Attention Map ({le.classes_[pred_idx]})")
        plt.axis('off')

        plt.tight_layout()
        plt.show()

Run it!
int("Generating AI Attention Map...")
sualize_gradcam(model, test_ds)
```

```
Generating AI Attention Map...
```