ADVANCED ARTIFICIAL INTELLIGENCE

A PRACTICAL REPORT

ON

ADVANCED ARTIFICIAL INTELLIGENCE

SUBMITTED BY

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Roll No: _____

UNDER THE GUIDANCE OF

PROF. AKBAR KHAN

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Department of Information Technology

R.D. & S.H. National College of Arts, Commerce & S.W.A.

Science College Bandra (West), Mumbai – 400 050

R. D. & S. H. National & S. W. A. Science College

Department of Information Technology

M.Sc.IT (Semester – III)

Certificate

This is to certify that ***Advanced Artificial Intelligence Practical's*** *performed at R.D. & S.H. National & S.W.A. Science College by* ***Mr. Shubham Singh*** *holding Seat No. _____ studying Master of Science in Information Technology Semester – III has been satisfactorily completed as prescribed by the University of Mumbai, during the year 2025 – 2026.*

Subject In-Charge Coordinator In-Charge External Examiner

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		corpus of text data and generate new text based on the patterns it has learned.		
12.		Experiment with neural networks like GANS (Generative Adversarial Networks) using Python libraries like TensorFlow or PyTorch to generate new images based on a dataset of images.	53	

Practical: 1

AIM: Implementing advanced deep learning algorithms such as convolutional neural networks (CNNs) or recurrent neural networks (RNNs) using Python libraries like TensorFlow or PyTorch.

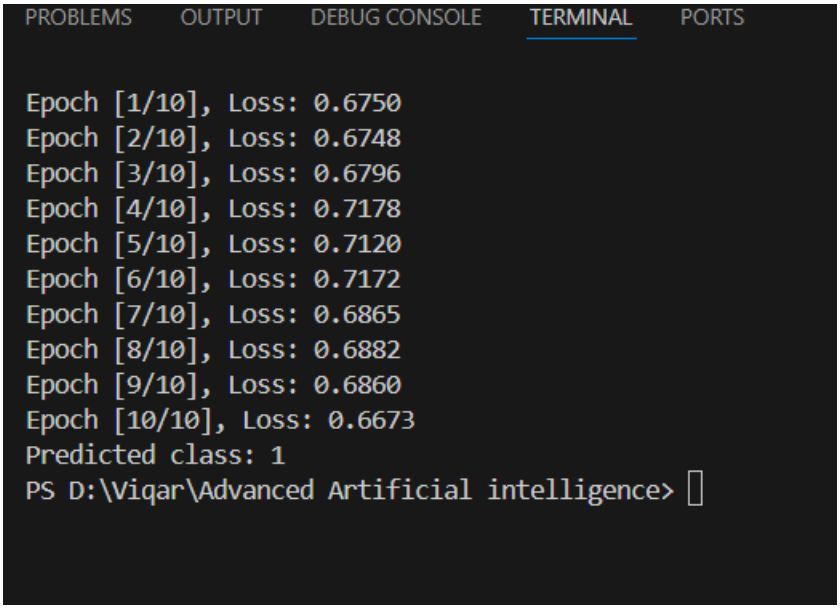
Writeup:

CODE:

```
import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader, Dataset
import numpy as np


class SequenceDataset(Dataset):
    def __init__(self, num_sequences=1000, sequence_length=10, num_classes=2):
        self.num_sequences = num_sequences
        self.sequence_length = sequence_length
        self.num_classes = num_classes
        self.data = np.random.randn(num_sequences, sequence_length, 1)
        self.labels = np.random.randint(0, num_classes, num_sequences)

    def __len__(self):
        return self.num_sequences

    def __getitem__(self, idx):
        sequence = self.data[idx]
        label = self.labels[idx]
        return torch.tensor(sequence, dtype=torch.float32), torch.tensor(label, dtype=torch.long)

class LSTMClassifier(nn.Module):
    def __init__(self, input_size=1, hidden_size=64, num_layers=2, num_classes=2):
        super(LSTMClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.num_layers = num_layers
        self.lstm = nn.LSTM(input_size, hidden_size, num_layers, batch_first=True)
        self.fc = nn.Linear(hidden_size, num_classes)

    def forward(self, x):
        h0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size).to(x.device)
        c0 = torch.zeros(self.num_layers, x.size(0), self.hidden_size).to(x.device)
        out, _ = self.lstm(x, (h0, c0))
```

```
        out = out[:, -1, :]
        out = self.fc(out)
        return out

input_size = 1
hidden_size = 64
num_layers = 2
num_classes = 2
num_epochs = 10
batch_size = 32
learning_rate = 0.001

dataset = SequenceDataset()
train_loader = DataLoader(dataset, batch_size=batch_size, shuffle=True)

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model = LSTMClassifier(input_size, hidden_size, num_layers, num_classes).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=learning_rate)

for epoch in range(num_epochs):
    for sequences, labels in train_loader:
        sequences, labels = sequences.to(device), labels.to(device)
        outputs = model(sequences)
        loss = criterion(outputs, labels)
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()
    print(f'Epoch [{epoch+1}/{num_epochs}], Loss: {loss.item():.4f}')

with torch.no_grad():
    test_sequence = torch.randn(1, dataset.sequence_length, input_size).to(device)
    prediction = model(test_sequence)
    predicted_class = torch.argmax(prediction, dim=1).item()
    print(f'Predicted class: {predicted_class}')
```

OUTPUT:


PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
Epoch [1/10], Loss: 0.6750
Epoch [2/10], Loss: 0.6748
Epoch [3/10], Loss: 0.6796
Epoch [4/10], Loss: 0.7178
Epoch [5/10], Loss: 0.7120
Epoch [6/10], Loss: 0.7172
Epoch [7/10], Loss: 0.6865
Epoch [8/10], Loss: 0.6882
Epoch [9/10], Loss: 0.6860
Epoch [10/10], Loss: 0.6673
Predicted class: 1
PS D:\Viqar\Advanced Artificial intelligence>

Practical: 2

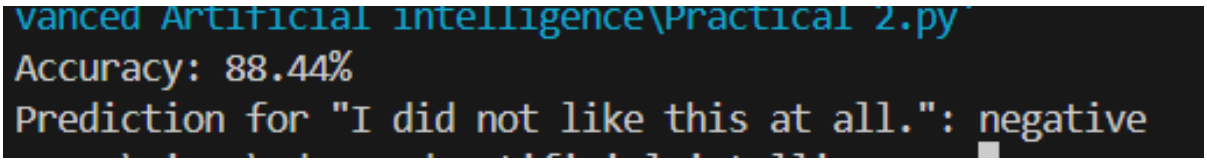
AIM: Building a natural language processing (NLP) model for sentiment analysis or text classification.

Writeup:

CODE:

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
from datasets import load_dataset

dataset = load_dataset("imdb")
df = pd.DataFrame({
    'text': dataset['train']['text'],
    'label': dataset['train']['label']
})

X_train, X_test, y_train, y_test = train_test_split(df['text'], df['label'], test_size=0.2, random_state=42)
vectorizer = TfidfVectorizer()
X_train_vectorized = vectorizer.fit_transform(X_train)
model = LogisticRegression(max_iter=1000)
model.fit(X_train_vectorized, y_train)
X_test_vectorized = vectorizer.transform(X_test)
predictions = model.predict(X_test_vectorized)
accuracy = accuracy_score(y_test, predictions)
print(f'Accuracy: {accuracy * 100:.2f}%')
new_text = ["I did not like this at all."]
new_vectorized = vectorizer.transform(new_text)
prediction = model.predict(new_vectorized)
print(f'Prediction for "{new_text[0]}": {"positive" if prediction[0] == 1 else "negative"}')
```

OUTPUT:



Practical: 3

AIM: Creating a chatbot using advanced techniques like transformer models.

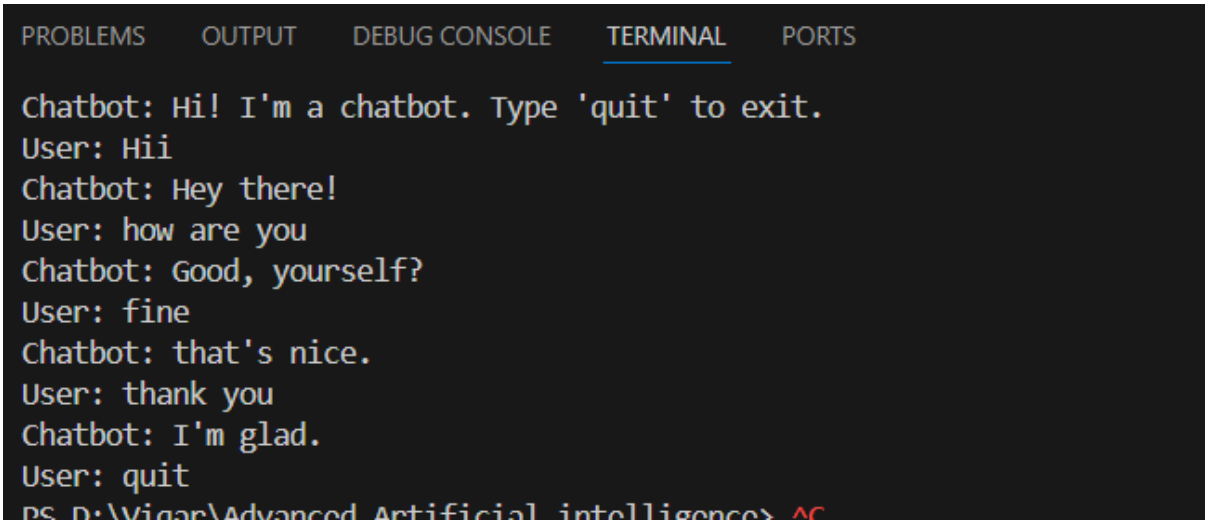
Writeup:

CODE:

```
import torch
from transformers import AutoModelForCausalLM, AutoTokenizer

tokenizer = AutoTokenizer.from_pretrained("microsoft/DialoGPT-medium")
model = AutoModelForCausalLM.from_pretrained("microsoft/DialoGPT-medium")

def chat():
    chat_history_ids = None
    print("Chatbot: Hi! I'm a chatbot. Type 'quit' to exit.")
    while True:
        user_input = input("User: ")
        if user_input.lower() == 'quit':
            break
        new_input_ids = tokenizer.encode(user_input + tokenizer.eos_token, return_tensors='pt')

        # Create attention mask
        if chat_history_ids is None:
            bot_input_ids = new_input_ids
            attention_mask = torch.ones(bot_input_ids.shape, dtype=torch.int)
        else:
            bot_input_ids = torch.cat([chat_history_ids, new_input_ids], dim=-1)
            attention_mask = torch.ones(bot_input_ids.shape, dtype=torch.int)

        chat_history_ids = model.generate(bot_input_ids,
                                          max_length=1000,
                                          pad_token_id=tokenizer.eos_token_id,
                                          temperature=0.9,
                                          do_sample=True,
                                          top_k=50,
                                          top_p=0.95,
                                          attention_mask=attention_mask)

        bot_response = tokenizer.decode(chat_history_ids[:, bot_input_ids.shape[-1]:][0],
skip_special_tokens=True)
```

```
    print(f"Chatbot: {bot_response}")

chat()
```

OUTPUT:



Practical: 4

AIM: Developing a recommendation system using collaborative filtering or deep learning approaches.

Writeup:

CODE:

```
import pandas as pd


# https://files.grouplens.org/datasets/movielens/ml-25m.zip
movies = pd.read_csv("movies.csv")
movies.head()
import re
def clean_title(title):
    title = re.sub("[^a-zA-Z0-9 ]", "", title)
    return title
movies["clean_title"] = movies["title"].apply(clean_title)
movies
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(ngram_range=(1,2))
tfidf = vectorizer.fit_transform(movies["clean_title"])
from sklearn.metrics.pairwise import cosine_similarity
import numpy as np
def search(title):
    title = clean_title(title)
    query_vec = vectorizer.transform([title])
    similarity = cosine_similarity(query_vec, tfidf).flatten()
    indices = np.argpartition(similarity, -5)[-5:]
    results = movies.iloc[indices].iloc[::-1]
    return results
# pip install ipywidgets
#jupyter labextension install @jupyter-widgets/jupyterlab-manager
import ipywidgets as widgets
from IPython.display import display
movie_input = widgets.Text(
    value='Toy Story',
    description='Movie Title:',
    disabled=False
)
```

```
movie_list = widgets.Output()
def on_type(data):
   with movie_list:
      movie_list.clear_output()
      title = data["new"]
      if len(title) > 5:
         display(search(title))
movie_input.observe(on_type, names='value')
display(movie_input, movie_list)
movie_id = 89745
#def find_similar_movies(movie_id):
movie = movies[movies["movieId"] == movie_id]
ratings = pd.read_csv("ratings.csv")
ratings.dtypes
similar_users = ratings[(ratings["movieId"] == movie_id) & (ratings["rating"] > 4)]["userId"].unique()
similar_user_recs = ratings[(ratings["userId"].isin(similar_users)) & (ratings["rating"] > 4)]["movieId"]
similar_user_recs = similar_user_recs.value_counts() / len(similar_users)
similar_user_recs = similar_user_recs[similar_user_recs > .10]
all_users = ratings[(ratings["movieId"].isin(similar_user_recs.index)) & (ratings["rating"] > 4)]
all_user_recs = all_users["movieId"].value_counts() / len(all_users["userId"].unique())
rec_percentages = pd.concat([similar_user_recs, all_user_recs], axis=1)
rec_percentages.columns = ["similar", "all"]
rec_percentages
rec_percentages["score"] = rec_percentages["similar"] / rec_percentages["all"]
rec_percentages = rec_percentages.sort_values("score", ascending=False)
rec_percentages.head(10).merge(movies, left_index=True, right_on="movieId")
def find_similar_movies(movie_id):
   similar_users = ratings[(ratings["movieId"] == movie_id) & (ratings["rating"] >
4)]["userId"].unique()
   similar_user_recs = ratings[(ratings["userId"].isin(similar_users)) & (ratings["rating"] >
4)]["movieId"]
   similar_user_recs = similar_user_recs.value_counts() / len(similar_users)

   similar_user_recs = similar_user_recs[similar_user_recs > .10]
   all_users = ratings[(ratings["movieId"].isin(similar_user_recs.index)) & (ratings["rating"] > 4)]
```

```
    all_user_recs = all_users["movieId"].value_counts() / len(all_users["userId"].unique())
    rec_percentages = pd.concat([similar_user_recs, all_user_recs], axis=1)
    rec_percentages.columns = ["similar", "all"]

    rec_percentages["score"] = rec_percentages["similar"] / rec_percentages["all"]
    rec_percentages = rec_percentages.sort_values("score", ascending=False)
    return rec_percentages.head(10).merge(movies, left_index=True, right_on="movieId")[["score",
"title", "genres"]]

import ipywidgets as widgets
from IPython.display import display

movie_name_input = widgets.Text(
    value='Toy Story',
    description='Movie Title:',
    disabled=False
)
recommendation_list = widgets.Output()

def on_type(data):
    with recommendation_list:
        recommendation_list.clear_output()
        title = data["new"]
        if len(title) > 5:
            results = search(title)
            movie_id = results.iloc[0]["movieId"]
            display(find_similar_movies(movie_id))

movie_name_input.observe(on_type, names='value')

display(movie_name_input, recommendation_list)
```

OUTPUT:

Movie Title: Toy Story

	score	title	genres
3021	18.841924	Toy Story 2 (1999)	Adventure|Animation|Children|Comedy|Fantasy
2264	8.210086	Bug's Life, A (1998)	Adventure|Animation|Children|Comedy
2669	6.868954	Iron Giant, The (1999)	Adventure|Animation|Children|Drama|Sci-Fi
14813	6.503216	Toy Story 3 (2010)	Adventure|Animation|Children|Comedy|Fantasy|IMAX
3650	6.272875	Chicken Run (2000)	Animation|Children|Comedy
1992	5.531892	Little Mermaid, The (1989)	Animation|Children|Comedy|Musical|Romance
1818	5.362941	Mulan (1998)	Adventure|Animation|Children|Comedy|Drama|Musi...
2895	5.349396	Who Framed Roger Rabbit? (1988)	Adventure|Animation|Children|Comedy|Crime|Fant...
0	5.287943	Toy Story (1995)	Adventure|Animation|Children|Comedy|Fantasy
3082	5.283613	Galaxy Quest (1999)	Adventure|Comedy|Sci-Fi

Practical: 5

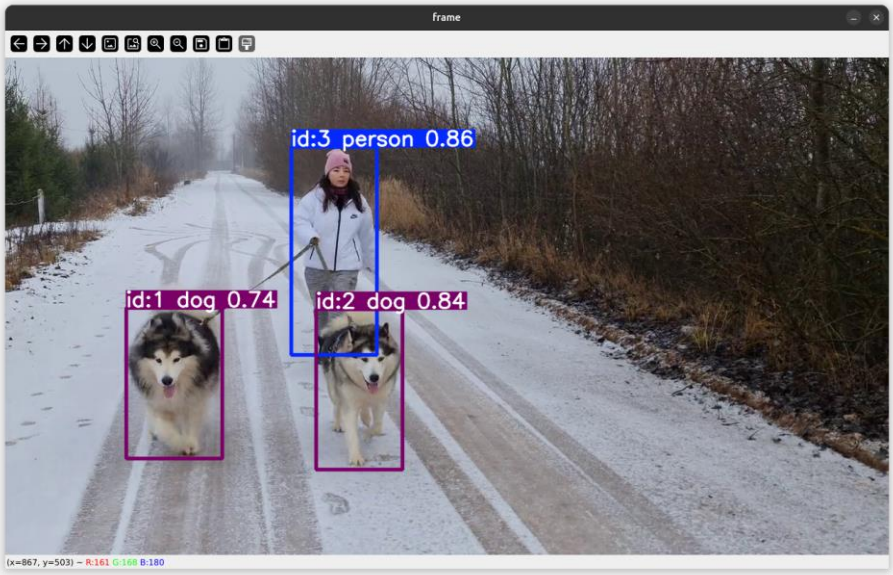
AIM: Implementing a computer vision project, such as object detection or image segmentation.

Writeup:

CODE:

```
from ultralytics import YOLO
import cv2

# load yolov8 model
model = YOLO('yolov8n.pt')

# load video
video_path = './test.mp4'
cap = cv2.VideoCapture(video_path)

ret = True
# read frames
while ret:
ret, frame = cap.read()

if ret:

# detect objects
# track objects
results = model.track(frame, persist=True)

# plot results
# cv2.rectangle
# cv2.putText
frame_ = results[0].plot()

# visualize
cv2.imshow('frame', frame_)
if cv2.waitKey(25) & 0xFF == ord('q'):
break
```

OUTPUT:



Practical: 6

AIM: Applying reinforcement learning algorithms to solve complex decision-making problems.

Writeup:

CODE:

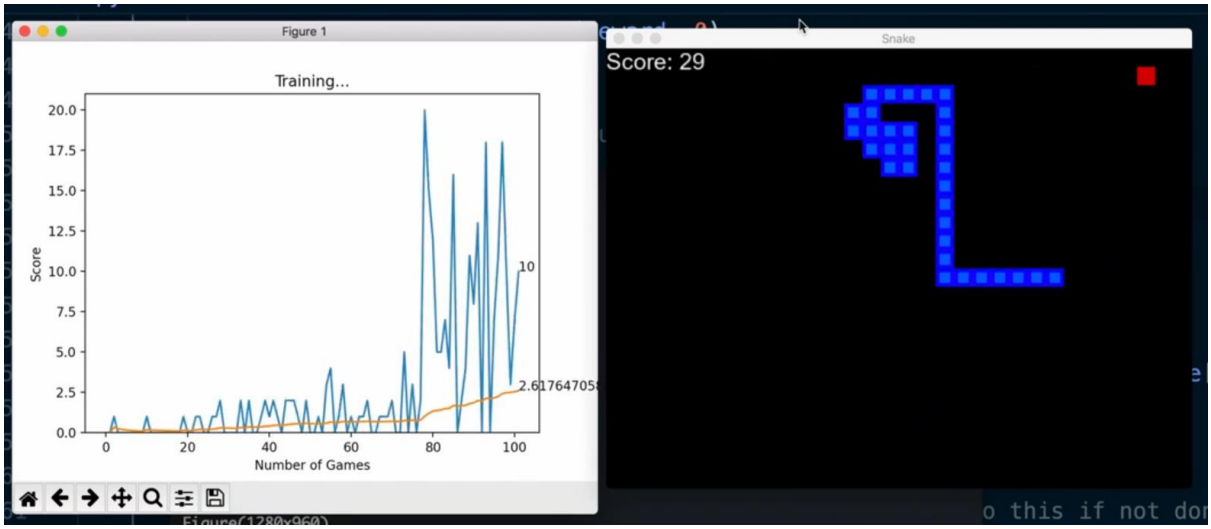
```
import torch
import random
import numpy as np
from collections import deque
from game import SnakeGameAI, Direction, Point
from model import Linear_QNet, QTrainer
from helper import plot
MAX_MEMORY = 100_000
BATCH_SIZE = 1000
LR = 0.001
class Agent:
    def __init__(self):
        self.n_games = 0
        self.epsilon = 0 # randomness
        self.gamma = 0.9 # discount rate
        self.memory = deque(maxlen=MAX_MEMORY) # popleft()
        self.model = Linear_QNet(11, 256, 3)
        self.trainer = QTrainer(self.model, lr=LR, gamma=self.gamma)
    def get_state(self, game):
        head = game.snake[0]
        point_l = Point(head.x - 20, head.y)
        point_r = Point(head.x + 20, head.y)
        point_u = Point(head.x, head.y - 20)
        point_d = Point(head.x, head.y + 20)
        dir_l = game.direction == Direction.LEFT
        dir_r = game.direction == Direction.RIGHT
        dir_u = game.direction == Direction.UP
        dir_d = game.direction == Direction.DOWN
        state = [
            # Danger straight
            (dir_r and game.is_collision(point_r)) or
            (dir_l and game.is_collision(point_l)) or
            (dir_u and game.is_collision(point_u)) or
            (dir_d and game.is_collision(point_d)),
```

```
            # Danger right
            (dir_u and game.is_collision(point_r)) or
            (dir_d and game.is_collision(point_l)) or
            (dir_l and game.is_collision(point_u)) or
            (dir_r and game.is_collision(point_d)),

            # Danger left
            (dir_d and game.is_collision(point_r)) or
            (dir_u and game.is_collision(point_l)) or
            (dir_r and game.is_collision(point_u)) or
            (dir_l and game.is_collision(point_d)),

            # Move direction
            dir_l,
            dir_r,
            dir_u,
            dir_d,

            # Food location
            game.food.x < game.head.x,  # food left
            game.food.x > game.head.x,  # food right
            game.food.y < game.head.y,  # food up
            game.food.y > game.head.y  # food down
            ]

        return np.array(state, dtype=int)

    def remember(self, state, action, reward, next_state, done):
        self.memory.append((state, action, reward, next_state, done)) # popleft if MAX_MEMORY is
reached

    def train_long_memory(self):
        if len(self.memory) > BATCH_SIZE:
            mini_sample = random.sample(self.memory, BATCH_SIZE) # list of tuples
```

```
        else:
            mini_sample = self.memory

        states, actions, rewards, next_states, dones = zip(*mini_sample)
        self.trainer.train_step(states, actions, rewards, next_states, dones)
        #for state, action, reward, nexrt_state, done in mini_sample:
        #    self.trainer.train_step(state, action, reward, next_state, done)

    def train_short_memory(self, state, action, reward, next_state, done):
        self.trainer.train_step(state, action, reward, next_state, done)

    def get_action(self, state):
        # random moves: tradeoff exploration / exploitation
        self.epsilon = 80 - self.n_games
        final_move = [0,0,0]
        if random.randint(0, 200) < self.epsilon:
            move = random.randint(0, 2)
            final_move[move] = 1
        else:
            state0 = torch.tensor(state, dtype=torch.float)
            prediction = self.model(state0)
            move = torch.argmax(prediction).item()
            final_move[move] = 1

        return final_move


def train():
    plot_scores = []
    plot_mean_scores = []
    total_score = 0
    record = 0
    agent = Agent()
    game = SnakeGameAI()
    while True:
```

```
        # get old state
        state_old = agent.get_state(game)
        # get move
        final_move = agent.get_action(state_old)
        # perform move and get new state
        reward, done, score = game.play_step(final_move)
        state_new = agent.get_state(game)
        # train short memory
        agent.train_short_memory(state_old, final_move, reward, state_new, done)

        # remember
        agent.remember(state_old, final_move, reward, state_new, done)

        if done:
            # train long memory, plot result
            game.reset()
            agent.n_games += 1
            agent.train_long_memory()

            if score > record:
                record = score
                agent.model.save()

            print('Game', agent.n_games, 'Score', score, 'Record:', record)

            plot_scores.append(score)
            total_score += score
            mean_score = total_score / agent.n_games
            plot_mean_scores.append(mean_score)
            plot(plot_scores, plot_mean_scores)
if __name__ == '__main__':
    train()
```

OUTPUT:



Practical: 7

AIM: Utilizing transfer learning to improve model performance on limited datasets.

Writeup:

CODE:

```
import torch
import torch.nn as nn
import torch.optim as optim
from torch.optim import lr_scheduler
import numpy as np
import torchvision
from torchvision import datasets, models, transforms
import matplotlib.pyplot as plt
import time
import os
import copy

mean = np.array([0.5, 0.5, 0.5])
std = np.array([0.25, 0.25, 0.25])

data_transforms = {
   'train': transforms.Compose([
      transforms.RandomResizedCrop(224),
      transforms.RandomHorizontalFlip(),
      transforms.ToTensor(),
      transforms.Normalize(mean, std)
   ]),
   'val': transforms.Compose([
      transforms.Resize(256),
      transforms.CenterCrop(224),
      transforms.ToTensor(),
      transforms.Normalize(mean, std)
   ]),
}

data_dir = 'data/hymenoptera_data'
image_datasets = {x: datasets.ImageFolder(os.path.join(data_dir, x),
                                          data_transforms[x])
                  for x in ['train', 'val']}
```

```
dataloaders = {x: torch.utils.data.DataLoader(image_datasets[x], batch_size=4,
                                              shuffle=True, num_workers=0)
               for x in ['train', 'val']}
dataset_sizes = {x: len(image_datasets[x]) for x in ['train', 'val']}
class_names = image_datasets['train'].classes

device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
print(class_names)



def imshow(inp, title):
    """Imshow for Tensor."""
    inp = inp.numpy().transpose((1, 2, 0))
    inp = std * inp + mean
    inp = np.clip(inp, 0, 1)
    plt.imshow(inp)
    plt.title(title)
    plt.show()



# Get a batch of training data
inputs, classes = next(iter(dataloaders['train']))

# Make a grid from batch
out = torchvision.utils.make_grid(inputs)

imshow(out, title=[class_names[x] for x in classes])

def train_model(model, criterion, optimizer, scheduler, num_epochs=25):
    since = time.time()

    best_model_wts = copy.deepcopy(model.state_dict())
    best_acc = 0.0

    for epoch in range(num_epochs):
```

```
    print('Epoch {}/{}'.format(epoch, num_epochs - 1))
    print('-' * 10)

    # Each epoch has a training and validation phase
    for phase in ['train', 'val']:
      if phase == 'train':
        model.train()  # Set model to training mode
      else:
        model.eval()   # Set model to evaluate mode

      running_loss = 0.0
      running_corrects = 0

      # Iterate over data.
      for inputs, labels in dataloaders[phase]:
        inputs = inputs.to(device)
        labels = labels.to(device)

        # forward
        # track history if only in train
        with torch.set_grad_enabled(phase == 'train'):
          outputs = model(inputs)
          _, preds = torch.max(outputs, 1)
          loss = criterion(outputs, labels)

          # backward + optimize only if in training phase
          if phase == 'train':
            optimizer.zero_grad()
            loss.backward()
            optimizer.step()

        # statistics
        running_loss += loss.item() * inputs.size(0)
        running_corrects += torch.sum(preds == labels.data)
```

```
            if phase == 'train':
                scheduler.step()

            epoch_loss = running_loss / dataset_sizes[phase]
            epoch_acc = running_corrects.double() / dataset_sizes[phase]

            print('{} Loss: {:.4f} Acc: {:.4f}'.format(
                phase, epoch_loss, epoch_acc))

            # deep copy the model
            if phase == 'val' and epoch_acc > best_acc:
                best_acc = epoch_acc
                best_model_wts = copy.deepcopy(model.state_dict())

        print()

    time_elapsed = time.time() - since
    print('Training complete in {:.0f}m {:.0f}s'.format(
        time_elapsed // 60, time_elapsed % 60))
    print('Best val Acc: {:4f}'.format(best_acc))

    # load best model weights
    model.load_state_dict(best_model_wts)
    return model


#### Finetuning the convnet ####
# Load a pretrained model and reset final fully connected layer.

model = models.resnet18(pretrained=True)
num_ftrs = model.fc.in_features
# Here the size of each output sample is set to 2.
# Alternatively, it can be generalized to nn.Linear(num_ftrs, len(class_names)).
model.fc = nn.Linear(num_ftrs, 2)
```

```
model = model.to(device)

criterion = nn.CrossEntropyLoss()

# Observe that all parameters are being optimized
optimizer = optim.SGD(model.parameters(), lr=0.001)

# StepLR Decays the learning rate of each parameter group by gamma every step_size epochs
# Decay LR by a factor of 0.1 every 7 epochs
# Learning rate scheduling should be applied after optimizer's update
# e.g., you should write your code this way:
# for epoch in range(100):
#     train(...)
#     validate(...)
#     scheduler.step()

step_lr_scheduler = lr_scheduler.StepLR(optimizer, step_size=7, gamma=0.1)

model = train_model(model, criterion, optimizer, step_lr_scheduler, num_epochs=25)



#### ConvNet as fixed feature extractor ####
# Here, we need to freeze all the network except the final layer.
# We need to set requires_grad == False to freeze the parameters so that the gradients are not
computed in backward()
model_conv = torchvision.models.resnet18(pretrained=True)
for param in model_conv.parameters():
   param.requires_grad = False

# Parameters of newly constructed modules have requires_grad=True by default
num_ftrs = model_conv.fc.in_features
model_conv.fc = nn.Linear(num_ftrs, 2)

model_conv = model_conv.to(device)
```

```
criterion = nn.CrossEntropyLoss()

# Observe that only parameters of final layer are being optimized as
# opposed to before.
optimizer_conv = optim.SGD(model_conv.fc.parameters(), lr=0.001, momentum=0.9)

# Decay LR by a factor of 0.1 every 7 epochs
exp_lr_scheduler = lr_scheduler.StepLR(optimizer_conv, step_size=7, gamma=0.1)

model_conv = train_model(model_conv, criterion, optimizer_conv,
                         exp_lr_scheduler, num_epochs=25)
```

OUTPUT:

```
Epoch 23/24
----------
train Loss: 0.3284 Acc: 0.8730
val Loss: 0.1729 Acc: 0.9477

Epoch 24/24
----------
train Loss: 0.2955 Acc: 0.8934
val Loss: 0.1615 Acc: 0.9477

Training complete in 1m 28s
Best val Acc: 0.954248

Process finished with exit code 0
```

Practical: 8

AIM: Building a deep learning model for time series forecasting or anomaly detection.

Writeup:

CODE:

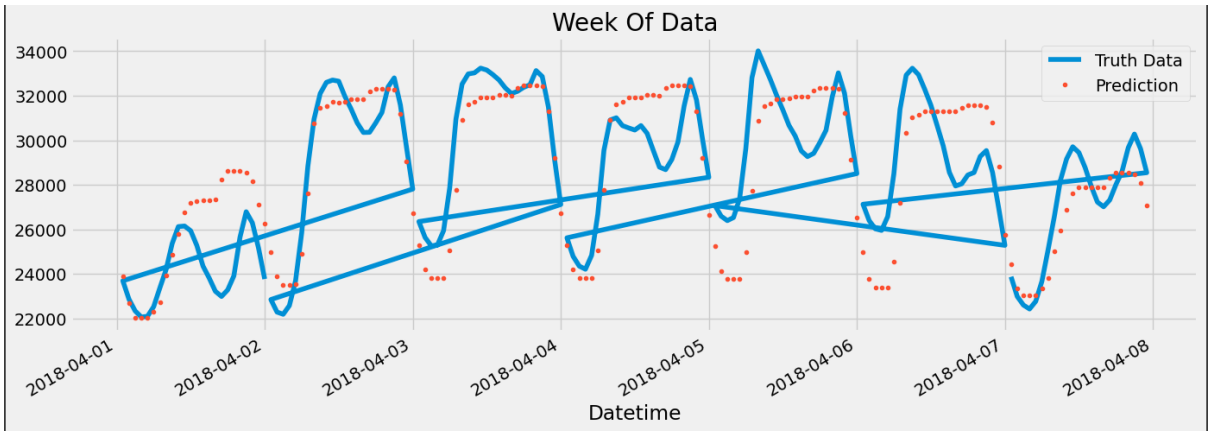
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

import xgboost as xgb
from sklearn.metrics import mean_squared_error
color_pal = sns.color_palette()
plt.style.use('fivethirtyeight')

df = pd.read_csv('/content/hourly-energy-consumption/PJME_hourly.csv')
df = df.set_index('Datetime')
df.index = pd.to_datetime(df.index)

df.plot(style='.',
        figsize=(15, 5),
        color=color_pal[0],
        title='PJME Energy Use in MW')
plt.show()

# Train / Test Split

train = df.loc[df.index < '01-01-2015']
test = df.loc[df.index >= '01-01-2015']

fig, ax = plt.subplots(figsize=(15, 5))
train.plot(ax=ax, label='Training Set', title='Data Train/Test Split')
test.plot(ax=ax, label='Test Set')
ax.axvline('01-01-2015', color='black', ls='--')
ax.legend(['Training Set', 'Test Set'])
plt.show()

df.loc[(df.index > '01-01-2010') & (df.index < '01-08-2010')] \
    .plot(figsize=(15, 5), title='Week Of Data')
```

```
plt.show()

# Feature Creation

def create_features(df):
    """
    Create time series features based on time series index.
    """
    df = df.copy()
    df['hour'] = df.index.hour
    df['dayofweek'] = df.index.dayofweek

df = create_features(df)

# Visualize our Feature / Target Relationship

fig, ax = plt.subplots(figsize=(10, 8))
sns.boxplot(data=df, x='hour', y='PJME_MW')
ax.set_title('MW by Hour')
plt.show()

fig, ax = plt.subplots(figsize=(10, 8))
sns.boxplot(data=df, x='month', y='PJME_MW', palette='Blues')
ax.set_title('MW by Month')
plt.show()

# Create our Model

train = create_features(train)
test = create_features(test)

FEATURES = ['dayofyear', 'hour', 'dayofweek', 'quarter', 'month', 'year']
TARGET = 'PJME_MW'

X_train = train[FEATURES]
```

```
y_train = train[TARGET]

X_test = test[FEATURES]
y_test = test[TARGET]

reg = xgb.XGBRegressor(base_score=0.5, booster='gbtree',
                   n_estimators=1000,
                   early_stopping_rounds=50,
                   objective='reg:linear',
                   max_depth=3,
                   learning_rate=0.01)
reg.fit(X_train, y_train,
        eval_set=[(X_train, y_train), (X_test, y_test)],
        verbose=100)

# Feature Importance

fi = pd.DataFrame(data=reg.feature_importances_,
             index=reg.feature_names_in_,
             columns=['importance'])
fi.sort_values('importance').plot(kind='barh', title='Feature Importance')
plt.show()

# Forecast on Test

test['prediction'] = reg.predict(X_test)
df = df.merge(test[['prediction']], how='left', left_index=True, right_index=True)
ax = df[['PJME_MW']].plot(figsize=(15, 5))
df['prediction'].plot(ax=ax, style='.')
plt.legend(['Truth Data', 'Predictions'])
ax.set_title('Raw Dat and Prediction')
plt.show()

ax = df.loc[(df.index > '04-01-2018') & (df.index < '04-08-2018')]['PJME_MW'] \
   .plot(figsize=(15, 5), title='Week Of Data')
```

```
df.loc[(df.index > '04-01-2018') & (df.index < '04-08-2018')]['prediction'] \
   .plot(style='.')
plt.legend(['Truth Data','Prediction'])
plt.show()

# Score (RMSE)

score = np.sqrt(mean_squared_error(test['PJME_MW'], test['prediction']))
print(f'RMSE Score on Test set: {score:0.2f}')

# Calculate Error
- Look at the worst and best predicted days

test['error'] = np.abs(test[TARGET] - test['prediction'])
test['date'] = test.index.date
test.groupby(['date'])['error'].mean().sort_values(ascending=False).head(10)
```

OUTPUT:



Practical: 9

AIM: Implementing a machine learning pipeline for automated feature engineering and model selection.

Writeup:

CODE:

```
!pip install evalml

### Loading The Dataset
- We can also read the dataset from csv
- then convert to datatable

import evalml
X, y = evalml.demos.load_breast_cancer()
X_train, X_test, y_train, y_test = evalml.preprocessing.split_data(X, y, problem_type='binary')

X_train.head()

### Running the AutoML to select the best algorithm

import evalml
evalml.problem_types.ProblemTypes.all_problem_types

from evalml.automl import AutoMLSearch
automl = AutoMLSearch(X_train=X_train, y_train=y_train, problem_type='binary')
automl.search()

automl.rankings

### Getting The Best Pipeline

automl.best_pipeline

best_pipeline=automl.best_pipeline

### Let's Check the detailed desscription

automl.describe_pipeline(automl.rankings.iloc[0]["id"])

### Evaluate on hold out data
```

```
best_pipeline.score(X_test, y_test, objectives=["auc","f1","Precision","Recall"])

### We can also optimize for a problem specific objective

automl_auc = AutoMLSearch(X_train=X_train, y_train=y_train,
                          problem_type='binary',
                          objective='auc',
                          additional_objectives=['f1', 'precision'],
                          max_batches=1,
                          optimize_thresholds=True)

automl_auc.search()

automl_auc.rankings

automl_auc.describe_pipeline(automl_auc.rankings.iloc[0]["id"])

best_pipeline_auc = automl_auc.best_pipeline

# get the score on holdout data
best_pipeline_auc.score(X_test, y_test,  objectives=["auc"])

best_pipeline.save("model.pkl")

#### Loading the Model

check_model=automl.load('model.pkl')

check_model.predict_proba(X_test).to_dataframe()
```

OUTPUT:

	id	pipeline_name	search_order	ranking_score	mean_cv_score	standard_deviation_cv_score	percent_better_than_baseline	high_variance_cv	parameters
0	6	Logistic Regression Classifier w/ Label Encode...	6	0.111823	0.111823	0.033800	99.169626	False	{'Label Encoder': {'positive_label': None}, 'I...
1	4	Elastic Net Classifier w/ Label Encoder + Impu...	4	0.114153	0.114153	0.031724	99.152325	False	{'Label Encoder': {'positive_label': None}, 'I...
2	1	Random Forest Classifier w/ Label Encoder + Im...	1	0.126770	0.126770	0.035172	99.058640	False	{'Label Encoder': {'positive_label': None}, 'I...
3	3	Extra Trees Classifier w/ Label Encoder + Impu...	3	0.150551	0.150551	0.034153	98.882044	False	{'Label Encoder': {'positive_label': None}, 'I...
4	5	XGBoost Classifier w/ Label Encoder + Imputer ...	5	0.150885	0.150885	0.046259	98.879567	False	{'Label Encoder': {'positive_label': None}, 'I...
5	2	LightGBM Classifier w/ Label Encoder + Imputer...	2	0.194301	0.194301	0.052339	98.557171	False	{'Label Encoder': {'positive_label': None}, 'I...
6	0	Mode Baseline Binary Classification Pipeline	0	13.466641	13.466641	0.086133	0.000000	False	{'Label Encoder': {'positive_label': None}, 'B...

```
**********************************************************************************************
INFO:evalml.pipelines.pipeline_base.describe:
**********************************************************************************************
* Logistic Regression Classifier w/ Label Encoder + Imputer + Standard Scaler + Select Columns Transformer *
INFO:evalml.pipelines.pipeline_base.describe:* Logistic Regression Classifier w/ Label Encoder + Imputer + Standard Scaler + Select Columns Transformer *
**********************************************************************************************
INFO:evalml.pipelines.pipeline_base.describe:**********************************************************************************************

INFO:evalml.pipelines.pipeline_base.describe:
Problem Type: binary
INFO:evalml.pipelines.pipeline_base.describe:Problem Type: binary
Model Family: Linear
```

Practical: 10

AIM: Using advanced optimization techniques like evolutionary algorithms or Bayesian optimization for hyperparameter tuning.

Writeup:

CODE:

```
# Startup Google CoLab
try:
   import google.colab
   COLAB = True
   print("Note: using Google CoLab")
except:
   print("Note: not using Google CoLab")
   COLAB = False

# Nicely formatted time string

def hms_string(sec_elapsed):
   h = int(sec_elapsed / (60 * 60))
   m = int((sec_elapsed % (60 * 60)) / 60)
   s = sec_elapsed % 60
   return "{}:{:>02}:{:>05.2f}".format(h, m, s)

# Make use of a GPU or MPS (Apple) if one is available.  (see module 3.2)
import torch
has_mps = torch.backends.mps.is_built()
device = "mps" if has_mps else "cuda" if torch.cuda.is_available() else "cpu"
print(f"Using device: {device}")

from scipy.stats import zscore
import pandas as pd
import logging
import os
logging.disable(logging.WARNING)

# Read the data set
df = pd.read_csv(
   "https://data.heatonresearch.com/data/t81-558/jh-simple-dataset.csv",
   na_values=['NA', '?'])
```

```
# Generate dummies for job
df = pd.concat(
   [df, pd.get_dummies(df['job'], prefix="job", dtype=int)], axis=1)
df.drop('job', axis=1, inplace=True)

# Generate dummies for area
df = pd.concat(
   [df, pd.get_dummies(df['area'], prefix="area", dtype=int)], axis=1)
df.drop('area', axis=1, inplace=True)

# Missing values for income
med = df['income'].median()
df['income'] = df['income'].fillna(med)

# Standardize ranges
df['income'] = zscore(df['income'])
df['aspect'] = zscore(df['aspect'])
df['save_rate'] = zscore(df['save_rate'])
df['age'] = zscore(df['age'])
df['subscriptions'] = zscore(df['subscriptions'])

# Convert to numpy - Classification
x_columns = df.columns.drop('product').drop('id')
x = df[x_columns].values
dummies = pd.get_dummies(df['product'])  # Classification
products = dummies.columns
y = dummies.values

import pandas as pd
import numpy as np
import time
import statistics
from scipy.stats import zscore
from sklearn import metrics
from sklearn.model_selection import StratifiedShuffleSplit
```

```
import torch
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import DataLoader, TensorDataset

# Convert data to PyTorch tensors
x_tensor = torch.FloatTensor(x).to(device)
y_tensor = torch.LongTensor(np.argmax(y, axis=1)).to(
    device)  # Convert one-hot to index

class NeuralNetwork(nn.Module):
    def __init__(self, input_dim, dropout, neuronPct, neuronShrink):
        super(NeuralNetwork, self).__init__()

        layers = []
        neuronCount = int(neuronPct * 5000)
        layer = 0

        prev_count = input_dim
        while neuronCount > 25 and layer < 10:
            layers.append(nn.Linear(prev_count, neuronCount))
            prev_count = neuronCount
            layers.append(nn.PReLU())
            layers.append(nn.Dropout(dropout))
            neuronCount = int(neuronCount * neuronShrink)
            layer += 1

        layers.append(nn.Linear(prev_count, y.shape[1]))
        layers.append(nn.Softmax(dim=1))
        self.model = nn.Sequential(*layers)

    def forward(self, x):
        return self.model(x)

# Create and print the model
```

```
model = NeuralNetwork(x.shape[1], 0.2, 0.1, 0.25).to(device)
print(model)

# Evaluation function
SPLITS = 2
EPOCHS = 500
PATIENCE = 10

def evaluate_network(learning_rate=1e-3,dropout=0.2,
                     neuronPct=0.1, neuronShrink=0.25):

  boot = StratifiedShuffleSplit(n_splits=SPLITS, test_size=0.1)
  mean_benchmark = []
  epochs_needed = []

  for train, test in boot.split(x, np.argmax(y, axis=1)):
    x_train = x_tensor[train]
    y_train = y_tensor[train]
    x_test = x_tensor[test]
    y_test = y_tensor[test]

    model = NeuralNetwork(x.shape[1],
                dropout=dropout,
                neuronPct=neuronPct,
                neuronShrink=neuronShrink).to(device)
    criterion = nn.CrossEntropyLoss()
    optimizer = optim.Adam(model.parameters(), lr=learning_rate)

    dataset_train = TensorDataset(x_train, y_train)
    loader_train = DataLoader(dataset_train, batch_size=32, shuffle=True)

    best_loss = float('inf')
    patience_counter = 0

    for epoch in range(EPOCHS):
```

```
        model.train()
        for batch_x, batch_y in loader_train:
            optimizer.zero_grad()
            outputs = model(batch_x)
            loss = criterion(outputs, batch_y)
            loss.backward()
            optimizer.step()

        model.eval()
        with torch.no_grad():
            outputs_test = model(x_test)
            val_loss = criterion(outputs_test, y_test).item()

        if val_loss < best_loss:
            best_loss = val_loss
            patience_counter = 0
        else:
            patience_counter += 1

        if patience_counter >= PATIENCE:
            epochs_needed.append(epoch)
            break

    # Evaluate
    with torch.no_grad():
        model.eval()
        # Move predictions to CPU for evaluation
        pred = model(x_test).cpu().numpy()
        y_compare = y_test.cpu().numpy()
        score = metrics.log_loss(y_compare, pred)
        mean_benchmark.append(score)

  return -statistics.mean(mean_benchmark)

print(evaluate_network(learning_rate=1e-3,
```

```
                dropout=0.2,
                neuronPct=0.1,
                neuronShrink=0.25))

print(evaluate_network(
   dropout=0.2,
   neuronPct=0.1,
   neuronShrink=0.25))

# HIDE OUTPUT
!pip install bayesian-optimization

from bayes_opt import BayesianOptimization
import time

# Supress NaN warnings
import warnings
warnings.filterwarnings("ignore", category=RuntimeWarning)

# Bounded region of parameter space
pbounds = {'dropout': (0.0, 0.499),
        'learning_rate': (0.0, 0.1),
        'neuronPct': (0.01, 1),
        'neuronShrink': (0.01, 1)
        }

optimizer = BayesianOptimization(
   f=evaluate_network,
   pbounds=pbounds,
   verbose=2,  # verbose = 1 prints only when a maximum
   # is observed, verbose = 0 is silent
   random_state=1,
)

start_time = time.time()
```

```
optimizer.maximize(init_points=10, n_iter=20,)
time_took = time.time() - start_time

print(f"Total runtime: {hms_string(time_took)}")
print(optimizer.max)
```

OUTPUT:

iter	target	dropout	learni...	neuronPct	neuron...
1	-8.29	0.2081	0.07203	0.01011	0.3093
2	-8.29	0.07323	0.009234	0.1944	0.3521
3	-12.71	0.198	0.05388	0.425	0.6884
4	-8.29	0.102	0.08781	0.03711	0.6738
5	-12.95	0.2082	0.05587	0.149	0.2061
6	-8.29	0.3996	0.09683	0.3203	0.6954
7	-8.29	0.4373	0.08946	0.09419	0.04866
8	-9.167	0.08475	0.08781	0.1074	0.4269
9	-9.167	0.478	0.05332	0.695	0.3224
10	-11.88	0.3426	0.08346	0.02811	0.7526
11	-12.0	0.4915	0.07209	0.7089	0.323
12	-9.167	0.2208	0.04135	0.5523	0.7468

Practical: 11

AIM: Use Python libraries such as GPT-2 or textgenrnn to train generative models on a corpus of text data and generate new text based on the patterns it has learned.

Writeup:

CODE:

```
!pip install transformers # Installing the transformers library

import transformers # transformers library
import torch # PyTorch, we are using PyTorch as our library

# We are going to load in GPT-2 using the transformers library
gpt_tokenizer = transformers.GPT2Tokenizer.from_pretrained('gpt2-large')
# Loading in model now...
gpt_model = transformers.GPT2LMHeadModel.from_pretrained('gpt2-large')
# Takes a while to run...

## Making a function that will generate text for us ##
def gen_text(prompt_text, tokenizer, model, n_seqs=1, max_length=25):
 # n_seqs is the number of sentences to generate
 # max_length is the maximum length of the sentence
 encoded_prompt = tokenizer.encode(prompt_text, add_special_tokens=False, return_tensors="pt")
 # We are encoding the text using the gpt tokenizer. The return tensors are of type "pt"
 # since we are using PyTorch, not tensorflow
 output_sequences = model.generate(
    input_ids=encoded_prompt,
    max_length=max_length+len(encoded_prompt), # The model has to generate something,
    # so we add the length of the original sequence to max_length
    temperature=1.0,
    top_k=0,
    top_p=0.9,
    repetition_penalty=1.2, # To ensure that we dont get repeated phrases
    do_sample=True,
    num_return_sequences=n_seqs
 ) # We feed the encoded input into the model.
 ## Getting the output ##
 if len(output_sequences.shape) > 2:
   output_sequences.squeeze_() # the _ indicates that the operation will be done in-place
 generated_sequences = []
 for generated_sequence_idx, generated_sequence in enumerate(output_sequences):
```

```
    generated_sequence = generated_sequence.tolist()
    text = tokenizer.decode(generated_sequence)
    total_sequence = (
        prompt_text + text[len(tokenizer.decode(encoded_prompt[0],
clean_up_tokenization_spaces=True, )) :]
    )
    generated_sequences.append(total_sequence)
  return generated_sequences

# Lots of syntax errors, but now we can test our model
## One important note: in our function, on line 5, make sure that
# return_tensor is return_tensors, otherwise you will get an error like
# this:
#####
# Another important note: on line 27 of the function, instead of
# clear_up_tokenization_spaces, write clean_up_tokenization_spaces
####
gen_text("Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war
cry",gpt_tokenizer,gpt_model)

# Sequence length was too small, lets increase it
gen_text("Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry",
        gpt_tokenizer,
        gpt_model,
        max_length=100)
# Will take some time.....

# We can demostrate n_seqs here
gen_text("Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry",
        gpt_tokenizer,
        gpt_model,
        max_length=40,
        n_seqs=3) # Will take even longer....
```

OUTPUT:-

```
The attention mask and the pad token id were not set. As a consequence, you may observe unexpected behavior. Please pass your input's `attention_mask` to obtain reliable results.
Setting `pad_token_id` to `eos_token_id`:50256 for open-end generation.
['Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry.\n\nAll four fell dead; because of them, many things happened, some nearsighted and out of focus',
 'Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry as they shouted. Behind them came tattered wood paneling leaking from around a ruined pool of red liquid,-',
 "Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry. Glorfindel looked at his hobbit companion expectantly, while Rohan's Master said a short prayer",
 'Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry. But they were quickly halted by lowing orc knights atop stilts on The Door to Mordor. Two of',
 'Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry. Their words were without rhyme or reason:\n\n"It is important to take this new information into consideration',
 "Legolas and Gimli advanced on the orcs, raising their weapons with a harrowing war cry. They did not bring the fight to an end in front of King Theoden's camp until the last orc"]
```

Practical: 12

AIM: Experiment with neural networks like GANS (Generative Adversarial Networks) using Python libraries like TensorFlow or PyTorch to generate new images based on a dataset of images.

Writeup:

CODE:

```
### Setup

import tensorflow as tf

tf.__version__

# To generate GIFs
!pip install imageio
!pip install git+https://github.com/tensorflow/docs

import glob
import imageio
import matplotlib.pyplot as plt
import numpy as np
import os
import PIL
from tensorflow.keras import layers
import time

from IPython import display

### Load and prepare the dataset


(train_images, train_labels), (_, _) = tf.keras.datasets.mnist.load_data()

train_images = train_images.reshape(train_images.shape[0], 28, 28, 1).astype('float32')
train_images = (train_images - 127.5) / 127.5  # Normalize the images to [-1, 1]

BUFFER_SIZE = 60000
BATCH_SIZE = 256

# Batch and shuffle the data
```

```
train_dataset =
tf.data.Dataset.from_tensor_slices(train_images).shuffle(BUFFER_SIZE).batch(BATCH_SIZE)

## Create the models

### The Generator


def make_generator_model():
    model = tf.keras.Sequential()
    model.add(layers.Dense(7*7*256, use_bias=False, input_shape=(100,)))
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Reshape((7, 7, 256)))
    assert model.output_shape == (None, 7, 7, 256)  # Note: None is the batch size

    model.add(layers.Conv2DTranspose(128, (5, 5), strides=(1, 1), padding='same', use_bias=False))
    assert model.output_shape == (None, 7, 7, 128)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(64, (5, 5), strides=(2, 2), padding='same', use_bias=False))
    assert model.output_shape == (None, 14, 14, 64)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(1, (5, 5), strides=(2, 2), padding='same', use_bias=False,
activation='tanh'))
    assert model.output_shape == (None, 28, 28, 1)

    return model

generator = make_generator_model()
```

```
noise = tf.random.normal([1, 100])
generated_image = generator(noise, training=False)

plt.imshow(generated_image[0, :, :, 0], cmap='gray')

### The Discriminator

def make_discriminator_model():
   model = tf.keras.Sequential()
   model.add(layers.Conv2D(64, (5, 5), strides=(2, 2), padding='same',
                           input_shape=[28, 28, 1]))
   model.add(layers.LeakyReLU())
   model.add(layers.Dropout(0.3))

   model.add(layers.Conv2D(128, (5, 5), strides=(2, 2), padding='same'))
   model.add(layers.LeakyReLU())
   model.add(layers.Dropout(0.3))

   model.add(layers.Flatten())
   model.add(layers.Dense(1))

   return model

discriminator = make_discriminator_model()
decision = discriminator(generated_image)
print (decision)

## Define the loss and optimizers



# This method returns a helper function to compute cross entropy loss
cross_entropy = tf.keras.losses.BinaryCrossentropy(from_logits=True)

### Discriminator loss
```

```
def discriminator_loss(real_output, fake_output):
    real_loss = cross_entropy(tf.ones_like(real_output), real_output)
    fake_loss = cross_entropy(tf.zeros_like(fake_output), fake_output)
    total_loss = real_loss + fake_loss
    return total_loss

### Generator loss

def generator_loss(fake_output):
    return cross_entropy(tf.ones_like(fake_output), fake_output)

generator_optimizer = tf.keras.optimizers.Adam(1e-4)
discriminator_optimizer = tf.keras.optimizers.Adam(1e-4)

### Save checkpoints

checkpoint_dir = './training_checkpoints'
checkpoint_prefix = os.path.join(checkpoint_dir, "ckpt")
checkpoint = tf.train.Checkpoint(generator_optimizer=generator_optimizer,
                                 discriminator_optimizer=discriminator_optimizer,
                                 generator=generator,
                                 discriminator=discriminator)

## Define the training loop

EPOCHS = 50
noise_dim = 100
num_examples_to_generate = 16

# You will reuse this seed overtime (so it's easier)
# to visualize progress in the animated GIF)
seed = tf.random.normal([num_examples_to_generate, noise_dim])

# Notice the use of `tf.function`
# This annotation causes the function to be "compiled".
```

```
@tf.function
def train_step(images):
    noise = tf.random.normal([BATCH_SIZE, noise_dim])

    with tf.GradientTape() as gen_tape, tf.GradientTape() as disc_tape:
      generated_images = generator(noise, training=True)

      real_output = discriminator(images, training=True)
      fake_output = discriminator(generated_images, training=True)

      gen_loss = generator_loss(fake_output)
      disc_loss = discriminator_loss(real_output, fake_output)

    gradients_of_generator = gen_tape.gradient(gen_loss, generator.trainable_variables)
    gradients_of_discriminator = disc_tape.gradient(disc_loss, discriminator.trainable_variables)

    generator_optimizer.apply_gradients(zip(gradients_of_generator, generator.trainable_variables))
    discriminator_optimizer.apply_gradients(zip(gradients_of_discriminator,
discriminator.trainable_variables))

def train(dataset, epochs):
  for epoch in range(epochs):
    start = time.time()

    for image_batch in dataset:
      train_step(image_batch)

    # Produce images for the GIF as you go
    display.clear_output(wait=True)
    generate_and_save_images(generator,
                             epoch + 1,
                             seed)

    # Save the model every 15 epochs
    if (epoch + 1) % 15 == 0:
```

```
    checkpoint.save(file_prefix = checkpoint_prefix)

   print ('Time for epoch {} is {} sec'.format(epoch + 1, time.time()-start))

 # Generate after the final epoch
 display.clear_output(wait=True)
 generate_and_save_images(generator,
                          epochs,
                          seed)
```

Generate and save images

```
def generate_and_save_images(model, epoch, test_input):
 # Notice `training` is set to False.
 # This is so all layers run in inference mode (batchnorm).
 predictions = model(test_input, training=False)

 fig = plt.figure(figsize=(4, 4))

 for i in range(predictions.shape[0]):
     plt.subplot(4, 4, i+1)
     plt.imshow(predictions[i, :, :, 0] * 127.5 + 127.5, cmap='gray')
     plt.axis('off')

 plt.savefig('image_at_epoch_{:04d}.png'.format(epoch))
 plt.show()
```

Train the model

```
train(train_dataset, EPOCHS)
```

Restore the latest checkpoint.

```
checkpoint.restore(tf.train.latest_checkpoint(checkpoint_dir))
```

```
## Create a GIF

# Display a single image using the epoch number
def display_image(epoch_no):
  return PIL.Image.open('image_at_epoch_{:04d}.png'.format(epoch_no))

display_image(EPOCHS)

anim_file = 'dcgan.gif'

with imageio.get_writer(anim_file, mode='I') as writer:
  filenames = glob.glob('image*.png')
  filenames = sorted(filenames)
  for filename in filenames:
    image = imageio.imread(filename)
    writer.append_data(image)
  image = imageio.imread(filename)
  writer.append_data(image)
import tensorflow_docs.vis.embed as embed
embed.embed_file(anim_file)}
```

OUTPUT: