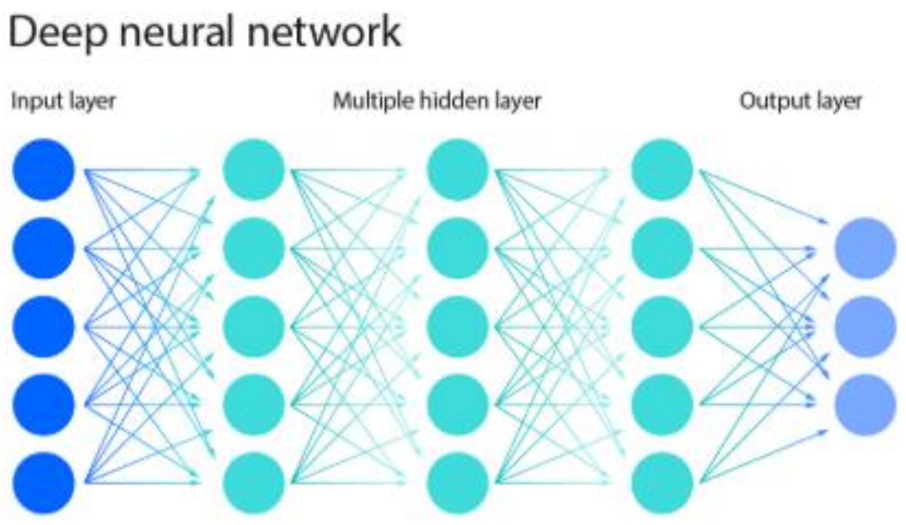
LAB No. 6

Implementation of Deep Neural Network

In this lab, students will study and implement a **Deep Neural Network (DNN)** for classification tasks. A DNN is an extension of Artificial Neural Networks that contains **multiple hidden layers**, enabling the model to learn complex and hierarchical patterns from data. Students will begin with a simple DNN on a small dataset to understand its structure and training process, and then apply DNN models to real-world datasets such as **Iris** and **MNIST**. Model performance will be evaluated using accuracy metrics.

Introduction

A **Deep Neural Network (DNN)** is a neural network with **more than one hidden layer** between the input and output layers. Each layer extracts increasingly complex features from the data. DNNs use **backpropagation** and **gradient descent–based optimizers** to update weights and minimize loss.



Key Components of DNN:

- **Input Layer** – receives raw data
- **Multiple Hidden Layers** – perform deep feature learning
- **Output Layer** – produces final prediction
- **Activation Functions** – ReLU, Sigmoid, Softmax
- **Loss Function** – measures prediction error
- **Optimizer** – Adam, SGD

DNNs are widely used in applications such as image recognition, speech processing, recommendation systems, and natural language processing.

Solved Examples

Example 1

Build a Deep Neural Network to predict whether a student **passes or fails** based on study hours and attendance **(Small Dataset)**

```
import pandas as pd
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Dataset
data = {
    'StudyHours': ['Low', 'High', 'High', 'Low', 'High'],
    'Attendance': ['Poor', 'Good', 'Poor', 'Good', 'Good'],
    'Result': ['Fail', 'Pass', 'Pass', 'Fail', 'Pass']
}

df = pd.DataFrame(data)

# Encode categorical data
encoder = LabelEncoder()
for col in df.columns:
    df[col] = encoder.fit_transform(df[col])

X = df[['StudyHours', 'Attendance']].values
y = df['Result'].values

# Build DNN
model = Sequential()
model.add(Dense(8, activation='relu', input_shape=(2,)))
model.add(Dense(6, activation='relu'))
model.add(Dense(4, activation='relu'))
model.add(Dense(1, activation='sigmoid'))

# Compile and train
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
model.fit(X, y, epochs=150, verbose=0)
```

```
# Prediction
prediction = model.predict([[1, 1]])
print("Predicted Result (Pass=1, Fail=0):", int(prediction[0][0] > 0.5))
```

The multiple hidden layers enable the DNN to learn deeper patterns compared to a shallow ANN.

Example 2:

Apply a Deep Neural Network to classify Iris flowers into three species.

Solution:

```
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils import to_categorical

# Load dataset
iris = load_iris()
X = iris.data
y = iris.target

# One-hot encoding
y = to_categorical(y)

# Train-test split
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.3, random_state=42
)

# Build DNN
model = Sequential()
model.add(Dense(16, activation='relu', input_shape=(4,)))
model.add(Dense(12, activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(3, activation='softmax'))

# Compile and train
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
model.fit(X_train, y_train, epochs=150, verbose=0)
```

```
# Evaluate
loss, accuracy = model.evaluate(X_test, y_test, verbose=0)
print("Test Accuracy:", accuracy)
```

The deeper architecture improves feature representation and classification accuracy.

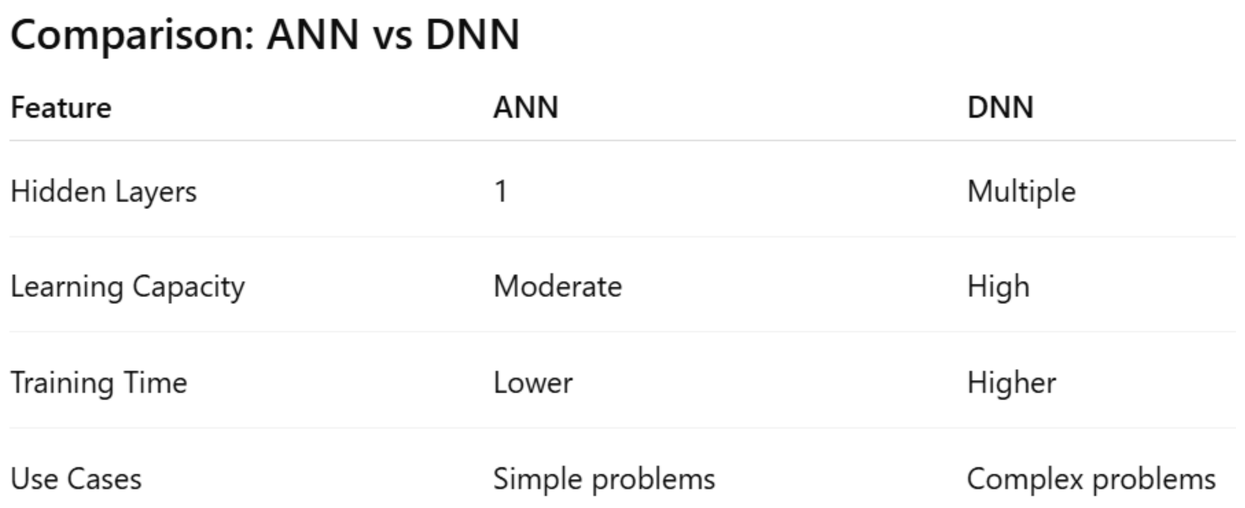
Example 3:

Use a Deep Neural Network to classify handwritten digits (0–9).

Solution:

```
from tensorflow.keras.datasets import mnist
from tensorflow.keras.utils import to_categorical

# Load MNIST dataset
(X_train, y_train), (X_test, y_test) = mnist.load_data()

# Preprocessing
X_train = X_train.reshape(-1, 28*28) / 255.0
X_test = X_test.reshape(-1, 28*28) / 255.0

# One-hot encode labels
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)

# Build DNN
model = Sequential()
model.add(Dense(256, activation='relu', input_shape=(784,)))
model.add(Dense(128, activation='relu'))
model.add(Dense(64, activation='relu'))
model.add(Dense(10, activation='softmax'))

# Compile and train
model.compile(optimizer='adam',                    loss='categorical_crossentropy',
metrics=['accuracy'])
model.fit(X_train, y_train, epochs=10, batch_size=128, verbose=1)

# Evaluate
loss, accuracy = model.evaluate(X_test, y_test)
print("Test Accuracy:", accuracy)
```

DNN learns hierarchical pixel features and achieves good accuracy, though CNNs are more suitable for image data.



Comparison: ANN vs DNN

Feature	ANN	DNN
Hidden Layers	1	Multiple
Learning Capacity	Moderate	High
Training Time	Lower	Higher
Use Cases	Simple problems	Complex problems

LAB Assignment No 6

Practice Question 1:

DNN Architecture Design

Create a Deep Neural Network to predict whether a student **passes or fails** using features such as *study hours* and *attendance*.

- Use **at least three hidden layers**
- Experiment with different numbers of neurons

- Compare the accuracy with a shallow ANN (one hidden layer)

Practice Question 2:

Activation Function Analysis

Using the **Iris dataset**, build two DNN models:

- Model A: Use **ReLU** activation in all hidden layers
- Model B: Use **tanh** activation in all hidden layers

Train both models and **compare their accuracy and training behavior**. Write your observation.

Practice Question 3:

Hyperparameter Tuning in DNN

Train a DNN on the **MNIST dataset** by changing:

- Number of hidden layers
- Number of neurons per layer
- Batch size

Record how these changes affect **training time and accuracy**

Practice Question 4:

Overfitting and Regularization

Build a deep neural network on any classification dataset and:

- Observe signs of **overfitting**
- Apply at least one regularization technique (Dropout or Early Stopping)
- Compare model performance **before and after regularization**

LAB Assessment

Student Name		**LAB Rubrics**	CLO3 , P5, PLO5

		Total Marks	10
Registration No		**Obtained Marks**	
		Teacher Name	Dr. Syed M Hamedoon
Date		**Signature**	