Midterm Report

Project: Vision Transformer

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NumPy, Pandas & Matplotlib

1. NumPy (Numerical Python)

NumPy is a core Python library used for numerical and scientific computations. It provides fast operations on arrays and matrices.

Key Features

- N-dimensional array object (`ndarray`)
- Faster than Python lists
- Supports vectorized operations

Important Concepts

- Array creation: `array()`, `zeros()`, `ones()`, `arange()`, `linspace()`
- Shape and size: `shape`, `size`, `reshape()`
- Mathematical operations: `sum()`, `mean()`, `max()`, `min()`

Example

```
import numpy as np
arr = np.array([1,2,3,4])
```

2. Pandas

Pandas is used for data manipulation and analysis. It works mainly with structured data.

Data Structures

- Series (1D)
- DataFrame (2D)

Important Functions

- `read_csv()`, `head()`, `tail()`

- `info()`, `describe()`
- Handling missing values: `isnull()`, `fillna()`

Example

```
import pandas as pd
df = pd.read_csv('data.csv')
```

3. Matplotlib

Matplotlib is a plotting library used for data visualization.

Common Plots

- Line plot
- Bar chart
- Histogram
- Scatter plot

Example

```
import matplotlib.pyplot as plt
plt.plot([1,2,3],[4,5,6])
plt.show()
```

Regression & Activation Functions

1. Regression

Regression is a supervised learning technique used to predict continuous values.

Types of Regression

- Linear Regression
- Multiple Linear Regression
- Polynomial Regression

Linear Regression Equation

$$y = mx + c$$

Where:

- m = slope
- c = intercept

Loss Function (MSE)

$$\text{MSE} = \frac{1}{n}\sum(y_{\text{true}} - y_{\text{pred}})^2$$

2. Activation Functions

Activation functions introduce non-linearity into neural networks.

Function	Formula	Range
Sigmoid	$\frac{1}{1+e^{-x}}$	$(0, 1)$
Tanh	$\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$	$(-1, 1)$
ReLU	$\max(0, x)$	$[0, \infty)$
softmax	$\frac{e^{z_i}}{\sum_{j=1}^{n} e^{z_j}}$	$(0, 1)$

Why Activation Functions?

- Introduce non-linearity
- Enable learning of complex patterns

K-Means Clustering

K-Means is an unsupervised learning algorithm used for clustering data into K groups.

Steps of K-Means Algorithm

1. Choose number of clusters K
2. Initialize centroids randomly
3. Assign data points to nearest centroid
4. Update centroids
5. Repeat until convergence

Distance Metric

Euclidean Distance:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Elbow Method

Used to determine optimal number of clusters by plotting WCSS vs K.

Artificial Neural Network (ANN)

ANN is inspired by the human brain and consists of interconnected neurons.

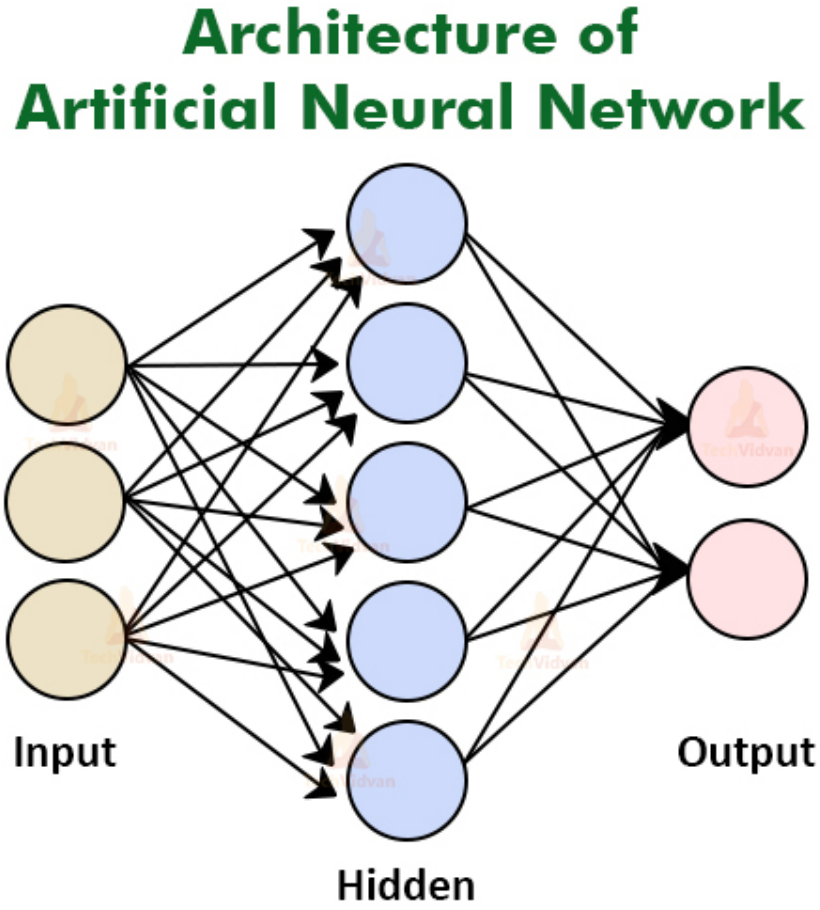

Figure 1: ANN Architecture

Structure of ANN

- Input Layer
- Hidden Layer(s)
- Output Layer

Working of ANN: Input is multiplied by weights, after which bias is added to the weighted sum. The resulting value is passed through an activation function, the loss is then calculated using a suitable loss function, and finally backpropagation is used to update the weights to minimize the loss.

Loss Functions: Mean Squared Error (MSE) and Cross Entropy Loss.

End of Midterm Report