

```

# Perceptron for OR Gate
# Implement the OR Boolean logic gate using perceptron Neural Network.
# Inputs = x1, x2 and bias, weights should be fed into the perceptron with single Output = y. Display final weights
# Inputs
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

# Weights and bias (predefined)
w1 = 1
w2 = 1
b = -0.5

def perceptron(x1, x2):
    z = w1*x1 + w2*x2 + b
    return 1 if z >= 0 else 0

# Test OR gate
for x1, x2 in inputs:
    print(f"{x1} OR {x2} = {perceptron(x1, x2)}")

print("Weights:", w1, w2)
print("Bias:", b)

```

```

0 OR 0 = 0
0 OR 1 = 1
1 OR 0 = 1
1 OR 1 = 1
Weights: 1 1
Bias: -0.5

```

```

# Task 2
# • Use the iris dataset Encode the input and show the new representation
# • Decode the lossy representation for the output
# • Map the input to reconstruction and visualize

import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

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

# Normalize data
X = MinMaxScaler().fit_transform(X)

# Encoder (4 → 3)
input_layer = Input(shape=(4,))
encoded = Dense(3, activation='relu')(input_layer)

# Decoder (3 → 4)
decoded = Dense(4, activation='sigmoid')(encoded)

# Autoencoder model
autoencoder = Model(input_layer, decoded)
autoencoder.compile(optimizer='adam', loss='mse')

# Train
autoencoder.fit(X, X, epochs=50, batch_size=16, verbose=0)

# Encode and Decode
encoded_data = Model(input_layer, encoded).predict(X)
decoded_data = autoencoder.predict(X)

# Visualization (first two features)
plt.scatter(X[:, 0], X[:, 1], label='Original')
plt.scatter(decoded_data[:, 0], decoded_data[:, 1], label='Reconstructed')
plt.legend()
plt.title('Iris Autoencoder Reconstruction (3 Neurons)')
plt.show()

```

```

# Question 2
# Task 2
# • Use the heart disease Dataset
# • Create an Auto Encoder and fit it with our data using 3 neurons in the dense layer
# • Display new reduced dimension values
# • Plot loss for different Auto encoders

# Autoencoder on Heart Disease Dataset

import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

# Load heart disease dataset
data = pd.read_csv(r"C:\Users\anupk\Downloads\heart.csv") # dataset should be in same folder
X = data.drop("target", axis=1)

# Normalize data
X = MinMaxScaler().fit_transform(X)

losses = []

# Autoencoders with different neurons
for neurons in [3, 5, 8]:
    input_layer = Input(shape=(X.shape[1],))
    encoded = Dense(neurons, activation='relu')(input_layer)
    decoded = Dense(X.shape[1], activation='sigmoid')(encoded)

    autoencoder = Model(input_layer, decoded)
    autoencoder.compile(optimizer='adam', loss='mse')

    history = autoencoder.fit(X, X, epochs=20, batch_size=16, verbose=0)
    losses.append(history.history['loss'])

# Reduced dimension using 3-neuron encoder
encoder = Model(input_layer, encoded)
reduced_data = encoder.predict(X)

print("Reduced Dimension Data (First 5 rows):")
print(reduced_data[:5])

# Plot loss
for i, neurons in enumerate([3, 5, 8]):
    plt.plot(losses[i], label=f"{neurons} Neurons")

plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.title("Autoencoder Loss Comparison")
plt.show()

```

```

# Question 3
# Task 2
# • Load the Intel Image dataset
# • Train and test the dataset
# • Create a model using CNN
# Evaluate the model using confusion matrix.

```

```
# !pip install tensorflow-datasets
```

```

import tensorflow as tf
import numpy as np
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt

# Load dataset from tensorflow-datasets
train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "Intel/train",
    image_size=(150, 150),
    batch_size=32
)

test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "Intel/test",
    image_size=(150, 150),
    batch_size=32,

```

```

        shuffle=False
    )
    # train_ds = tf.keras.utils.image_dataset_from_directory(
    #     r"C:\Users\anupk\Downloads\Intel\train",
    #     image_size=(150, 150),
    #     batch_size=32
    # )

    # test_ds = tf.keras.utils.image_dataset_from_directory(
    #     r"C:\Users\anupk\Downloads\Intel\test",
    #     image_size=(150, 150),
    #     batch_size=32,
    #     shuffle=False
    # )
    class_names = train_ds.class_names

    # CNN Model
    model = tf.keras.Sequential([
        tf.keras.layers.Rescaling(1./255, input_shape=(150,150,3)),
        tf.keras.layers.Conv2D(16, 3, activation='relu'),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(32, 3, activation='relu'),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(len(class_names), activation='softmax')
    ])

    model.compile(
        optimizer='adam',
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )

    # Train
    model.fit(train_ds, epochs=5)

    # Predictions
    y_true = np.concatenate([y for x, y in test_ds], axis=0)
    y_pred = np.argmax(model.predict(test_ds), axis=1)

    # Confusion Matrix
    cm = confusion_matrix(y_true, y_pred)

    sns.heatmap(cm, annot=True, fmt="d",
                xticklabels=class_names,
                yticklabels=class_names)

    plt.xlabel("Predicted")
    plt.ylabel("Actual")
    plt.title("Confusion Matrix")
    plt.show()

```

```

FileNotFoundError                                Traceback (most recent call last)
Cell In[18], line 8
      5 import matplotlib.pyplot as plt
      7 # Load dataset from tensorflow-datasets
----> 8 train_ds = tf.keras.preprocessing.image_dataset_from_directory(
      9     "Intel/train",
     10     image_size=(150, 150),
     11     batch_size=32
     12 )
     14 test_ds = tf.keras.preprocessing.image_dataset_from_directory(
     15     "Intel/test",
     16     image_size=(150, 150),
     17     batch_size=32,
     18     shuffle=False
     19 )
     20 # train_ds = tf.keras.utils.image_dataset_from_directory(
     21 #     r"C:\Users\anupk\Downloads\Intel\train",
     22 #     image_size=(150, 150),
     (... ) 30 #     shuffle=False
     31 # )

File ~\anaconda3\Lib\site-packages\keras\src\utils\image_dataset_utils.py:265, in
image_dataset_from_directory(directory, labels, label_mode, class_names, color_mode, batch_size, image_size,
shuffle, seed, validation_split, subset, interpolation, follow_links, crop_to_aspect_ratio, pad_to_aspect_ratio,
data_format, format, verbose)
     263 if seed is None:
     264     seed = np.random.randint(1e6)
--> 265 image_paths, labels, class_names = dataset_utils.index_directory(
     266     directory,
     267     labels,
     268     formats=ALLOWLIST_FORMATS,
     269     class_names=class_names,
     270     shuffle=shuffle,
     271     seed=seed,
     272     follow_links=follow_links,
     273     verbose=verbose,
     274 )
     276 if label_mode == "binary" and len(class_names) != 2:
     277     raise ValueError(
     278         'When passing `label_mode="binary"`, there must be exactly 2 '
     279         f"class_names. Received: class_names={class_names}"
     280     )

File ~\anaconda3\Lib\site-packages\keras\src\utils\dataset_utils.py:743, in index_directory(directory, labels,
formats, class_names, shuffle, seed, follow_links, verbose)
     741 if labels == "inferred":
     742     subdirs = []
--> 743     for subdir in sorted(os_module.listdir(directory)):
     744         if path_module.isdir(path_module.join(directory, subdir)):
     745             if not subdir.startswith("."):

FileNotFoundError: [WinError 3] The system cannot find the path specified: 'Intel/train'

```

- # • Implement autoencoder
- # • Use the Iris Dataset
- # • Create an autoencoder and fit it with our data using 2 neurons in the dense layer
- # • Plot loss w.r.t. epoch
- # • Calculate reconstruction error using Mean Squared Error (MSE).

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

# Load Iris dataset
iris = load_iris()
X = iris.data

# Normalize data
X = MinMaxScaler().fit_transform(X)

# Autoencoder
input_layer = Input(shape=(4,))
encoded = Dense(2, activation='relu')(input_layer) # 2 neurons
decoded = Dense(4, activation='sigmoid')(encoded)

```

```

autoencoder = Model(input_layer, decoded)
autoencoder.compile(optimizer='adam', loss='mse')

# Train model
history = autoencoder.fit(X, X, epochs=50, batch_size=16, verbose=0)

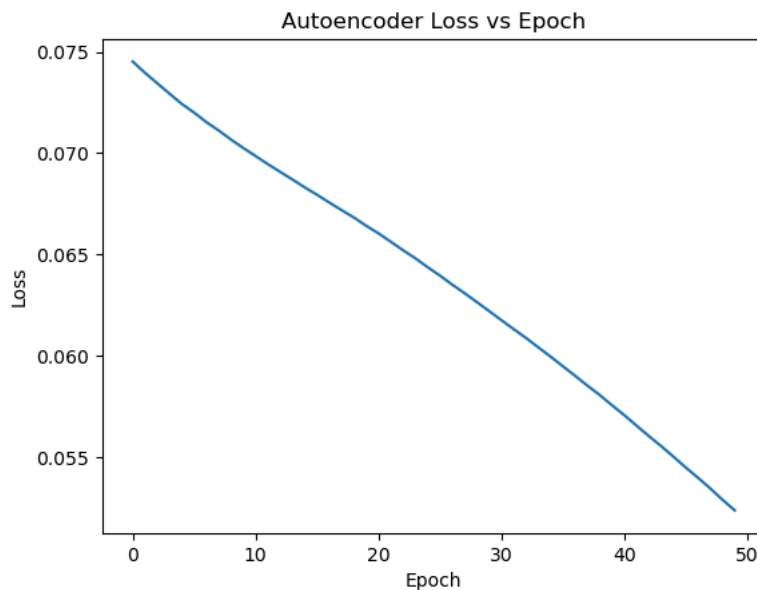
# Reconstruction
X_reconstructed = autoencoder.predict(X)

# Reconstruction error (MSE)
mse = mean_squared_error(X, X_reconstructed)
print("Reconstruction Error (MSE):", mse)

# Plot loss vs epoch
plt.plot(history.history['loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Autoencoder Loss vs Epoch")
plt.show()

```

5/5 ————— 0s 41ms/step
 Reconstruction Error (MSE): 0.05206129710677191



NOT Perceptron

```

# Inputs for NOT gate
# x2 is kept 0 (dummy input)
inputs = [
    (0, 0),
    (1, 0)
]

# Weights and bias (predefined for NOT gate)
w1 = -1    # negative weight
w2 = 1     # x2 not used
b = 0.5    # positive bias

def perceptron(x1, x2):
    z = w1*x1 + w2*x2 + b
    return 1 if z >= 0 else 0

# Test NOT gate
for x1, x2 in inputs:
    print(f"NOT {x1} = {perceptron(x1, x2)}")

print("Final Weights:")
print("w1 =", w1)
print("w2 =", w2)
print("Bias =", b)

```

```

NOT 0 = 1
NOT 1 = 0
Final Weights:
w1 = -1
w2 = 1
Bias = 0.5

```

```
# Task 2
# 1. Use the Iris Dataset
# 2. Create an Auto Encoder and fit it with our data using 3 neurons in the dense layer
# 3. Display new reduced dimension values
# 4. Plot loss for different encoders
```

```
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense
from sklearn.datasets import load_iris

# Load heart disease dataset
iris = load_iris()
X = iris.data # only features (no target)

# Normalize data
X = MinMaxScaler().fit_transform(X)

losses = []

# Autoencoders with different neurons
for neurons in [3, 5, 8]:
    input_layer = Input(shape=(X.shape[1],))
    encoded = Dense(neurons, activation='relu')(input_layer)
    decoded = Dense(X.shape[1], activation='sigmoid')(encoded)

    autoencoder = Model(input_layer, decoded)
    autoencoder.compile(optimizer='adam', loss='mse')

    history = autoencoder.fit(X, X, epochs=20, batch_size=16, verbose=0)
    losses.append(history.history['loss'])

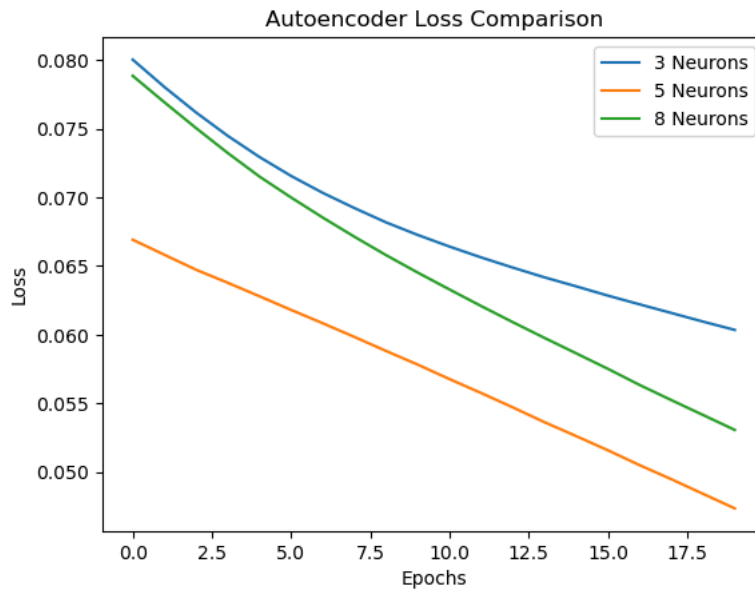
# Reduced dimension using 3-neuron encoder
encoder = Model(input_layer, encoded)
reduced_data = encoder.predict(X)

print("Reduced Dimension Data (First 5 rows):")
print(reduced_data[:5])

# Plot loss
for i, neurons in enumerate([3, 5, 8]):
    plt.plot(losses[i], label=f"{neurons} Neurons")

plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend()
plt.title("Autoencoder Loss Comparison")
plt.show()
```

5/5 — 0s 29ms/step
 Reduced Dimension Data (First 5 rows):
 [[0.39879888 0.31047794 0.5005562 0.15473068 0.4278604 0.
 0. 0.]
 [0.30298638 0.26453623 0.31692946 0.06958024 0.2887673 0.
 0. 0.]
 [0.37214488 0.27177307 0.35836422 0.09104973 0.32976875 0.
 0. 0.]
 [0.3487213 0.26284915 0.2970516 0.08332117 0.28781304 0.
 0. 0.]
 [0.430924 0.3146951 0.5172708 0.16817498 0.44587705 0.
 0. 0.]]



```
# # Task 2
# Use the heart disease dataset and do the following
# • Use the Dataset
# • Create an autoencoder and fit it with our data using 2 neurons in the dense layer
# • Plot loss w.r.t. epochs
# • Calculate reconstruction error using Mean Squared Error (MSE).
```

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

# 1. Load Heart Disease Dataset
data = pd.read_csv(r"C:\Users\anupk\Downloads\heart.csv")
X = data.drop("target", axis=1) # remove label

# 2. Normalize the data
X = MinMaxScaler().fit_transform(X)

# 3. Create Autoencoder (2 neurons in dense layer)
input_layer = Input(shape=(X.shape[1],))
encoded = Dense(2, activation='relu')(input_layer) # 2 neurons
decoded = Dense(X.shape[1], activation='sigmoid')(encoded)

autoencoder = Model(input_layer, decoded)
autoencoder.compile(optimizer='adam', loss='mse')

# 4. Fit the model
history = autoencoder.fit(
    X, X,
    epochs=50,
    batch_size=16,
    verbose=0
)

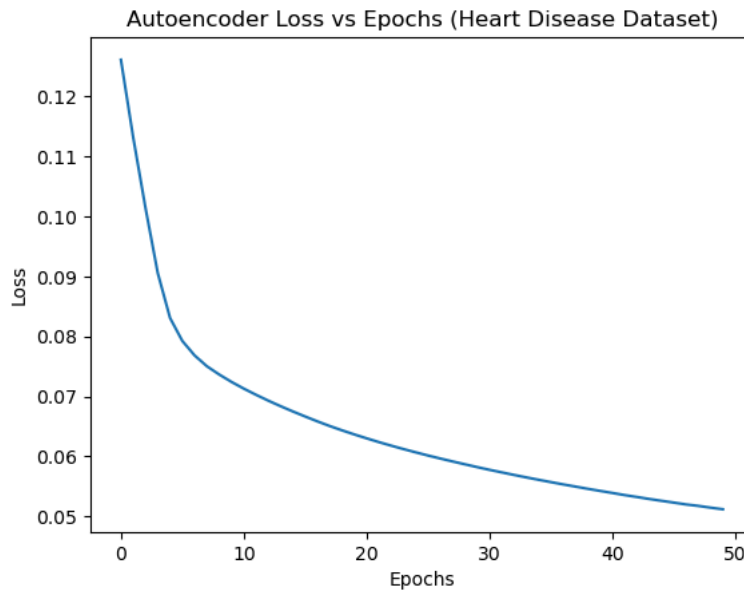
# 5. Reconstruction
X_reconstructed = autoencoder.predict(X)

# 6. Reconstruction Error (MSE)
mse = mean_squared_error(X, X_reconstructed)
```

```
print("Reconstruction Error (MSE):", mse)

# 7. Plot Loss vs Epochs
plt.plot(history.history['loss'])
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.title("Autoencoder Loss vs Epochs (Heart Disease Dataset)")
plt.show()
```

33/33 ————— 0s 10ms/step
Reconstruction Error (MSE): 0.05102842683033198



```
# • Load California Housing dataset and select 2 features (e.g., Median Income, House Age) and 1 target (Med
# • Normalize inputs and initialize a single-layer NN with random weights and bias.
# • Perform forward propagation, calculate prediction error, Squared Error, and MSE.
# • Update weights and bias using gradient descent.
# • Plot Loss vs Weight, Loss vs Bias, and Error Surface.
```

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import fetch_california_housing
from sklearn.preprocessing import MinMaxScaler

# Load dataset
data = pd.read_csv(r"C:\Users\anupk\Downloads\housing.csv")
# data = fetch_california_housing()
X = data[['MedInc', 'HouseAge']].values
y = data['MedHouseValue'].values.reshape(-1, 1)

# Normalize inputs
X = MinMaxScaler().fit_transform(X)
y = MinMaxScaler().fit_transform(y)

# Initialize weights and bias
w = np.random.rand(2,1)
b = np.random.rand(1)
lr = 0.1
epochs = 20

losses = []
weights = []
biases = []

# Training
for _ in range(epochs):
    y_pred = np.dot(X, w) + b          # Forward propagation
    error = y - y_pred
    squared_error = error ** 2
    mse = np.mean(squared_error)

    # Store values
    losses.append(mse)
    weights.append(w[0][0])
    biases.append(b[0])
```

```
# Gradient descent
dw = -2 * np.mean(X * error, axis=0).reshape(2,1)
db = -2 * np.mean(error)

w = w - lr * dw
b = b - lr * db

print("Final Weights:", w.flatten())
print("Final Bias:", b)
print("Final MSE:", mse)
plt.plot(weights, losses)
plt.xlabel("Weight")
plt.ylabel("Loss")
plt.title("Loss vs Weight")
plt.show()
plt.plot(biases, losses)
plt.xlabel("Bias")
plt.ylabel("Loss")
plt.title("Loss vs Bias")
plt.show()
W, B = np.meshgrid(np.linspace(0,1,20), np.linspace(0,1,20))
Z = []

for w0, b0 in zip(W.flatten(), B.flatten()):
    pred = X[:,0].reshape(-1,1) * w0 + b0
    Z.append(np.mean((y - pred) ** 2))

Z = np.array(Z).reshape(W.shape)

plt.contourf(W, B, Z, cmap='viridis')
plt.xlabel("Weight")
plt.ylabel("Bias")
plt.title("Error Surface")
plt.colorbar()
plt.show()
```



```
C:\Users\anupk\anaconda3\Lib\site-packages\sklearn\datasets\_base.py:1518: UserWarning: Retry downloading from i
warnings.warn(f"Retry downloading from url: {remote.url}")
```

```
-----
HTTPError                                         Traceback (most recent call last)
```

```
Cell In[35], line 7
      4 from sklearn.preprocessing import MinMaxScaler
      6 # Load dataset
----> 7 data = fetch_california_housing()
      8 X = data.data[:, [0, 1]] # Median Income, House Age
      9 y = data.target.reshape(-1,1)
```

```
File ~\anaconda3\Lib\site-packages\sklearn\utils\_param_validation.py:218, in validate_params.
<locals>.<decorator>.<locals>.wrapper(*args, **kwargs)
```

```
212 try:
213     with config_context(
214         skip_parameter_validation=(
215             prefer_skip_nested_validation or global_skip_validation
216         )
217     ):
218         # Parameter validation is disabled
```

```
# Take the dataset of Life expectancy
# Initialize a neural network with random weights.
# a) Calculate output of Neural Network
# b) Calculate squared error loss
# c) Plot the mean squared error for each iteration in stochastic Gradient Descent.
```

```
224 msa = re.sub(
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler

# Load dataset
data = pd.read_csv("Life_Expectancy_Data.csv")

# Select 2 input features and target
X = data[['Adult Mortality', 'BMI']].dropna()
y = data.loc[X.index, 'Life expectancy ']

# Normalize
X = MinMaxScaler().fit_transform(X)
y = MinMaxScaler().fit_transform(y.values.reshape(-1,1))

# Initialize random weights and bias
w = np.random.rand(2)
b = np.random.rand()
lr = 0.1
epochs = 30

mse_list = []

# Stochastic Gradient Descent updates weights for each sample
for _ in range(epochs):
    for i in range(len(X)):
        xi = X[i]
        yi = y[i]

        # (a) Forward propagation
        y_pred = np.dot(xi, w) + b

        # (b) Squared error
        error = yi - y_pred
        squared_error = error ** 2

        # Store MSE
        mse_list.append(squared_error)

        # Gradient descent update
        w = w + lr * error * xi
        b = b + lr * error

print("Final Weights:", w)
print("Final Bias:", b)
plt.plot(mse_list)
plt.xlabel("Iteration")
plt.ylabel("Mean Squared Error")
plt.title("MSE vs Iteration (SGD)")
plt.show()
```

```
605         'http' request_response_code_msg_hdrs)
```

```
# Implement autoencoder
# • Use the Wine Dataset
# • Create an autoencoder and fit it with our data using 3 neurons in the dense layer
```

```
# • Calculate loss w.r.t to different epochs and plot using line graph.
```

```
464 for handler in handlers:

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_wine
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

# Load Wine dataset
wine = load_wine()
X = wine.data

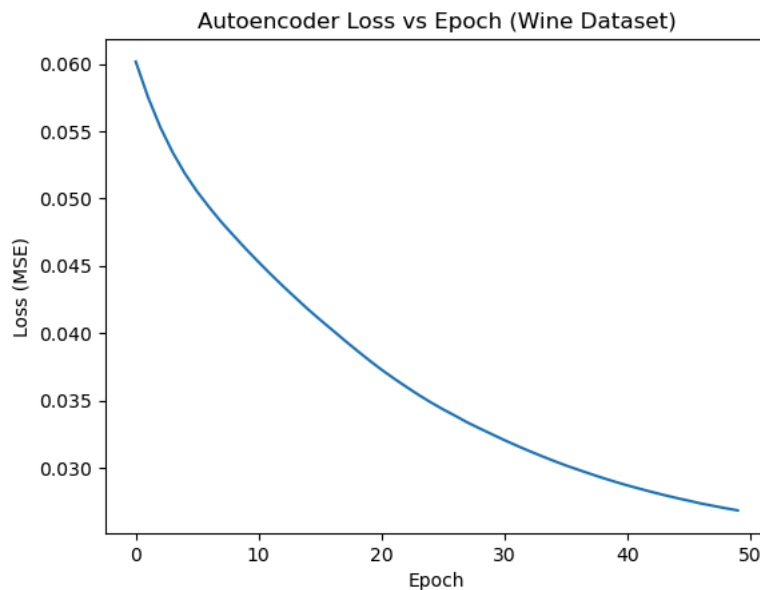
# Normalize data
X = MinMaxScaler().fit_transform(X)

# Autoencoder architecture
input_layer = Input(shape=(X.shape[1],))
encoded = Dense(3, activation='relu')(input_layer) # 3 neurons
decoded = Dense(X.shape[1], activation='sigmoid')(encoded)

autoencoder = Model(input_layer, decoded)
autoencoder.compile(optimizer='adam', loss='mse')

# Train model
history = autoencoder.fit(X, X, epochs=50, batch_size=16, verbose=0)

# Plot loss vs epoch
plt.plot(history.history['loss'])
plt.xlabel("Epoch")
plt.ylabel("Loss (MSE)")
plt.title("Autoencoder Loss vs Epoch (Wine Dataset)")
plt.show()
```



```
# Implement Self Organizing Map for anomaly Detection
# • Use Credit Card Applications Dataset:
# • Detect fraud customers in the dataset using SOM and perform hyperparameter tuning
# • Show map and use markers to distinguish frauds.
```

```
!pip install minisom
```

```
Collecting minisom
  Downloading minisom-2.3.5.tar.gz (12 kB)
  Installing build dependencies: started
  Installing build dependencies: finished with status 'done'
  Getting requirements to build wheel: started
  Getting requirements to build wheel: finished with status 'done'
  Preparing metadata (pyproject.toml): started
  Preparing metadata (pyproject.toml): finished with status 'done'
Building wheels for collected packages: minisom
  Building wheel for minisom (pyproject.toml): started
  Building wheel for minisom (pyproject.toml): finished with status 'done'
  Created wheel for minisom: filename=minisom-2.3.5-py3-none-any.whl size=12132 sha256=7a940e27d015ef6c6632dbe27f
  Stored in directory: c:\users\anupk\appdata\local\pip\cache\wheels\df\bc\51\5a64336510519dc8062d6e17d458721906b
```

```
Successfully built minisom
Installing collected packages: minisom
Successfully installed minisom-2.3.5
```

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from minisom import MiniSom
from sklearn.preprocessing import MinMaxScaler

# Load dataset
dataset = pd.read_csv(r"C:\Users\anupk\Downloads\creditcard.csv")

X = dataset.iloc[:, :-1].values # features
y = dataset.iloc[:, -1].values # approved / not approved

# Normalize data
sc = MinMaxScaler(feature_range=(0, 1))
X = sc.fit_transform(X)

# -----
# Hyperparameter tuning (simple)
# -----
som_x, som_y = 10, 10
sigma = 1.0
learning_rate = 0.5

# Initialize SOM
som = MiniSom(
    x=som_x,
    y=som_y,
    input_len=X.shape[1],
    sigma=sigma,
    learning_rate=learning_rate
)

som.random_weights_init(X)
som.train_random(data=X, num_iteration=100)

# -----
# Visualization
# -----
plt.figure(figsize=(7,7))
plt.pcolor(som.distance_map(), cmap='coolwarm')
plt.colorbar(label='Distance (Anomaly Score)')

# Mark frauds
for i, x in enumerate(X):
    w = som.winner(x)
    if y[i] == 0: # not approved → potential fraud
        plt.text(w[0]+0.5, w[1]+0.5, 'F',
                 color='red', fontsize=12, ha='center', va='center')
    else:
        plt.text(w[0]+0.5, w[1]+0.5, 'N',
                 color='green', fontsize=9, ha='center', va='center')

plt.title("SOM Fraud Detection Map")
plt.show()

# -----
# Extract fraud customers
# -----
mappings = som.win_map(X)
frauds = np.concatenate(
    [mappings[cell] for cell in mappings if som.distance_map()[cell] > 0.9],
    axis=0
)

frauds = sc.inverse_transform(frauds)
print("Fraud Customers (Sample):")
print(frauds[:5])
```



```

KeyboardInterrupt                                Traceback (most recent call last)
Cell In[41], line 54
    50     plt.text(w[0]+0.5, w[1]+0.5, 'N',
    51               color='green', fontsize=9, ha='center', va='center')
    53 plt.title("SOM Fraud Detection Map")
--> 54 plt.show()
    56 # -----
    57 # Extract fraud customers
    58 # -----
    59 mappings = som.win_map(X)

File ~\anaconda3\Lib\site-packages\matplotlib\pyplot.py:614, in show(*args, **kwargs)
    570 """
    571 Display all open figures.
    572
    (...) 611 explicitly there.
    612 """
    613 _warn_if_gui_out_of_main_thread()
--> 614 return _get_backend_mod().show(*args, **kwargs)

File ~\anaconda3\Lib\site-packages\matplotlib_inline\backend_inline.py:90, in show(close, block)
    88 try:
    89     for figure_manager in Gcf.get_all_fig_managers():
--> 90         display(
    91             figure_manager.canvas.figure,
    92             metadata=_fetch_figure_metadata(figure_manager.canvas.figure),
    93         )
    94 finally:
    95     show._to_draw = []

File ~\anaconda3\Lib\site-packages\IPython\core\display_functions.py:278, in display(include, exclude, metadata, transient, display_id, raw, clear, *objs, **kwargs)
    276     publish_display_data(data=obj, metadata=metadata, **kwargs)
    277 else:
--> 278     format_dict, md_dict = format(obj, include=include, exclude=exclude)
    279     if not format_dict:
    280         # nothing to display (e.g. _ipython_display_ took over)
    281         continue

File ~\anaconda3\Lib\site-packages\IPython\core\formatters.py:238, in DisplayFormatter.format(self, obj, include, exclude)
    236 md = None
    237 try:
--> 238     data = formatter(obj)
    239 except:
    240     # FIXME: log the exception
    241     raise

File ~\anaconda3\Lib\site-packages\decorator.py:235, in decorate.<locals>.fun(*args, **kw)
    233 if not kwsyntax:
    234     args, kw = fix(args, kw, sig)
--> 235 return caller(func, *(extras + args), **kw)

File ~\anaconda3\Lib\site-packages\IPython\core\formatters.py:282, in catch_format_error(method, self, *args, **kwargs)
    280 """show traceback on failed format call"""
    281 try:
--> 282     r = method(self, *args, **kwargs)
    283 except NotImplementedError:
    284     # don't warn on NotImplementedError
    285     return self._check_return(None, args[0])

File ~\anaconda3\Lib\site-packages\IPython\core\formatters.py:402, in BaseFormatter.__call__(self, obj)
    400     pass
    401 else:
--> 402     return printer(obj)
    403 # Finally look for special method names
    404 method = get_real_method(obj, self.print_method)

File ~\anaconda3\Lib\site-packages\IPython\core\pylabtools.py:170, in print_figure(fig, fmt, bbox_inches, base64, **kwargs)
    167     from matplotlib.backend_bases import FigureCanvasBase
    168     FigureCanvasBase(fig)
--> 170 fig.canvas.print_figure(bytes_io, **kw)
    171 data = bytes_io.getvalue()
    172 if fmt == 'svg':

File ~\anaconda3\Lib\site-packages\matplotlib\backend_bases.py:2157, in FigureCanvasBase.print_figure(self, filename, dpi, facecolor, edgecolor, orientation, format, bbox_inches, pad_inches, bbox_extra_artists, backend, **kwargs)
    2154     # we do this instead of `self.figure.draw_without_rendering`
    2155     # so that we can inject the orientation
    2156     with getattr(renderer, "_draw_disabled", nullcontext)():
--> 2157         self.figure.draw(renderer)
    2158 if bbox_inches:

# Train a small neural network (dataset - MNIST classification)
# Compare the optimizers:
# 1.     SGD

```

```
# 2.    SGD + Momentum
# 3.    Adam
# Plot:
# 1.    Training loss vs epochs
# 2.    Accuracy vs epochs
```

```
<locs>.draw_wrapper(artist, renderer)
```

```
import tensorflow as tf
import matplotlib.pyplot as plt
import numpy as np

# Load MNIST dataset
# with np.load(r"C:\Users\anupk\Downloads\mnist.npz") as data:
#     x_train = data['x_train']
#     y_train = data['y_train']
#     x_test  = data['x_test']
#     y_test  = data['y_test']

# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# Normalize
x_train = x_train / 255.0
x_test = x_test / 255.0

# Small neural network model
def create_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Flatten(input_shape=(28,28)),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

epochs = 10
histories = {}

# 1. SGD
model_sgd = create_model(tf.keras.optimizers.SGD())
histories['SGD'] = model_sgd.fit(x_train, y_train, epochs=epochs, verbose=0)

# 2. SGD + Momentum
model_momentum = create_model(tf.keras.optimizers.SGD(momentum=0.9))
histories['SGD + Momentum'] = model_momentum.fit(x_train, y_train, epochs=epochs, verbose=0)

# 3. Adam
model_adam = create_model(tf.keras.optimizers.Adam())
histories['Adam'] = model_adam.fit(x_train, y_train, epochs=epochs, verbose=0)
for name, history in histories.items():
    plt.plot(history.history['loss'], label=name)

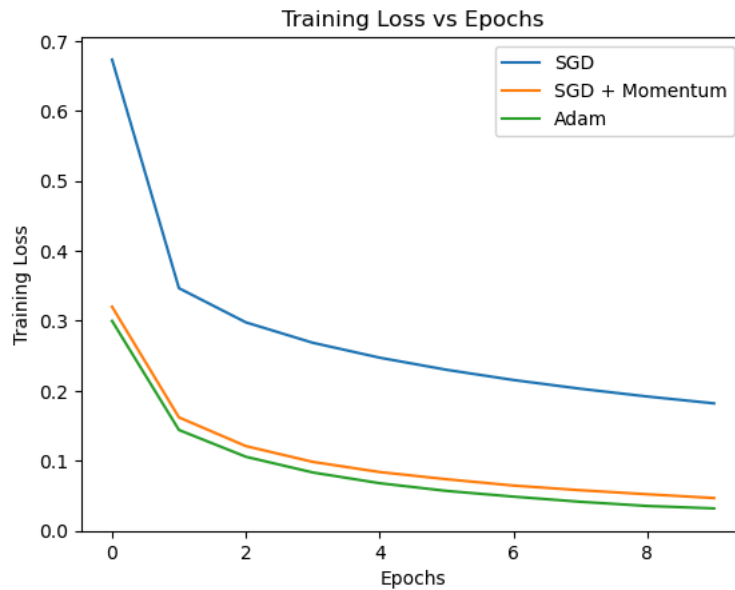
plt.xlabel("Epochs")
plt.ylabel("Training Loss")
plt.title("Training Loss vs Epochs")
plt.legend()
plt.show()

for name, history in histories.items():
    plt.plot(history.history['accuracy'], label=name)

plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Epochs")
plt.legend()
plt.show()
```

Downloading data from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz>
 11490434/11490434 — 12s 1us/step

C:\Users\anupk\anaconda3\Lib\site-packages\keras\src\layers\reshaping\flatten.py:37: UserWarning: Do not pass an
 super().__init__(**kwargs)



- # 1. Use MNIST or IRIS/ Cifar-10 Dataset
- # 2. Train a model with and without data augmentation (horizontal flip, rotation, noise).
- # 3. Compare generalization performance on the validation set. (Accuracy & Error)
- # 4. Evaluate the model using confusion matrix, precision, recall

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, precision_score, recall_score
import seaborn as sns

# Load MNIST
# with np.load(r"C:\Users\anupk\Downloads\mnist.npz") as data:
#     x_train = data['x_train']
#     y_train = data['y_train']
#     x_test = data['x_test']
#     y_test = data['y_test']
# mnist
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# iris
# data = pd.read_csv("Iris.csv")

# X = data.iloc[:, :-1].values
# y = data.iloc[:, -1].astype('category').cat.codes.values

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# y = iris.target

# cifar-10
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/train",
#     image_size=(32,32),
#     batch_size=32
# )

# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/test",
```

```

# image_size=(32,32),
# batch_size=32
# )
# x_train = np.concatenate([x.numpy() for x, y in train_ds])
# y_train = np.concatenate([y.numpy() for x, y in train_ds])

# x_test = np.concatenate([x.numpy() for x, y in test_ds])
# y_test = np.concatenate([y.numpy() for x, y in test_ds])

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

x_train = x_train / 255.0
x_test = x_test / 255.0

x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# Simple CNN model
def create_model():
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(16, 3, activation='relu', input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer='adam',
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model
model_no_aug = create_model()
history_no_aug = model_no_aug.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    verbose=0
)
# Data Augmentation
datagen = tf.keras.preprocessing.image.ImageDataGenerator(
    rotation_range=20,
    horizontal_flip=True
)

model_aug = create_model()
history_aug = model_aug.fit(
    datagen.flow(x_train, y_train, batch_size=32),
    validation_data=(x_test, y_test),
    epochs=5,
    verbose=0
)
print("Validation Accuracy (No Augmentation data):", history_no_aug.history['val_accuracy'][-1])
print("Validation Accuracy (Aug):", history_aug.history['val_accuracy'][-1])

print("Validation Error (No Aug):", 1 - history_no_aug.history['val_accuracy'][-1])
print("Validation Error (Aug):", 1 - history_aug.history['val_accuracy'][-1])
y_pred = np.argmax(model_aug.predict(x_test), axis=1)

cm = confusion_matrix(y_test, y_pred)

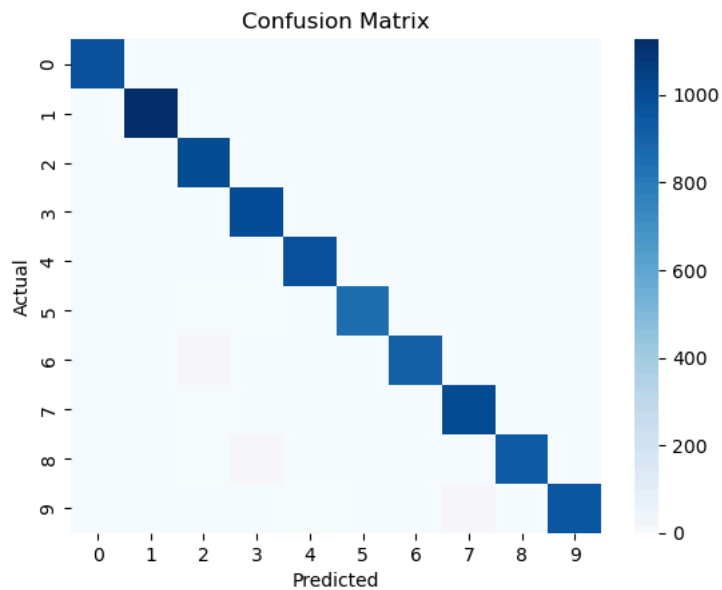
sns.heatmap(cm, annot=False, cmap='Blues')
plt.title("Confusion Matrix")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()

precision = precision_score(y_test, y_pred, average='macro')
recall = recall_score(y_test, y_pred, average='macro')

print("Precision:", precision)
print("Recall:", recall)

```

```
C:\Users\anupk\anaconda3\Lib\site-packages\keras\src\layers\convolutional\base_conv.py:113: UserWarning: Do not p
super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Validation Accuracy (No Aug): 0.9833333492279053
Validation Accuracy (Aug): 0.9746999740600586
Validation Error (No Aug): 0.016666650772094727
Validation Error (Aug): 0.025300025939941406
313/313 ————— 2s 6ms/step
```



```
Precision: 0.975068244882007
Recall: 0.9742276317262935
```

- # 1. Implement a tiny SimCLR framework using a small dataset (e.g., CIFAR-10 subset).
- # 2. Use data augmentations.
- # 3. Implement the NT-Xent loss function to compute similarity between pairs.
- # 4. Compare Data with and without Augmentation.

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# -----
# Load CIFAR-10 (small subset)
# -----
# with np.load(r"C:\Users\anupk\Downloads\cifar-10.npz") as data:
#     x_train = data['x_train']

# # Use small subset + normalize
# x_train = x_train[:2000] / 255.0
(x_train, _) = tf.keras.datasets.cifar10.load_data()
x_train = x_train[:2000] / 255.0 # small subset

# -----
# Data Augmentation
# -----
augment = tf.keras.Sequential([
    tf.keras.layers.RandomFlip("horizontal"),
    tf.keras.layers.RandomRotation(0.1)
])

# Without augmentation
def no_augment(x):
    return x

# -----
# Encoder Network
# -----
def encoder():
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu', input_shape=(32,32,3)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(64, 3, activation='relu'),
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(64)
    ])
    return model
```

```

# -----
# NT-Xent Loss
# -----
def nt_xent_loss(z1, z2, temperature=0.5):
    z1 = tf.math.l2_normalize(z1, axis=1)
    z2 = tf.math.l2_normalize(z2, axis=1)

    similarity = tf.matmul(z1, z2, transpose_b=True)
    similarity /= temperature

    labels = tf.range(tf.shape(z1)[0])
    loss = tf.keras.losses.sparse_categorical_crossentropy(
        labels, similarity, from_logits=True
    )
    return tf.reduce_mean(loss)

# -----
# Training Step
# -----
def train_simclr(augment_fn):
    enc = encoder()
    optimizer = tf.keras.optimizers.Adam()
    losses = []

    for epoch in range(10):
        with tf.GradientTape() as tape:
            x1 = augment_fn(x_train)
            x2 = augment_fn(x_train)

            z1 = enc(x1, training=True)
            z2 = enc(x2, training=True)

            loss = nt_xent_loss(z1, z2)
            grads = tape.gradient(loss, enc.trainable_variables)
            optimizer.apply_gradients(zip(grads, enc.trainable_variables))
            losses.append(loss.numpy())

    return losses

# -----
# Train with & without augmentation
# -----
loss_no_aug = train_simclr(no_augment)
loss_aug = train_simclr(augment)
plt.plot(loss_no_aug, label="Without Augmentation")
plt.plot(loss_aug, label="With Augmentation")
plt.xlabel("Epoch")
plt.ylabel("NT-Xent Loss")
plt.title("SimCLR: Augmentation Comparison")
plt.legend()
plt.show()

```

- # 1. Use a pretrained model (e.g., ResNet-50 or MobileNet).
- # 2. Freeze its encoder.
- # 3. Train a classifier head on a different dataset (e.g., Flowers dataset).
- # 4. Compare accuracy with fine tuning

```

import tensorflow as tf
import tensorflow_datasets as tfds

# =====
# DATASET LOADING
# =====

# OPTION ❶: LOAD FROM LIBRARY (USE THIS)
(train_ds, val_ds), info = tfds.load(
    "tf_flowers",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True,
    with_info=True
)
num_classes = info.features['label'].num_classes

# OPTION ❷: LOAD FROM LOCAL PC (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "flowers/train", image_size=(224,224), batch_size=32)
# val_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "flowers/val", image_size=(224,224), batch_size=32)
# num_classes = train_ds.cardinality().numpy()

```

```

# Preprocess
def preprocess(x, y):
    return tf.image.resize(x, (224,224))/255.0, y

train_ds = train_ds.map(preprocess).batch(32)
val_ds = val_ds.map(preprocess).batch(32)

# =====
# PRETRAINED MODEL
# =====
base = tf.keras.applications.MobileNetV2(
    weights="imagenet", include_top=False, input_shape=(224,224,3))

# ----- FROZEN ENCODER -----
base.trainable = False
model_frozen = tf.keras.Sequential([
    base,
    tf.keras.layers.GlobalAveragePooling2D(),
    tf.keras.layers.Dense(num_classes, activation="softmax")
])

model_frozen.compile(optimizer="adam",
                    loss="sparse_categorical_crossentropy",
                    metrics=["accuracy"])

h1 = model_frozen.fit(train_ds, validation_data=val_ds, epochs=3, verbose=0)

# ----- FINE TUNING -----
base.trainable = True
model_finetune = tf.keras.Sequential([
    base,
    tf.keras.layers.GlobalAveragePooling2D(),
    tf.keras.layers.Dense(num_classes, activation="softmax")
])

model_finetune.compile(
    optimizer=tf.keras.optimizers.Adam(1e-5),
    loss="sparse_categorical_crossentropy",
    metrics=["accuracy"]
)

h2 = model_finetune.fit(train_ds, validation_data=val_ds, epochs=3, verbose=0)

# =====
# ACCURACY COMPARISON
# =====
print("Frozen Encoder Accuracy:", h1.history['val_accuracy'][-1])
print("Fine-tuned Accuracy:", h2.history['val_accuracy'][-1])

```

```

# Choose two datasets with different distributions (dogs & cats , cars).
# 1.   Resize images to the required input size of the chosen pre-trained model.
# 2.   Load Pre-trained Model (LeNet-5 or VGG-16)
# 3.   Compare the performances of all the models and visualize
# 4.   Write down your observations and conclusions

```

```

import tensorflow as tf
import tensorflow_datasets as tfds
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32


# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
dogs_train, dogs_val = tfds.load(
    "cats_vs_dogs",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

cars_train, cars_val = tfds.load(
    "cars196",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

```

```

# OPTION  LOAD FROM LOCAL PC (COMMENTED)
# dogs_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/train", image_size=IMG_SIZE, batch_size=BATCH)
# dogs_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/val", image_size=IMG_SIZE, batch_size=BATCH)
#
# cars_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/train", image_size=IMG_SIZE, batch_size=BATCH)
# cars_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/val", image_size=IMG_SIZE, batch_size=BATCH)

def preprocess(x, y):
    return tf.image.resize(x, IMG_SIZE)/255.0, y

dogs_train = dogs_train.map(preprocess).batch(BATCH)
dogs_val = dogs_val.map(preprocess).batch(BATCH)

cars_train = cars_train.map(preprocess).batch(BATCH)
cars_val = cars_val.map(preprocess).batch(BATCH)

# =====
# PRETRAINED MODEL (VGG-16)
# =====
base = tf.keras.applications.VGG16(
    weights="imagenet", include_top=False, input_shape=(224,224,3)
)
# LeNet
# from tensorflow.keras.models import Sequential
# from tensorflow.keras.layers import Conv2D, AveragePooling2D, Flatten, Dense

# base = Sequential([
#     Conv2D(6, (5,5), activation='relu', input_shape=(32,32,1)),
#     AveragePooling2D(),
#     Conv2D(16, (5,5), activation='relu'),
#     AveragePooling2D(),
#     Flatten(),
#     Dense(120, activation='relu'),
#     Dense(84, activation='relu')
# ])
# AlexNet
# from tensorflow.keras.models import Sequential
# from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense

# base = Sequential([
#     Conv2D(96, (11,11), strides=4, activation='relu', input_shape=(224,224,3)),
#     MaxPooling2D((3,3), strides=2),
#     Conv2D(256, (5,5), padding='same', activation='relu'),
#     MaxPooling2D((3,3), strides=2),
#     Conv2D(384, (3,3), padding='same', activation='relu'),
#     Conv2D(384, (3,3), padding='same', activation='relu'),
#     Conv2D(256, (3,3), padding='same', activation='relu'),
#     MaxPooling2D((3,3), strides=2)
# ])
# ResNet
# base = tf.keras.applications.ResNet50(
#     weights="imagenet",
#     include_top=False,
#     input_shape=(224, 224, 3)
# )
# Freeze the base (pretrained) model so its weights are NOT updated during training.
base.trainable = False
# Build and train two classifiers on top of the same ResNet-50:
def build_model(classes):
    model = tf.keras.Sequential([
        base,
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(classes, activation="softmax")
    ])
    model.compile(
        optimizer="adam",
        loss="sparse_categorical_crossentropy",
        metrics=["accuracy"]
    )
    return model

# Dogs vs Cats
model_dogs = build_model(2)
h_dogs = model_dogs.fit(dogs_train, validation_data=dogs_val,
                        epochs=3, verbose=0)

# Cars dataset

```

```
model_cars = build_model(196)
h_cars = model_cars.fit(cars_train, validation_data=cars_val,
                        epochs=3, verbose=0)

# =====
# VISUALIZATION
# =====
plt.plot(h_dogs.history['val_accuracy'], label="Dogs vs Cats")
plt.plot(h_cars.history['val_accuracy'], label="Cars")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Performance Comparison (VGG-16)")
plt.legend()
plt.show()
```



```

WARNING:absl:Variant folder C:\Users\anupk\tensorflow_datasets\cats_vs_dogs\4.0.1 has no dataset_info.json
Downloading and preparing dataset Unknown size (download: Unknown size, generated: Unknown size, total: Unknown size)
DL Completed...: 0 url [00:00, ? url/s]
DL Size...: 0 MiB [00:00, ? MiB/s]
Generating splits...: 0% | 0/1 [00:00<?, ? splits/s]
Generating train examples...: 0 examples [00:00, ? examples/s]
-----
KeyError                                Traceback (most recent call last)
Cell In[45], line 13
      6 BATCH = 32
      8 # =====
      9 # DATASET LOADING
     10 # =====
     11
     12 # OPTION  LOAD FROM LIBRARY (USE THIS)
--> 13 dogs_train, dogs_val = tfds.load(
     14     "cats_vs_dogs",
     15     split=["train[:80%]", "train[80%:]"],
     16     as_supervised=True
     17 )
     18
     19 cars_train, cars_val = tfds.load(
     20     "cars196",
     21     split=["train[:80%]", "train[80%:]"],
     22     as_supervised=True
     23 )
     24
     25 # OPTION  LOAD FROM LOCAL PC (COMMENTED)
     26 # dogs_train = tf.keras.preprocessing.image_dataset_from_directory(
     27 #     "dogs_cats/train", image_size=IMG_SIZE, batch_size=BATCH)
(... ) 33 # cars_val = tf.keras.preprocessing.image_dataset_from_directory(
     34 #     "cars/val", image_size=IMG_SIZE, batch_size=BATCH)

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\logging\_init__.py:176, in
_FunctionDecorator.__call__(self, function, instance, args, kwargs)
     174 metadata = self._start_call()
     175 try:
--> 176     return function(*args, **kwargs)
     177 except Exception:
     178     metadata.mark_error()

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\load.py:666, in load(name, split, data_dir,
batch_size, shuffle_files, download, as_supervised, decoders, read_config, with_info, builder_kwargs,
download_and_prepare_kwargs, as_dataset_kwargs, try_gcs, file_format)
     541 """Loads the named dataset into a `tf.data.Dataset`.
     542
     543 `tfds.load` is a convenience method that:
(... ) 548     Split-specific information is available in `ds_info.splits`.
     549 """
     550 # fmt: skip
     551 dbuilder = _fetch_builder(
     552     name=name,
     553     data_dir=data_dir,
     554     builder_kwargs=builder_kwargs,
     555     try_gcs=try_gcs,
     556 )
--> 557 _download_and_prepare_builder(dbuilder, download, download_and_prepare_kwargs)
     558 if as_dataset_kwargs is None:
     559     as_dataset_kwargs = {}

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\load.py:518, in
_download_and_prepare_builder(dbuilder, download, download_and_prepare_kwargs)
     516 if download:
     517     download_and_prepare_kwargs = download_and_prepare_kwargs or {}
--> 518     dbuilder.download_and_prepare(**download_and_prepare_kwargs)

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\logging\_init__.py:176, in
_FunctionDecorator.__call__(self, function, instance, args, kwargs)
     174 metadata = self._start_call()
     175 try:
--> 176     return function(*args, **kwargs)
     177 except Exception:
     178     metadata.mark_error()

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\dataset_builder.py:763, in
DatasetBuilder.download_and_prepare(self, download_dir, download_config, file_format, permissions)
     761 self.info.read_from_directory(self.data_dir)
     762 else:
--> 763     self._download_and_prepare(
     764         dl_manager=dl_manager,
     765         download_config=download_config,
     766     )
     767
     768 # NOTE: If modifying the lines below to put additional information in
     769 # DatasetInfo, you'll likely also want to update
     770 # DatasetInfo.read_from_directory to possibly restore these attributes
     771 # when reading from package data.
     772 self.info.download_size = dl_manager.downloaded_size

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\dataset_builder.py:1808, in
GeneratorBasedBuilder.download_and_prepare(self, dl_manager, download_config)
    1805 if download_config.max_examples_per_split == 0:
    1806     return
--> 1808 split_infos = self._generate_splits(dl_manager, download_config)

```

```

1810 # Update the info object with the splits.
1811 split_dict = splits_lib.SplitDict(split_infos)

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\dataset_builder.py:1782, in
GeneratorBasedBuilder._generate_splits(self, dl_manager, download_config)
1775     for split_name, generator in tqdm(
1776         split_generators.items(),
1777         desc="Generating splits...",
1778         unit=" splits",
1779         leave=False,
1780     ):
1781         filename_template = self._get_filename_template(split_name=split_name)
-> 1782         future = split_builder.submit_split_generation(
1783             split_name=split_name,
1784             generator=generator,
1785             filename_template=filename_template,
1786             disable_shuffling=self.info.disable_shuffling,
1787             nondeterministic_order=download_config.nondeterministic_order,
1788         )
1789         split_info_futures.append(future)
1791 # Process the result of the beam pipeline.

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\split_builder.py:447, in
SplitBuilder.submit_split_generation(self, split_name, generator, filename_template, disable_shuffling,
nondeterministic_order)
442     logging.warning(
443         '`nondeterministic_order` is set to True for a dataset that does'
444         '`not use beam. Setting `disable_shuffling` to True.'
445     )
446     build_kwargs['disable_shuffling'] = True
-> 447     return self._build_from_generator(**build_kwargs)
448 else: # Otherwise, beam required
449     unknown_generator_type = TypeError(
450         f'Invalid split generator value for split `{split_name}`. '
451         f'Expected generator or apache_beam object. Got: '
452         f'{type(generator)}'
453     )

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\core\split_builder.py:508, in
SplitBuilder._build_from_generator(self, split_name, generator, filename_template, disable_shuffling)
498     serialized_info = self._features.get_serialized_info()
499     writer = writer_lib.Writer(
500         serializer=example_serializer.ExampleSerializer(serialized_info),
501         filename_template=filename_template,
502         ignore_duplicates=self._ignore_duplicates,
503     )
-> 508     for i, (key, example) in enumerate(
509         tqdm(
510             generator,
511             desc=f'Generating {split_name} examples...',
512             unit=' examples',
513             total=total_num_examples,
514             leave=False,
515             mininterval=1.0,
516         )
517     ):
518         try:
519             example = self._features.encode_example(example)

File ~\anaconda3\Lib\site-packages\tqdm\notebook.py:250, in tqdm_notebook.__iter__(self)
248     try:
249         it = super().__iter__()
-> 250         for obj in it:
251             # return super(tqdm...) will not catch exception
252             yield obj
253 # NB: except ... [ as ...] breaks IPython async KeyboardInterrupt

File ~\anaconda3\Lib\site-packages\tqdm\std.py:1181, in tqdm.__iter__(self)
1178     time = self._time
1180     try:
-> 1181         for obj in iterable:
1182             yield obj
1183             # Update and possibly print the progressbar.
1184             # Note: does not call self.update(1) for speed optimisation.

File ~\anaconda3\Lib\site-packages\tensorflow_datasets\image_classification\cats_vs_dogs.py:119, in
CatsVsDogs._generate_examples(self, archive)
117     with zipfile.ZipFile(buffer, "w") as new_zip:
118         new_zip.writestr(norm_fname, img_recoded.numpy())
-> 119     new_fobj = zipfile.ZipFile(buffer).open(norm_fname)
121     record = {
122         "image": new_fobj,
123         "image/filename": norm_fname,
124         "label": label,
125     }
126     yield norm_fname, record

File ~\anaconda3\Lib\zipfile\__init__.py:1639, in ZipFile.open(self, name, mode, pwd, force_zip64)
1636     zinfo.compress_level = self.compresslevel
1637 else:
1638     # Get info object for name

```

```
# Choose two datasets with different distributions (dogs & cats , cars).
# 1.  Resize images to the required input size of the chosen pre-trained model.
# 2.  Load Pre-trained Model ( AlexNet or ResNet-50)
# 3.  Compare the performances of all the models and visualize
# 4.  Write down your observations and conclusions
```

```
→ 100% False KeyError
```

```
import tensorflow as tf
import tensorflow_datasets as tfds
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
dogs_train, dogs_val = tfds.load(
    "cats_vs_dogs",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

cars_train, cars_val = tfds.load(
    "cars196",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# dogs_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/train", image_size=IMG_SIZE, batch_size=BATCH)
# dogs_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/val", image_size=IMG_SIZE, batch_size=BATCH)
#
# cars_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/train", image_size=IMG_SIZE, batch_size=BATCH)
# cars_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/val", image_size=IMG_SIZE, batch_size=BATCH)

def preprocess(x, y):
    return tf.image.resize(x, IMG_SIZE)/255.0, y

dogs_train = dogs_train.map(preprocess).batch(BATCH)
dogs_val = dogs_val.map(preprocess).batch(BATCH)

cars_train = cars_train.map(preprocess).batch(BATCH)
cars_val = cars_val.map(preprocess).batch(BATCH)

# =====
# PRETRAINED MODEL (ResNet-50)
# =====
base = tf.keras.applications.ResNet50(
    weights="imagenet", include_top=False, input_shape=(224,224,3)
)
base.trainable = False

def build_model(classes):
    model = tf.keras.Sequential([
        base,
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(classes, activation="softmax")
    ])
    model.compile(
        optimizer="adam",
        loss="sparse_categorical_crossentropy",
        metrics=["accuracy"]
    )
    return model

# Dogs & Cats
model_dogs = build_model(2)
h_dogs = model_dogs.fit(dogs_train, validation_data=dogs_val,
                        epochs=3, verbose=0)

# Cars
model_cars = build_model(196)
h_cars = model_cars.fit(cars_train, validation_data=cars_val,
                        epochs=3, verbose=0)
```

```
# =====
# VISUALIZATION
# =====
plt.plot(h_dogs.history['val_accuracy'], label="Dogs & Cats")
plt.plot(h_cars.history['val_accuracy'], label="Cars")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("ResNet-50 Performance Comparison")
plt.legend()
plt.show()
```

- # 1. Choose two datasets with different distributions (dogs & cats , cars).
- # 2. Resize images to the required input size of the chosen pre-trained model.
- # 3. Load Pre-trained Model (ResNet-50)
- # 4. Compare the performances of all the models and visualize
- # 5. Write down your observations and conclusions

```
import tensorflow as tf
import tensorflow_datasets as tfds
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
dogs_train, dogs_val = tfds.load(
    "cats_vs_dogs",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

cars_train, cars_val = tfds.load(
    "cars196",
    split=["train[:80%]", "train[80%:]"],
    as_supervised=True
)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# dogs_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/train", image_size=IMG_SIZE, batch_size=BATCH)
# dogs_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "dogs_cats/val", image_size=IMG_SIZE, batch_size=BATCH)
#
# cars_train = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/train", image_size=IMG_SIZE, batch_size=BATCH)
# cars_val = tf.keras.preprocessing.image_dataset_from_directory(
#     "cars/val", image_size=IMG_SIZE, batch_size=BATCH)

def preprocess(x, y):
    return tf.image.resize(x, IMG_SIZE)/255.0, y

dogs_train = dogs_train.map(preprocess).batch(BATCH)
dogs_val = dogs_val.map(preprocess).batch(BATCH)

cars_train = cars_train.map(preprocess).batch(BATCH)
cars_val = cars_val.map(preprocess).batch(BATCH)

# =====
# PRETRAINED MODEL (ResNet-50)
# =====
base = tf.keras.applications.ResNet50(
    weights="imagenet", include_top=False, input_shape=(224,224,3)
)
base.trainable = False

def build_model(classes):
    model = tf.keras.Sequential([
        base,
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(classes, activation="softmax")
    ])
    model.compile(
        optimizer="adam",
        loss="sparse_categorical_crossentropy",
```

```

        metrics=["accuracy"]
    )
    return model

# Dogs & Cats
model_dogs = build_model(2)
h_dogs = model_dogs.fit(
    dogs_train, validation_data=dogs_val, epochs=3, verbose=0)

# Cars
model_cars = build_model(196)
h_cars = model_cars.fit(
    cars_train, validation_data=cars_val, epochs=3, verbose=0)

# =====
# VISUALIZATION
# =====
plt.plot(h_dogs.history['val_accuracy'], label="Dogs & Cats")
plt.plot(h_cars.history['val_accuracy'], label="Cars")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("ResNet-50 Performance Comparison")
plt.legend()
plt.show()
# Dogs & Cats dataset achieves higher accuracy
# Cars dataset is more complex (fine-grained classes)
# Same pretrained model behaves differently due to data distribution
# ResNet-50 generalizes well on simpler datasets, while complex datasets like Cars need more data or fine-tuning

```

```

# • Take the dataset of Breast cancer
# • Initialize a neural network with random weights.
# • Calculate output of Neural Network:
# • Calculate MSE
# • Plot error surface using loss function verses weight, bias
# • Perform this cycle in step c for every input output pair
# • Perform 5 epochs of step d.
# • Update weights accordingly using stochastic gradient descend.
# • Plot the mean squared error for each iteration in stochastic Gradient Descent.
# • Similarly plot accuracy for iteration and note the results

```

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_breast_cancer
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
data = load_breast_cancer()
X = data.data[:, :2] # take 2 features
y = data.target.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = np.loadtxt("breast_cancer.csv", delimiter=",")
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 5

mse_list = []
acc_list = []
w_list = []
b_list = []

# =====
# TRAINING (SGD)
# =====
for _ in range(epochs):
    for i in range(len(X)):

```

```

xi = X[i].reshape(1,-1)
yi = y[i]

# Forward propagation
y_pred = np.dot(xi, w) + b

# Error & MSE
error = yi - y_pred
mse = error ** 2

mse_list.append(mse.item())
w_list.append(w[0][0])
b_list.append(b)

# Accuracy
y_class = 1 if y_pred >= 0.5 else 0
acc_list.append(1 if y_class == yi else 0)

# SGD update
w = w + lr * error * xi.T
b = b + lr * error

print("Final Weights:", w.flatten())
print("Final Bias:", b)
# ERROR SURFACE (LOSS vs WEIGHT & BIAS)
W, B = np.meshgrid(np.linspace(0,1,30), np.linspace(0,1,30))
Z = []

for wi, bi in zip(W.flatten(), B.flatten()):
    pred = X[:,0].reshape(-1,1) * wi + bi
    Z.append(np.mean((y - pred)**2))

Z = np.array(Z).reshape(W.shape)

plt.contourf(W, B, Z, cmap="viridis")
plt.xlabel("Weight")
plt.ylabel("Bias")
plt.title("Error Surface (MSE)")
plt.colorbar()
plt.show()

plt.plot(mse_list)
plt.xlabel("Iteration")
plt.ylabel("Mean Squared Error")
plt.title("MSE vs Iteration (SGD)")
plt.show()

plt.plot(acc_list)
plt.xlabel("Iteration")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Iteration (SGD)")
plt.show()

```

```

# • Take the dataset of Iris.
# • Initialize a neural network with random weights.
# • Calculate output of Neural Network:
# • Calculate MSE
# • Plot error surface using loss function verses weight, bias
# • Perform this cycle in step c for every input output pair
# • Perform 10 epochs of step d.
# • Update weights accordingly using stochastic gradient descend.
# • Plot the mean squared error for each iteration in stochastic Gradient Descent.
# • Similarly plot accuracy for iteration and note the results

```

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
iris = load_iris()
X = iris.data[:, :2] # take 2 features
y = (iris.target == 0).astype(int).reshape(-1,1) # binary output

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)

```

```

# data = np.loadtxt("iris.csv", delimiter=",")
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 10

mse_list = []
acc_list = []
w_list = []
b_list = []

# =====
# TRAINING (SGD)
# =====
for _ in range(epochs):
    for i in range(len(X)):
        xi = X[i].reshape(1,-1)
        yi = y[i]

        # Forward propagation
        y_pred = np.dot(xi, w) + b

        # Error & MSE
        error = yi - y_pred
        mse = error ** 2

        mse_list.append(mse.item())
        w_list.append(w[0][0])
        b_list.append(b)

        # Accuracy
        y_class = 1 if y_pred >= 0.5 else 0
        acc_list.append(1 if y_class == yi else 0)

        # SGD update
        w = w + lr * error * xi.T
        b = b + lr * error

print("Final Weights:", w.flatten())
print("Final Bias:", b)
# ERROR SURFACE (LOSS vs WEIGHT & BIAS)
W, B = np.meshgrid(np.linspace(0,1,30), np.linspace(0,1,30))
Z = []

for wi, bi in zip(W.flatten(), B.flatten()):
    pred = X[:,0].reshape(-1,1) * wi + bi
    Z.append(np.mean((y - pred)**2))

Z = np.array(Z).reshape(W.shape)

plt.contourf(W, B, Z, cmap="viridis")
plt.xlabel("Weight")
plt.ylabel("Bias")
plt.title("Error Surface (MSE)")
plt.colorbar()
plt.show()

plt.plot(mse_list)
plt.xlabel("Iteration")
plt.ylabel("Mean Squared Error")
plt.title("MSE vs Iteration (SGD)")
plt.show()

plt.plot(acc_list)
plt.xlabel("Iteration")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Iteration (SGD)")
plt.show()

```

```

# Implement batch gradient descent optimizer function
# Take the dataset of Titanic
# • Initialize a neural network with random weights.

```

```
# • Calculate output of Neural Network:
# • Calculate squared error loss
# • Update network parameter using batch gradient descent optimizer function Implementation.
# • Display updated weight and bias values
# • Plot loss w.r.t. Iterations
```

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
titanic = pd.read_csv(
    "https://raw.githubusercontent.com/datasciencedojo/datasets/master/titanic.csv"
)
X = titanic[['Age', 'Fare']].fillna(0).values
y = titanic['Survived'].values.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# titanic = pd.read_csv("titanic.csv")
# X = titanic[['Age', 'Fare']].fillna(0).values
# y = titanic['Survived'].values.reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 20

loss_list = []

# =====
# BATCH GRADIENT DESCENT
# =====
for _ in range(epochs):

    # Forward propagation (whole dataset)
    y_pred = np.dot(X, w) + b

    # Squared error loss
    error = y - y_pred
    loss = np.mean(error ** 2)
    loss_list.append(loss)

    # Gradients (batch)
    dw = -2 * np.mean(X * error, axis=0).reshape(2,1)
    db = -2 * np.mean(error)

    # Update weights and bias
    w = w - lr * dw
    b = b - lr * db

print("Updated Weights:", w.flatten())
print("Updated Bias:", b)

plt.plot(loss_list)
plt.xlabel("Iteration")
plt.ylabel("Loss (MSE)")
plt.title("Loss vs Iteration (Batch Gradient Descent)")
plt.show()
```

```
# task 1
# Implement the NOR Boolean logic gate using perceptron Neural Network.
# Inputs = x1, x2 and bias, weights should be fed into the perceptron with single Output = y.
# Display final weights and bias of each perceptron.
```

```
# Inputs
inputs = [
    (0, 0),
```

```

    (0, 1),
    (1, 0),
    (1, 1)
]

# Weights and bias (predefined for NOR gate)
w1 = -1
w2 = -1
b = 0.5

def perceptron(x1, x2):
    z = w1*x1 + w2*x2 + b
    return 1 if z >= 0 else 0

# Test NOR gate
for x1, x2 in inputs:
    print(f"{x1} NOR {x2} = {perceptron(x1, x2)}")

print("Final Weights:", w1, w2)
print("Final Bias:", b)

```

```

0 NOR 0 = 1
0 NOR 1 = 0
1 NOR 0 = 0
1 NOR 1 = 0
Final Weights: -1 -1
Final Bias: 0.5

```

```

# 2.    Take the dataset of Diabetes 2
# b) Initialize a neural network with random weights.
# c) Calculate output of Neural Network:
# i.    Calculate squared error loss
# ii.   Update network parameter using batch Mini Batch gradient descent optimizer function Implementation.
# Iii.  Display updated weight and bias values
# iv.   Plot loss w.r.t. bias values

```

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_diabetes
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
data = load_diabetes()
X = data.data[:, :2]          # take 2 features
y = data.target.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = np.loadtxt("diabetes.csv", delimiter=",")
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)
y = MinMaxScaler().fit_transform(y)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 20
batch_size = 20

loss_list = []
bias_list = []

# =====
# MINI-BATCH GRADIENT DESCENT
# =====
for _ in range(epochs):
    for i in range(0, len(X), batch_size):

        Xb = X[i:i+batch_size]
        yb = y[i:i+batch_size]

```

```

# Forward propagation
y_pred = np.dot(Xb, w) + b

# Squared error loss
error = yb - y_pred
loss = np.mean(error ** 2)

loss_list.append(loss)
bias_list.append(b)

# Gradients (mini-batch)
dw = -2 * np.mean(Xb * error, axis=0).reshape(2,1)
db = -2 * np.mean(error)

# Update parameters
w = w - lr * dw
b = b - lr * db

print("Updated Weights:", w.flatten())
print("Updated Bias:", b)

plt.plot(bias_list, loss_list, 'o')
plt.xlabel("Bias")
plt.ylabel("Loss (MSE)")
plt.title("Loss vs Bias (Mini-Batch Gradient Descent)")
plt.show()

```

```

# • Take the dataset of Diabetes
# • Initialize a neural network with random weights.
# □ c) Calculate output of Neural Network:
# □ Calculate Mean squared error loss
# □ Update network parameter using batch momentum based gradient descent optimizer function Implementation.
# □ Display updated weight and bias values
# □ Plot loss w.r.t. iterations

```

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_diabetes
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
data = load_diabetes()
X = data.data[:, :2]          # take 2 features
y = data.target.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = np.loadtxt("diabetes.csv", delimiter=",")
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)
y = MinMaxScaler().fit_transform(y)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 30
beta = 0.9          # momentum factor

vw = np.zeros_like(w)    # velocity for weights
vb = 0.0               # velocity for bias

loss_list = []

# =====
# BATCH MOMENTUM GD
# =====
for _ in range(epochs):

    # Forward propagation (whole batch)
    y_pred = np.dot(X, w) + b

```

```

# MSE loss
error = y - y_pred
loss = np.mean(error ** 2)
loss_list.append(loss)

# Gradients (batch) derivate of weight wrt to loss
dw = -2 * np.mean(X * error, axis=0).reshape(2,1)
db = -2 * np.mean(error)

# Momentum update
vw = beta * vw + lr * dw
vb = beta * vb + lr * db

w = w - vw
b = b - vb

print("Updated Weights:", w.flatten())
print("Updated Bias:", b)

plt.plot(loss_list)
plt.xlabel("Iteration")
plt.ylabel("Loss (MSE)")
plt.title("Loss vs Iteration (Momentum Gradient Descent)")
plt.show()

```

```

# Implement the XOR Boolean logic gate using perceptron Neural Network.
# Inputs = x1, x2 and bias, weights should be fed into the perceptron with single Output = y.
# Display final weights and bias of each perceptron.

```

```

# Inputs
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

# ----- Hidden Layer -----
# Perceptron 1 (OR)
w1_or = 1
w2_or = 1
b_or = -0.5

# Perceptron 2 (NAND)
w1_nand = -1
w2_nand = -1
b_nand = 1.5

# ----- Output Layer -----
# Perceptron (AND)
w1_and = 1
w2_and = 1
b_and = -1.5

def perceptron(x1, x2, w1, w2, b):
    z = w1*x1 + w2*x2 + b
    return 1 if z >= 0 else 0

# Test XOR gate
for x1, x2 in inputs:
    h1 = perceptron(x1, x2, w1_or, w2_or, b_or) # OR
    h2 = perceptron(x1, x2, w1_nand, w2_nand, b_nand) # NAND
    y = perceptron(h1, h2, w1_and, w2_and, b_and) # AND
    print(f"{x1} XOR {x2} = {y}")

print("\nFinal Weights and Biases:")
print("Hidden Perceptron 1 (OR): w1 =", w1_or, "w2 =", w2_or, "bias =", b_or)
print("Hidden Perceptron 2 (NAND): w1 =", w1_nand, "w2 =", w2_nand, "bias =", b_nand)
print("Output Perceptron (AND): w1 =", w1_and, "w2 =", w2_and, "bias =", b_and)

```

```

0 XOR 0 = 0
0 XOR 1 = 1
1 XOR 0 = 1
1 XOR 1 = 0

```

```

Final Weights and Biases:
Hidden Perceptron 1 (OR): w1 = 1 w2 = 1 bias = -0.5
Hidden Perceptron 2 (NAND): w1 = -1 w2 = -1 bias = 1.5
Output Perceptron (AND): w1 = 1 w2 = 1 bias = -1.5

```

```
# 2. Take the dataset of Penguin
# 3. b) Initialize a neural network with random weights.
# c) Calculate output of Neural Network:
# i. Calculate squared error loss
# ii. Update network parameter using batch Adaptive delta gradient descent optimizer function Implementation.
# iii. Display updated weight and bias values
# iv. Plot accuracy w.r.t. epoch values
```

```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
penguins = sns.load_dataset("penguins").dropna()
X = penguins[['bill_length_mm', 'bill_depth_mm']].values
y = (penguins['species'] == 'Adelie').astype(int).values.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = np.loadtxt("penguins.csv", delimiter=",", skiprows=1)
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
w = np.random.rand(2,1)
b = np.random.rand()
epochs = 20
rho = 0.95
eps = 1e-6
# Stores running average of squared gradients
Eg2_w = np.zeros_like(w)
Eg2_b = 0
# Stores running average of squared parameter updates
Edx2_w = np.zeros_like(w)
Edx2_b = 0

acc_list = []

# =====
# BATCH ADADELTA GD
# =====
for _ in range(epochs):

    # Forward propagation
    y_pred = np.dot(X, w) + b

    # Squared error loss
    error = y - y_pred

    # Gradients
    dw = -2 * np.mean(X * error, axis=0).reshape(2,1)
    db = -2 * np.mean(error)

    # AdaDelta updates
    Eg2_w = rho * Eg2_w + (1 - rho) * (dw ** 2)
    Eg2_b = rho * Eg2_b + (1 - rho) * (db ** 2)

    delta_w = - (np.sqrt(Edx2_w + eps) / np.sqrt(Eg2_w + eps)) * dw
    delta_b = - (np.sqrt(Edx2_b + eps) / np.sqrt(Eg2_b + eps)) * db

    Edx2_w = rho * Edx2_w + (1 - rho) * (delta_w ** 2)
    Edx2_b = rho * Edx2_b + (1 - rho) * (delta_b ** 2)

    w = w + delta_w
    b = b + delta_b

    # Accuracy
    y_class = (y_pred >= 0.5).astype(int)
    acc = np.mean(y_class == y)
    acc_list.append(acc)
```

```

print("Updated Weights:", w.flatten())
print("Updated Bias:", b)

plt.plot(acc_list)
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Epoch (AdaDelta Gradient Descent)")
plt.show()

```

```

# 1.    Implement backpropagation algorithm from scratch.
# a)    Take Iris Dataset
# b)    Initialize a neural network with random weights.
# c)    Calculate Squared Error (SE)
# d)    Perform multiple iterations.
# e)    Update weights accordingly.
# f)    Plot accuracy for iterations and note the results.

```

```

import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
iris = load_iris()
X = iris.data[:, :2]          # take 2 features
y = (iris.target == 0).astype(int)  # binary class
y = y.reshape(-1,1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = np.loadtxt("iris.csv", delimiter=",")
# X = data[:, :2]
# y = data[:, -1].reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
np.random.seed(1)
W1 = np.random.rand(2,3)    # input → hidden
b1 = np.random.rand(1,3)
W2 = np.random.rand(3,1)    # hidden → output
b2 = np.random.rand(1,1)

lr = 0.1
epochs = 50
acc_list = []

# Sigmoid function
def sigmoid(x):
    return 1 / (1 + np.exp(-x))

def sigmoid_deriv(x):
    return x * (1 - x)

# =====
# TRAINING (BACKPROPAGATION)
# =====
for _ in range(epochs):

    # Forward pass
    h_in = np.dot(X, W1) + b1
    h_out = sigmoid(h_in)

    o_in = np.dot(h_out, W2) + b2
    y_pred = sigmoid(o_in)

    # Squared Error
    error = y - y_pred
    SE = error ** 2

    # Backpropagation
    d_out = error * sigmoid_deriv(y_pred)

```

```

dW2 = np.dot(h_out.T, d_out)
db2 = np.sum(d_out, axis=0, keepdims=True)

d_hidden = np.dot(d_out, W2.T) * sigmoid_deriv(h_out)
dW1 = np.dot(X.T, d_hidden)
db1 = np.sum(d_hidden, axis=0, keepdims=True)

# Update weights
W2 += lr * dW2
b2 += lr * db2
W1 += lr * dW1
b1 += lr * db1

# Accuracy
y_class = (y_pred >= 0.5).astype(int)
acc = np.mean(y_class == y)
acc_list.append(acc)

print("Final Accuracy:", acc_list[-1])

plt.plot(acc_list)
plt.xlabel("Iteration")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Iteration (Backpropagation)")
plt.show()

```

```

# Build a multiclass image categorization CNN network which correctly classifies different categories of images
# (handwritten digits from Mnist digit dataset
# • Split original dataset to train and test set
# • Build CNN Model
# • Generate the accuracy of the built model using Adam Optimizer and Adagrad Optimizer.
# • Compare performance of different optimizer on Digit categorization.
# • Plot training vs validation accuracy
# • Evaluate the model using confusion matrix, precision, recall.

```

```

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, precision_score, recall_score
import seaborn as sns

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# with np.load(r"C:\Users\anupk\Downloads\mnist.npz") as data:
#     x = np.concatenate([data['x_train'], data['x_test']], axis=0)
#     y = np.concatenate([data['y_train'], data['y_test']], axis=0)
#     x = x / 255.0
# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/train", image_size=(28,28), color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/test", image_size=(28,28), color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x, y in train_ds]), np.concatenate([y for x, y in train_ds])
# x_test, y_test = np.concatenate([x for x, y in test_ds]), np.concatenate([y for x, y in test_ds])

# x_train = np.load("x_train.npy")
# y_train = np.load("y_train.npy")
# x_test = np.load("x_test.npy")
# y_test = np.load("y_test.npy")

# Normalize & reshape
x_train = x_train / 255.0
x_test = x_test / 255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(16, 3, activation='relu', input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(32, 3, activation='relu'),

```

```

        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# TRAIN WITH ADAM
# =====
model_adam = build_model(tf.keras.optimizers.Adam())
hist_adam = model_adam.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    verbose=0
)

# =====
# TRAIN WITH ADAGRAD
# =====
model_adagrad = build_model(tf.keras.optimizers.Adagrad())
hist_adagrad = model_adagrad.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    verbose=0
)

# =====
# PLOT ACCURACY
# =====
plt.plot(hist_adam.history['val_accuracy'], label="Adam")
plt.plot(hist_adagrad.history['val_accuracy'], label="Adagrad")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Optimizer Comparison on MNIST")
plt.legend()
plt.show()

# =====
# EVALUATION (ADAM MODEL)
# =====
y_pred = np.argmax(model_adam.predict(x_test), axis=1)

cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, cmap="Blues")
plt.title("Confusion Matrix (Adam)")
plt.show()

precision = precision_score(y_test, y_pred, average='macro')
recall = recall_score(y_test, y_pred, average='macro')

print("Precision:", precision)
print("Recall:", recall)

# =====
# EVALUATION - ADAGRAD MODEL
# =====
y_pred_adagrad = np.argmax(model_adagrad.predict(x_test), axis=1)

cm_adagrad = confusion_matrix(y_test, y_pred_adagrad)
sns.heatmap(cm_adagrad, cmap="Greens")
plt.title("Confusion Matrix (Adagrad)")
plt.show()

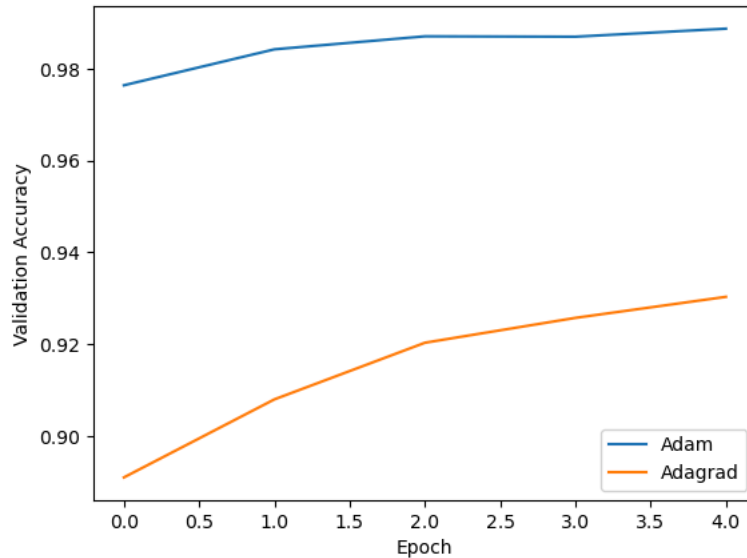
precision_adagrad = precision_score(y_test, y_pred_adagrad, average='macro')
recall_adagrad = recall_score(y_test, y_pred_adagrad, average='macro')

print("Adagrad Precision:", precision_adagrad)
print("Adagrad Recall:", recall_adagrad)

```

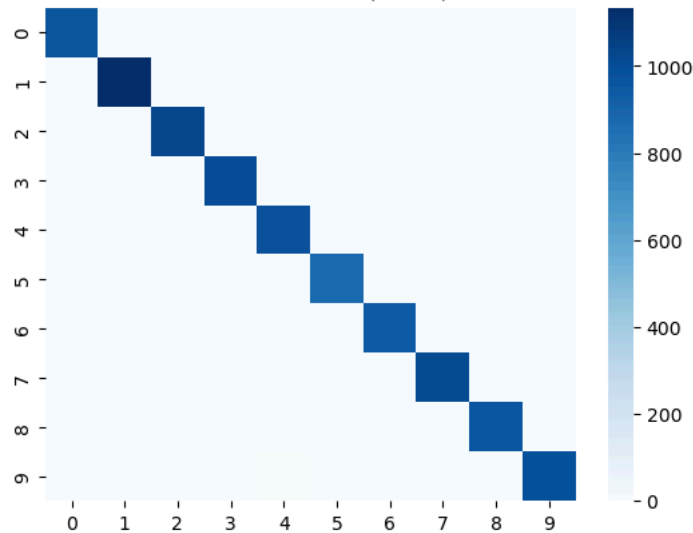
```
C:\Users\anupk\anaconda3\Lib\site-packages\keras\src\layers\convolutional\base_conv.py:113: UserWarning: Do not p
super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

Optimizer Comparison on MNIST



313/313 — 3s 7ms/step

Confusion Matrix (Adam)

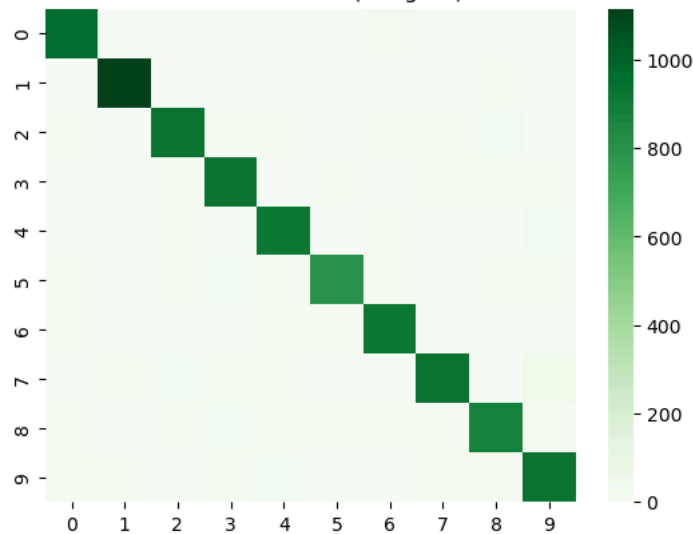


Precision: 0.9890122203105116

Recall: 0.9887764721932643

313/313 — 3s 8ms/step

Confusion Matrix (Adagrad)



Adagrad Precision: 0.9316720325718155

Adagrad Recall: 0.9313357049020079

```
# Build a multiclass image categorization CNN network which correctly classifies different categories of images
# ( Fashion Mnist dataset.)
```

```
# • Split original dataset to train and test set
# • Build CNN Model
# • Generate the accuracy of the built model using RMSProp and SGDOptimizer.
# • Perform hyperparameter tuning to increase the accuracy of the CNN.
# • Compare performance of different optimizer on Cloth categorization.
# • Plot training vs validation loss
# • Evaluate the model using confusion matrix, precision.
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, precision_score
import seaborn as sns

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.fashion_mnist.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize & reshape
x_train = x_train/255.0
x_test = x_test/255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu', input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(64, 3, activation='relu'),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# HYPERPARAMETER TUNING
# =====
sgd_opt = tf.keras.optimizers.SGD(learning_rate=0.01)
rms_opt = tf.keras.optimizers.RMSprop(learning_rate=0.001)

# =====
# TRAIN WITH SGD
# =====
model_sgd = build_model(sgd_opt)
hist_sgd = model_sgd.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    verbose=0
)

# =====
# TRAIN WITH RMSPROP
# =====
model_rms = build_model(rms_opt)
hist_rms = model_rms.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
```

```
        verbose=0
    )

    # =====
    # PLOT TRAINING vs VALIDATION LOSS
    # =====
    plt.plot(hist_sgd.history['loss'], label="SGD Train")
    plt.plot(hist_sgd.history['val_loss'], label="SGD Val")
    plt.plot(hist_rms.history['loss'], label="RMSProp Train")
    plt.plot(hist_rms.history['val_loss'], label="RMSProp Val")
    plt.xlabel("Epoch")
    plt.ylabel("Loss")
    plt.title("Training vs Validation Loss (Fashion-MNIST)")
    plt.legend()
    plt.show()

    # =====
    # EVALUATION - SGD
    # =====
    y_pred_sgd = np.argmax(model_sgd.predict(x_test), axis=1)
    cm_sgd = confusion_matrix(y_test, y_pred_sgd)
    sns.heatmap(cm_sgd, cmap="Blues")
    plt.title("Confusion Matrix - SGD")
    plt.show()
    print("Precision (SGD):", precision_score(y_test, y_pred_sgd, average='macro'))

    # =====
    # EVALUATION - RMSPROP
    # =====
    y_pred_rms = np.argmax(model_rms.predict(x_test), axis=1)
    cm_rms = confusion_matrix(y_test, y_pred_rms)
    sns.heatmap(cm_rms, cmap="Greens")
    plt.title("Confusion Matrix - RMSProp")
    plt.show()
    print("Precision (RMSProp):", precision_score(y_test, y_pred_rms, average='macro'))
```


Downloading data from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-labels-idx1-ubyte.gz>
 29515/29515 ————— 0s 0us/step

1. Implement CNN and compare its performance using different optimizers
 # Take the MNIST dataset
 # b) Initialize a neural network basic layers with random weights.
 # c) Perform practical analysis of optimizers on MNIST dataset keeping batch size, and epochs same but with diff
 # d) Compare the results by choosing 5 different optimizers [SGD, Adadelata, Adagrad, Adam, RMSprop] on a simple

```
super().__init__(activity_regularizer=activity_regularizer, **kwargs)

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# x_train = np.load("x_train.npy")
# y_train = np.load("y_train.npy")
# x_test = np.load("x_test.npy")
# y_test = np.load("y_test.npy")

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize & reshape
x_train = x_train / 255.0
x_test = x_test / 255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(16, 3, activation='relu',
                                input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# OPTIMIZERS
# =====
optimizers = {
    "SGD": tf.keras.optimizers.SGD(),
    "Adadelata": tf.keras.optimizers.Adadelata(),
    "Adagrad": tf.keras.optimizers.Adagrad(),
    "Adam": tf.keras.optimizers.Adam(),
    "RMSprop": tf.keras.optimizers.RMSprop()
}

histories = {}

# =====
# TRAINING (SAME EPOCHS & BATCH)
# =====
for name, opt in optimizers.items():
    model = build_model(opt)
    histories[name] = model.fit(
        x_train, y_train,
```

```

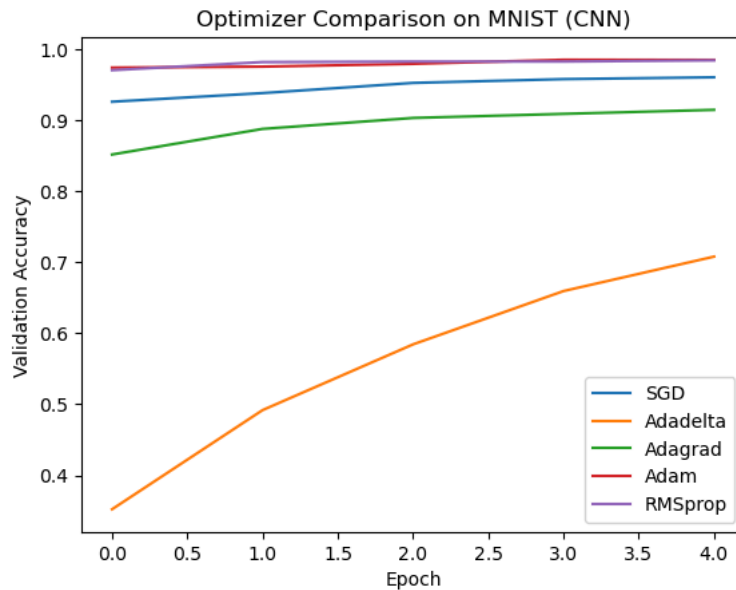
        validation_split=0.2,
        epochs=5,
        batch_size=32,
        verbose=0
    )

# =====
# ACCURACY COMPARISON
# =====
for name, hist in histories.items():
    plt.plot(hist.history['val_accuracy'], label=name)

plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Optimizer Comparison on MNIST (CNN)")
plt.legend()
plt.show()

```

C:\Users\anupk\anaconda3\Lib\site-packages\keras\src\layers\convolutional\base_conv.py:113: UserWarning: Do not p
 super().__init__(activity_regularizer=activity_regularizer, **kwargs)



```

# • Load the CIFAR-10 image dataset.
# • Split the dataset into training and testing sets.
# • Design a CNN model for object classification.
# • Train and evaluate the model.
# • Plot accuracy and loss curves.

```

```

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.cifar10.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/train", image_size=(32,32), batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/test", image_size=(32,32), batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])
# agar ye nhi chala toh niche wala dekho loading wala part
# Normalize
x_train = x_train / 255.0
x_test = x_test / 255.0

# =====
# CNN MODEL
# =====
model = tf.keras.Sequential([

```

```

tf.keras.layers.Conv2D(32, 3, activation='relu', input_shape=(32,32,3)),
tf.keras.layers.MaxPooling2D(),
tf.keras.layers.Conv2D(64, 3, activation='relu'),
tf.keras.layers.MaxPooling2D(),
tf.keras.layers.Flatten(),
tf.keras.layers.Dense(128, activation='relu'),
tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(
    optimizer='adam',
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

# =====
# TRAIN & EVALUATE
# =====
history = model.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    batch_size=32,
    verbose=0
)

test_loss, test_acc = model.evaluate(x_test, y_test, verbose=0)
print("Test Accuracy:", test_acc)

# =====
# PLOTS: ACCURACY & LOSS
# =====
plt.plot(history.history['accuracy'], label="Train Acc")
plt.plot(history.history['val_accuracy'], label="Val Acc")
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Accuracy Curve (CIFAR-10)")
plt.legend()
plt.show()

plt.plot(history.history['loss'], label="Train Loss")
plt.plot(history.history['val_loss'], label="Val Loss")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Loss Curve (CIFAR-10)")
plt.legend()
plt.show()

```

```

# • Use alpaca dataset
# • CNN must include : Convolution layer, Pooling layer, Flatten layer,Dense layer
# Plot:
# • Accuracy vs Epochs
# • Loss (Error) vs Epochs

```

```

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

IMG_SIZE = (64,64)
BATCH = 32

# =====
# DATASET LOADING
# =====

# OPTION ❶ LOAD FROM LIBRARY (USE THIS – EXAM DEMO)
# (Illustrative – alpaca-style binary dataset)
# dataset = tfds.load("alpaca", as_supervised=True)

# OPTION ❷ LOAD FROM LOCAL FOLDER (COMMENTED – REAL ALPACA DATASET)
# Folder structure:
# alpaca/
#   train/
#     alpaca/
#     not_alpaca/
#   test/
#     alpaca/
#     not_alpaca/

# train_ds = tf.keras.preprocessing.image_dataset_from_directory(

```

```

# "alpaca/train", image_size=IMG_SIZE, batch_size=BATCH)

# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "alpaca/test", image_size=IMG_SIZE, batch_size=BATCH)

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "alpaca",
    validation_split=0.2,
    subset="training",
    seed=42,
    image_size=IMG_SIZE,
    batch_size=BATCH
)

test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "alpaca",
    validation_split=0.2,
    subset="validation",
    seed=42,
    image_size=IMG_SIZE,
    batch_size=BATCH
)

# Normalize
train_ds = train_ds.map(lambda x,y: (x/255.0, y))
test_ds = test_ds.map(lambda x,y: (x/255.0, y))

# =====
# CNN MODEL
# =====
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(16, 3, activation='relu',
                           input_shape=(64,64,3)),
    tf.keras.layers.MaxPooling2D(),

    tf.keras.layers.Conv2D(32, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),

    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(64, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])

model.compile(
    optimizer='adam',
    loss='binary_crossentropy',
    metrics=['accuracy']
)

# =====
# TRAIN MODEL
# =====
history = model.fit(
    train_ds,
    validation_data=test_ds,
    epochs=5,
    verbose=0
)

# =====
# PLOTS
# =====
plt.plot(history.history['accuracy'], label="Train Accuracy")
plt.plot(history.history['val_accuracy'], label="Validation Accuracy")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Epochs (Alpaca CNN)")
plt.legend()
plt.show()

plt.plot(history.history['loss'], label="Train Loss")
plt.plot(history.history['val_loss'], label="Validation Loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.title("Loss vs Epochs (Alpaca CNN)")
plt.legend()
plt.show()

```

- # 1. Load the Corn 3–Classes image dataset.
- # 2. Preprocess the images:
 - # a. Resize images to a fixed size (e.g., 224×224)

```

# b.      Normalize pixel values.
# 3.      Split the dataset into training and testing sets.
# 4.      Create a CNN model using:
# a.      Convolution layer
# b.      Max Pooling layer
# c.      Flatten layer
# d.      Dense layer
# 5.      Train the CNN model for multi-class classification.
# 6.      Test the model on unseen images.
# 7.      Plot graphs:
# a.      Training vs Validation Accuracy
# b.      Training vs Validation Loss (Error)

```

```

import tensorflow as tf
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32

# =====
# DATASET LOADING (SINGLE FOLDER)
# =====

# Folder structure:
# corn/
#   class1/
#   class2/
#   class3/

dataset = tf.keras.preprocessing.image_dataset_from_directory(
    "corn",
    image_size=IMG_SIZE,
    batch_size=BATCH,
    validation_split=0.2,      # auto split
    subset="training",
    seed=123
)

val_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "corn",
    image_size=IMG_SIZE,
    batch_size=BATCH,
    validation_split=0.2,
    subset="validation",
    seed=123
)

num_classes = len(dataset.class_names)

# Normalize
dataset = dataset.map(lambda x,y: (x/255.0, y))
val_ds = val_ds.map(lambda x,y: (x/255.0, y))

# =====
# CNN MODEL
# =====
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(32, 3, activation='relu',
                           input_shape=(224,224,3)),
    tf.keras.layers.MaxPooling2D(),

    tf.keras.layers.Conv2D(64, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),

    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(num_classes, activation='softmax')
])

model.compile(
    optimizer='adam',
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

# =====
# TRAIN MODEL
# =====
history = model.fit(
    dataset,
    validation_data=val_ds,

```

```

        epochs=5,
        verbose=0
    )

    # =====
    # TEST ON UNSEEN IMAGES (VALIDATION)
    # =====
    val_loss, val_acc = model.evaluate(val_ds, verbose=0)
    print("Validation Accuracy:", val_acc)

    # =====
    # PLOTS
    # =====

    # Accuracy
    plt.plot(history.history['accuracy'], label="Train Accuracy")
    plt.plot(history.history['val_accuracy'], label="Validation Accuracy")
    plt.xlabel("Epoch")
    plt.ylabel("Accuracy")
    plt.title("Training vs Validation Accuracy (Corn CNN)")
    plt.legend()
    plt.show()

    # Loss
    plt.plot(history.history['loss'], label="Train Loss")
    plt.plot(history.history['val_loss'], label="Validation Loss")
    plt.xlabel("Epoch")
    plt.ylabel("Loss")
    plt.title("Training vs Validation Loss (Corn CNN)")
    plt.legend()
    plt.show()

```

```

# Implement Self Organizing Map for anomaly Detection
# 1.   Use Credit Card Applications Dataset:
# 2.   Detect fraud customers in the dataset using SOM and perform hyperparameter tuning
# 3.   Show map and use markers to distinguish frauds.

```

```

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from minisom import MiniSom
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM CSV (USE THIS)
data = pd.read_csv("Credit_Card_Applications.csv")

X = data.iloc[:, :-1].values    # features
y = data.iloc[:, -1].values     # approval (0/1)

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# data = pd.read_csv(r"C:\data\credit_card.csv")
# X = data.iloc[:, :-1].values
# y = data.iloc[:, -1].values

# Normalize
sc = MinMaxScaler(feature_range=(0,1))
X = sc.fit_transform(X)

# =====
# SOM + HYPERPARAMETERS
# =====
som_x, som_y = 10, 10          # map size (tuning)
sigma = 1.0
lr = 0.5

som = MiniSom(
    x=som_x,
    y=som_y,
    input_len=X.shape[1],
    sigma=sigma,
    learning_rate=lr
)

som.random_weights_init(X)

```

```

som.train_random(X, num_iteration=100)

# =====
# VISUALIZATION
# =====
plt.figure(figsize=(7,7))
plt.pcolor(som.distance_map(), cmap='coolwarm')
plt.colorbar(label="Distance (Anomaly Score)")

for i, x in enumerate(X):
    w = som.winner(x)
    if y[i] == 0: # not approved → fraud
        plt.text(w[0]+0.5, w[1]+0.5, 'F',
                 color='red', ha='center', va='center')
    else:
        plt.text(w[0]+0.5, w[1]+0.5, 'N',
                 color='green', ha='center', va='center')

plt.title("SOM Fraud Detection Map")
plt.show()

# =====
# FRAUD CUSTOMERS
# =====
mappings = som.win_map(X)
frauds = np.concatenate(
    [mappings[cell] for cell in mappings if som.distance_map()[cell] > 0.9],
    axis=0
)

frauds = sc.inverse_transform(frauds)
print("Detected Fraud Customers (sample):")
print(frauds[:5])

```

```

# Implement the NAND Boolean Logic Gate using a Perceptron Neural Network.
# • Inputs: x1, x2, bias
# • Train using perceptron learning rule
# • Output: y
# • Display final weights and bias
# • Verify truth table results

```

```

# Inputs and target outputs for NAND gate
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

targets = [1, 1, 1, 0] # NAND outputs

# Initialize weights and bias
w1 = 0.0
w2 = 0.0
b = 0.0

learning_rate = 0.1
epochs = 10

def perceptron(x1, x2, w1, w2, b):
    z = w1*x1 + w2*x2 + b
    return 1 if z >= 0 else 0

# -----
# Training using Perceptron Rule
# -----
for epoch in range(epochs):
    for (x1, x2), target in zip(inputs, targets):
        y = perceptron(x1, x2, w1, w2, b)
        error = target - y

        # Update weights and bias
        w1 = w1 + learning_rate * error * x1
        w2 = w2 + learning_rate * error * x2
        b = b + learning_rate * error

# -----
# Testing / Verification
# -----

```

```

print("NAND Gate Output:")
for x1, x2 in inputs:
    print(f"{x1} NAND {x2} = {perceptron(x1, x2, w1, w2, b)}")

print("\nFinal Weights and Bias:")
print("w1 =", w1)
print("w2 =", w2)
print("bias =", b)

```

NAND Gate Output:

```

0 NAND 0 = 1
0 NAND 1 = 1
1 NAND 0 = 1
1 NAND 1 = 0

```

Final Weights and Bias:

```

w1 = -0.2
w2 = -0.1
bias = 0.2

```

```

# Use the Iris Dataset
# • Normalize the input features
# • Perform Min-Max scaling
# • Visualize original vs normalized features

```

```

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# feature_names = iris.feature_names

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED FOR REAL DATASETS)
data = pd.read_csv("Iris.csv")

X = data.iloc[:, :-1].values      # all feature columns
feature_names = data.columns[:-1] # feature names

# =====
# MIN-MAX NORMALIZATION
# =====
scaler = MinMaxScaler()
X_norm = scaler.fit_transform(X)

# =====
# VISUALIZATION
# =====
plt.figure(figsize=(10,4))

# Original features
plt.subplot(1,2,1)
plt.boxplot(X)
plt.title("Original Features")
plt.xticks(range(1, X.shape[1]+1), feature_names, rotation=45)

# Normalized features
plt.subplot(1,2,2)
plt.boxplot(X_norm)
plt.title("Normalized Features (Min-Max)")
plt.xticks(range(1, X.shape[1]+1), feature_names, rotation=45)

plt.tight_layout()
plt.show()

```

```

# Implement Multi-output Perceptron for
# • AND gate
# • OR gate
# • Display weight matrix and bias vector

```

```

# Inputs
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

# Targets: [AND, OR]
targets = [
    (0, 0),
    (0, 1),
    (0, 1),
    (1, 1)
]

# Weight matrix (2 inputs x 2 outputs)
# Column 0 → AND, Column 1 → OR
W = [
    [1, 1], # weights for x1
    [1, 1] # weights for x2
]

# Bias vector
b = [-1.5, -0.5] # [AND bias, OR bias]

def perceptron(x1, x2):
    outputs = []
    for j in range(2): # two outputs
        z = x1 * W[0][j] + x2 * W[1][j] + b[j]
        y = 1 if z >= 0 else 0
        outputs.append(y)
    return outputs

# Test Multi-output Perceptron
print("x1 x2 | AND OR")
for x1, x2 in inputs:
    y_and, y_or = perceptron(x1, x2)
    print(f"{x1} {x2} | {y_and} {y_or}")

print("\nFinal Weight Matrix (W):")
print(W)

print("\nFinal Bias Vector (b):")
print(b)

```

```

x1 x2 | AND OR
0 0 | 0 0
0 1 | 0 1
1 0 | 0 1
1 1 | 1 1

```

```

Final Weight Matrix (W):
[[1, 1], [1, 1]]

```

```

Final Bias Vector (b):
[-1.5, -0.5]

```

```

# Load Flowers Dataset
# • Train CNN model with 3 kernels.
# • Plot training and validation accuracy using graph.

```

```

import tensorflow as tf
import tensorflow_datasets as tfds
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32

# =====
# DATASET LOADING (SINGLE DATASET)
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
train_ds = tfds.load(
    "tf_flowers",
    split="train[:80%]",
    as_supervised=True
)

val_ds = tfds.load(

```

```

    "tf_flowers",
    split="train[80%:]",
    as_supervised=True
)

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "flowers", image_size=IMG_SIZE,
#     validation_split=0.2, subset="training",
#     seed=123, batch_size=BATCH)
# val_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "flowers", image_size=IMG_SIZE,
#     validation_split=0.2, subset="validation",
#     seed=123, batch_size=BATCH)

# Preprocess
def preprocess(x, y):
    return tf.image.resize(x, IMG_SIZE)/255.0, y

train_ds = train_ds.map(preprocess).batch(BATCH)
val_ds = val_ds.map(preprocess).batch(BATCH)

# =====
# CNN MODEL (3 KERNELS)
# =====
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(3, 3, activation='relu',
                           input_shape=(224,224,3)), # 3 kernels
    tf.keras.layers.MaxPooling2D(),

    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(64, activation='relu'),
    tf.keras.layers.Dense(5, activation='softmax')
])

model.compile(
    optimizer='adam',
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

# =====
# TRAIN MODEL
# =====
history = model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=5,
    verbose=0
)

# =====
# PLOT ACCURACY
# =====
plt.plot(history.history['accuracy'], label="Train Accuracy")
plt.plot(history.history['val_accuracy'], label="Validation Accuracy")
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Training vs Validation Accuracy (Flowers CNN)")
plt.legend()
plt.show()

```

```

# Implement perceptron
# • Train on AND,OR gate
# • Compare convergence with normal perceptron

```

```

# Inputs
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

targets_and = [0, 0, 0, 1]
targets_or = [0, 1, 1, 1]

lr = 0.1
epochs = 20

```

```
def train_perceptron(targets):
    w1, w2, b = 0.0, 0.0, 0.0
    for epoch in range(epochs):
        total_error = 0
        for (x1, x2), t in zip(inputs, targets):
            z = w1*x1 + w2*x2 + b
            y = 1 if z >= 0 else 0
            error = t - y
            total_error += abs(error)

            # Perceptron learning rule
            w1 += lr * error * x1
            w2 += lr * error * x2
            b += lr * error
        if total_error == 0:
            return epoch + 1, w1, w2, b
    return epochs, w1, w2, b
# Train AND and OR Perceptrons
epochs_and, w1a, w2a, ba = train_perceptron(targets_and)
epochs_or, w1o, w2o, bo = train_perceptron(targets_or)

print("AND Gate:")
print("Converged in epochs:", epochs_and)
print("Weights:", w1a, w2a, "Bias:", ba)

print("\nOR Gate:")
print("Converged in epochs:", epochs_or)
print("Weights:", w1o, w2o, "Bias:", bo)
# OR gate converges faster AND gate takes more epochs
```

```
AND Gate:
Converged in epochs: 4
Weights: 0.2 0.1 Bias: -0.20000000000000004

OR Gate:
Converged in epochs: 4
Weights: 0.1 0.1 Bias: -0.1
```

```
# Use Iris Dataset
# • Encode using Autoencoder (3 neurons)
# • Decode and reconstruct
# • Plot original vs reconstructed data
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Dense

# =====
# DATASET LOADING
# =====

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED FOR REAL DATASETS)
data = pd.read_csv("Iris.csv")

X = data.iloc[:, :-1].values      # all feature columns
feature_names = data.columns[:-1] # feature names

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# feature_names = iris.feature_names

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# AUTOENCODER MODEL (3 NEURONS)
# =====
input_layer = Input(shape=(X.shape[1],))
encoded = Dense(3, activation='relu')(input_layer) # Encoder
decoded = Dense(X.shape[1], activation='sigmoid')(encoded) # Decoder

autoencoder = Model(input_layer, decoded)
autoencoder.compile(optimizer='adam', loss='mse')

# =====
```

```
# TRAIN AUTOENCODER
# =====
autoencoder.fit(X, X, epochs=50, batch_size=16, verbose=0)

# =====
# RECONSTRUCTION
# =====
X_reconstructed = autoencoder.predict(X)

# =====
# VISUALIZATION
# =====
plt.figure(figsize=(10,4))

# Original data
plt.subplot(1,2,1)
plt.boxplot(X)
plt.title("Original Iris Features")
plt.xticks(range(1,5), feature_names, rotation=45)

# Reconstructed data
plt.subplot(1,2,2)
plt.boxplot(X_reconstructed)
plt.title("Reconstructed Features (Autoencoder)")
plt.xticks(range(1,5), feature_names, rotation=45)

plt.tight_layout()
plt.show()
```

```
# Use dataset with initial values X = [1.0, 2.0], Y = [0.5, 1.5]
# • Initialize neural network with random weights
# • Compute output using linear activation
# • Calculate MAE and MSE
# • Plot loss surface (weight vs loss)
```

```
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET
# =====
X = np.array([1.0, 2.0])
Y = np.array([0.5, 1.5])

# =====
# INITIALIZATION
# =====
w = np.random.rand() # random weight
b = np.random.rand() # random bias

# =====
# FORWARD PROPAGATION (LINEAR)
# =====
Y_pred = w * X + b

# =====
# LOSS CALCULATION
# =====
mae = np.mean(np.abs(Y - Y_pred))
mse = np.mean((Y - Y_pred) ** 2)

print("Weight:", w)
print("Bias:", b)
print("MAE:", mae)
print("MSE:", mse)

# =====
# LOSS SURFACE (WEIGHT vs LOSS)
# =====
weights = np.linspace(-2, 2, 50)
losses = []

for wi in weights:
    y_hat = wi * X + b
    loss = np.mean((Y - y_hat) ** 2)
    losses.append(loss)

plt.plot(weights, losses)
plt.xlabel("Weight")
```

```
plt.ylabel("Loss (MSE)")
plt.title("Loss Surface (Weight vs MSE)")
plt.show()
```

```
# Use CIFAR-10 Dataset
# • Train CNN with and without data augmentation
# • Augmentations: rotate, zoom, distort images
# • Compare validation accuracy and loss and plot using Graph
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.cifar10.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/train", image_size=(32,32), batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/test", image_size=(32,32), batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize
x_train = x_train / 255.0
x_test = x_test / 255.0

# =====
# CNN MODEL
# =====
def build_model():
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu',
                                input_shape=(32,32,3)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(64, 3, activation='relu'),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer='adam',
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# MODEL WITHOUT AUGMENTATION
# =====
model_no_aug = build_model()
hist_no_aug = model_no_aug.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    batch_size=32,
    verbose=0
)

# =====
# DATA AUGMENTATION
# =====
datagen = tf.keras.preprocessing.image.ImageDataGenerator(
    rotation_range=20,
    zoom_range=0.2,
    shear_range=0.2 # distortion
)

# =====
# MODEL WITH AUGMENTATION
# =====
model_aug = build_model()
hist_aug = model_aug.fit(
```

```

    datagen.flow(x_train, y_train, batch_size=32),
    validation_data=(x_test, y_test),
    epochs=5,
    verbose=0
)

# =====
# PLOTS: ACCURACY
# =====
plt.plot(hist_no_aug.history['val_accuracy'], label="No Aug - Val Acc")
plt.plot(hist_aug.history['val_accuracy'], label="Aug - Val Acc")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Validation Accuracy Comparison (CIFAR-10)")
plt.legend()
plt.show()

# =====
# PLOTS: LOSS
# =====
plt.plot(hist_no_aug.history['val_loss'], label="No Aug - Val Loss")
plt.plot(hist_aug.history['val_loss'], label="Aug - Val Loss")
plt.xlabel("Epoch")
plt.ylabel("Validation Loss")
plt.title("Validation Loss Comparison (CIFAR-10)")
plt.legend()
plt.show()

```

```

# Implement XOR gate using 2-layer Neural Network
# • Use Adadelata optimizer
# • Plot accuracy vs epoch

```

```

import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt

# =====
# XOR DATASET
# =====
X = np.array([[0,0],
              [0,1],
              [1,0],
              [1,1]], dtype=float)

y = np.array([0,1,1,0], dtype=float)

# =====
# 2-LAYER NEURAL NETWORK
# =====
model = tf.keras.Sequential([
    tf.keras.layers.Dense(4, activation='relu', input_shape=(2,)), # Hidden layer
    tf.keras.layers.Dense(1, activation='sigmoid')                  # Output layer
])

model.compile(
    optimizer=tf.keras.optimizers.Adadelata(),
    loss='binary_crossentropy',
    metrics=['accuracy']
)

# =====
# TRAIN MODEL
# =====
history = model.fit(
    X, y,
    epochs=100,
    verbose=0
)

# =====
# PLOT ACCURACY vs EPOCH
# =====
plt.plot(history.history['accuracy'])
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Epoch (XOR using Adadelata)")
plt.show()

```

```
# Fashion-MNIST Classification
# • CNN with RMSProp & Adam
# • Compare confusion matrices
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
import seaborn as sns

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.fashion_mnist.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize & reshape
x_train = x_train/255.0
x_test = x_test/255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu',
                                input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(64, 3, activation='relu'),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# TRAIN WITH RMSPROP
# =====
model_rms = build_model(tf.keras.optimizers.RMSprop())
model_rms.fit(x_train, y_train, epochs=5, batch_size=32, verbose=0)

# =====
# TRAIN WITH ADAM
# =====
model_adam = build_model(tf.keras.optimizers.Adam())
model_adam.fit(x_train, y_train, epochs=5, batch_size=32, verbose=0)

# =====
# CONFUSION MATRIX - RMSPROP
# =====
y_pred_rms = np.argmax(model_rms.predict(x_test), axis=1)
cm_rms = confusion_matrix(y_test, y_pred_rms)

sns.heatmap(cm_rms, cmap="Blues")
plt.title("Confusion Matrix - RMSProp")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()

# =====
# CONFUSION MATRIX - ADAM
# =====
```

```

y_pred_adam = np.argmax(model_adam.predict(x_test), axis=1)
cm_adam = confusion_matrix(y_test, y_pred_adam)

sns.heatmap(cm_adam, cmap="Greens")
plt.title("Confusion Matrix - Adam")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()

```

```

# Implement the backpropagation algorithm.
# 1.   Take Iris Dataset
# 2.   Initialize a neural network with random weights.
# 3.   Calculate error
# 4.   Perform multiple iterations of NN
# 5.   Update weights accordingly.
# 6.   Plot accuracy for iterations and note the results.

```

```

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED .csv)
data = pd.read_csv("Iris.csv")

X = data.iloc[:, :-1].values
y = (data.iloc[:, -1] == data.iloc[:, -1].unique()[0]).astype(int).values.reshape(-1,1)

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# y = (iris.target == 0).astype(int).reshape(-1,1)

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# NN INITIALIZATION
# =====
np.random.seed(1)
W1 = np.random.rand(X.shape[1], 3) # input → hidden
b1 = np.random.rand(1,3)
W2 = np.random.rand(3,1)           # hidden → output
b2 = np.random.rand(1,1)

lr = 0.1
epochs = 50
acc_list = []

# Activation
def sigmoid(x):
    return 1 / (1 + np.exp(-x))

def sigmoid_deriv(x):
    return x * (1 - x)

# =====
# BACKPROPAGATION TRAINING
# =====
for _ in range(epochs):

    # Forward pass
    h_in = np.dot(X, W1) + b1
    h_out = sigmoid(h_in)

    o_in = np.dot(h_out, W2) + b2
    y_pred = sigmoid(o_in)

    # Error
    error = y - y_pred

    # Backpropagation
    d_out = error * sigmoid_deriv(y_pred)
    dW2 = np.dot(h_out.T, d_out)

```

```

db2 = np.sum(d_out, axis=0, keepdims=True)

d_hidden = np.dot(d_out, W2.T) * sigmoid_deriv(h_out)
dW1 = np.dot(X.T, d_hidden)
db1 = np.sum(d_hidden, axis=0, keepdims=True)

# Update weights
W2 += lr * dW2
b2 += lr * db2
W1 += lr * dW1
b1 += lr * db1

# Accuracy
y_class = (y_pred >= 0.5).astype(int)
acc = np.mean(y_class == y)
acc_list.append(acc)

print("Final Accuracy:", acc_list[-1])
plt.plot(acc_list)
plt.xlabel("Iteration")
plt.ylabel("Accuracy")
plt.title("Accuracy vs Iterations (Backpropagation)")
plt.show()

```

```

# Build a multiclass image categorization of CNN network which correctly classifies different categories of image
# 1. Take Flower dataset
# 2. Split original dataset to train and test set
# 3. Build CNN Model
# 4. Generate the accuracy of the built model using any optimizer.
# 5. Compare performance of different optimizers on Flower categorization.

```

```

import tensorflow as tf
import tensorflow_datasets as tfds
import matplotlib.pyplot as plt

IMG_SIZE = (224,224)
BATCH = 32

# =====
# DATASET LOADING
# =====

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED)
# Folder structure:
# flowers/
#   daisy/
#   dandelion/
#   roses/
#   sunflowers/
#   tulips/

train_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "flowers",
    image_size=IMG_SIZE,
    batch_size=BATCH,
    validation_split=0.2,
    subset="training",
    seed=123
)

test_ds = tf.keras.preprocessing.image_dataset_from_directory(
    "flowers",
    image_size=IMG_SIZE,
    batch_size=BATCH,
    validation_split=0.2,
    subset="validation",
    seed=123
)

num_classes = len(train_ds.class_names)

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# train_ds = tfds.load("tf_flowers", split="train[:80%]", as_supervised=True)
# test_ds = tfds.load("tf_flowers", split="train[80%:]", as_supervised=True)

# Normalize
train_ds = train_ds.map(lambda x,y: (x/255.0, y))
test_ds = test_ds.map(lambda x,y: (x/255.0, y))

```

```
# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu',
                                input_shape=(224,224,3)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(64, 3, activation='relu'),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(num_classes, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# OPTIMIZERS
# =====
optimizers = {
    "Adam": tf.keras.optimizers.Adam(),
    "SGD": tf.keras.optimizers.SGD(),
    "RMSprop": tf.keras.optimizers.RMSprop()
}

histories = {}

# =====
# TRAIN MODELS
# =====
for name, opt in optimizers.items():
    model = build_model(opt)
    histories[name] = model.fit(
        train_ds,
        validation_data=test_ds,
        epochs=5,
        verbose=0
    )

# =====
# ACCURACY COMPARISON
# =====
for name, hist in histories.items():
    plt.plot(hist.history['val_accuracy'], label=name)

plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Optimizer Comparison on Flower Dataset")
plt.legend()
plt.show()
```

```
# Train a small neural network (dataset – Cifar- 100 Classification)
# Compare the optimizers:
# • Adagrad
# • SGD
# • Adam
# Plot:
# • Training loss vs epochs
# • Accuracy vs epochs
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET LOADING
# =====

# OPTION ❶ LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.cifar100.load_data()

# OPTION ❷ LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar100/train", image_size=(32,32), batch_size=32)
```

```

# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar100/test", image_size=(32,32), batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize
x_train = x_train / 255.0
x_test = x_test / 255.0

# =====
# SMALL CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(32, 3, activation='relu',
                                input_shape=(32,32,3)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(100, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# OPTIMIZERS
# =====
optimizers = {
    "Adagrad": tf.keras.optimizers.Adagrad(),
    "SGD": tf.keras.optimizers.SGD(),
    "Adam": tf.keras.optimizers.Adam()
}

histories = {}

# =====
# TRAIN MODELS (SAME EPOCHS)
# =====
for name, opt in optimizers.items():
    model = build_model(opt)
    histories[name] = model.fit(
        x_train, y_train,
        validation_split=0.2,
        epochs=5,
        batch_size=32,
        verbose=0
    )

# =====
# PLOT: TRAINING LOSS vs EPOCHS
# =====
for name, hist in histories.items():
    plt.plot(hist.history['loss'], label=name)

plt.xlabel("Epoch")
plt.ylabel("Training Loss")
plt.title("Training Loss vs Epochs (CIFAR-100)")
plt.legend()
plt.show()

# =====
# PLOT: ACCURACY vs EPOCHS
# =====
for name, hist in histories.items():
    plt.plot(hist.history['val_accuracy'], label=name)

plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Accuracy vs Epochs (CIFAR-100)")
plt.legend()
plt.show()

```

- # • Use IRIS Dataset
- # • Train a model with and without data augmentation (horizontal flip, rotation, noise).
- # • Compare generalization performance on the validation set. (Accuracy & Error)
- # • Plot accuracy vs epochs

• Plot loss vs epochs

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
import tensorflow as tf

# =====
# DATASET LOADING
# =====

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED)
data = pd.read_csv("Iris.csv")

X = data.iloc[:, :-1].values
y = data.iloc[:, -1].astype('category').cat.codes.values

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# y = iris.target

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# DATA AUGMENTATION (TABULAR)
# =====
def augment_data(X):
    noise = X + 0.05 * np.random.normal(size=X.shape) # noise
    shuffled = np.roll(X, shift=1, axis=1) # feature shift
    return np.vstack([X, noise, shuffled])

X_aug = augment_data(X)
y_aug = np.hstack([y, y, y])

# =====
# MODEL
# =====
def build_model():
    model = tf.keras.Sequential([
        tf.keras.layers.Dense(16, activation='relu', input_shape=(4,)),
        tf.keras.layers.Dense(3, activation='softmax')
    ])
    model.compile(
        optimizer='adam',
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# TRAIN WITHOUT AUGMENTATION
# =====
model_no_aug = build_model()
hist_no_aug = model_no_aug.fit(
    X, y,
    validation_split=0.2,
    epochs=50,
    verbose=0
)

# =====
# TRAIN WITH AUGMENTATION
# =====
model_aug = build_model()
hist_aug = model_aug.fit(
    X_aug, y_aug,
    validation_split=0.2,
    epochs=50,
    verbose=0
)

# =====
# PLOT ACCURACY
# =====
plt.plot(hist_no_aug.history['val_accuracy'], label="No Aug")
plt.plot(hist_aug.history['val_accuracy'], label="With Aug")
plt.xlabel("Epoch")
```

```
plt.ylabel("Validation Accuracy")
plt.title("Accuracy vs Epochs (Iris)")
plt.legend()
plt.show()

# =====
# PLOT LOSS
# =====
plt.plot(hist_no_aug.history['val_loss'], label="No Aug")
plt.plot(hist_aug.history['val_loss'], label="With Aug")
plt.xlabel("Epoch")
plt.ylabel("Validation Loss")
plt.title("Loss vs Epochs (Iris)")
plt.legend()
plt.show()
```

```
# Build a small CNN for MNIST digits dataset
# • Split dataset into train/test
# • Use 2 convolution layers + pooling + dense
# • Metrics / Plots: Accuracy, Confusion Matrix, Precision & Recall, plot training vs validation accuracy and lo
# Task 2: Compare Adam vs SGD optimizer
# • Metrics / Plots: Plot training loss & accuracy for each optimizer
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, precision_score, recall_score
import seaborn as sns

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize & reshape
x_train = x_train/255.0
x_test = x_test/255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(16, 3, activation='relu', input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Conv2D(32, 3, activation='relu'),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# TRAIN WITH ADAM
# =====
model_adam = build_model(tf.keras.optimizers.Adam())
hist_adam = model_adam.fit(
    x_train, y_train,
    validation_split=0.2,
```

```

        epochs=5,
        batch_size=32,
        verbose=0
    )

# =====
# TRAIN WITH SGD
# =====
model_sgd = build_model(tf.keras.optimizers.SGD())
hist_sgd = model_sgd.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    batch_size=32,
    verbose=0
)

# =====
# PLOTS: TRAIN vs VAL ACCURACY
# =====
plt.plot(hist_adam.history['accuracy'], label="Adam Train")
plt.plot(hist_adam.history['val_accuracy'], label="Adam Val")
plt.plot(hist_sgd.history['accuracy'], label="SGD Train")
plt.plot(hist_sgd.history['val_accuracy'], label="SGD Val")
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.title("Training vs Validation Accuracy")
plt.legend()
plt.show()

# =====
# PLOTS: TRAIN vs VAL LOSS
# =====
plt.plot(hist_adam.history['loss'], label="Adam Train")
plt.plot(hist_adam.history['val_loss'], label="Adam Val")
plt.plot(hist_sgd.history['loss'], label="SGD Train")
plt.plot(hist_sgd.history['val_loss'], label="SGD Val")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.title("Training vs Validation Loss")
plt.legend()
plt.show()

# =====
# EVALUATION - ADAM
# =====
y_pred_adam = np.argmax(model_adam.predict(x_test), axis=1)
cm_adam = confusion_matrix(y_test, y_pred_adam)
sns.heatmap(cm_adam, cmap="Blues")
plt.title("Confusion Matrix - Adam")
plt.show()

print("Adam Precision:", precision_score(y_test, y_pred_adam, average='macro'))
print("Adam Recall:", recall_score(y_test, y_pred_adam, average='macro'))

# =====
# EVALUATION - SGD
# =====
y_pred_sgd = np.argmax(model_sgd.predict(x_test), axis=1)
cm_sgd = confusion_matrix(y_test, y_pred_sgd)
sns.heatmap(cm_sgd, cmap="Greens")
plt.title("Confusion Matrix - SGD")
plt.show()

print("SGD Precision:", precision_score(y_test, y_pred_sgd, average='macro'))
print("SGD Recall:", recall_score(y_test, y_pred_sgd, average='macro'))

```

```

# • Calculate and plot all activation functions (Sigmoid and tanh) for input ranging in (-10, +10)
# • Calculate and plot Derivative of given Activation function and plot also observe the behaviour of curves.
# • Consider a target vector Y and prediction vector Ŷ. Calculate MSE and MAE.

```

```

import numpy as np
import matplotlib.pyplot as plt

# =====
# INPUT RANGE
# =====
x = np.linspace(-10, 10, 200)

```

```
# =====
# ACTIVATION FUNCTIONS
# =====
sigmoid = 1 / (1 + np.exp(-x))
tanh = np.tanh(x)

# =====
# DERIVATIVES
# =====
sigmoid_der = sigmoid * (1 - sigmoid)
tanh_der = 1 - tanh**2

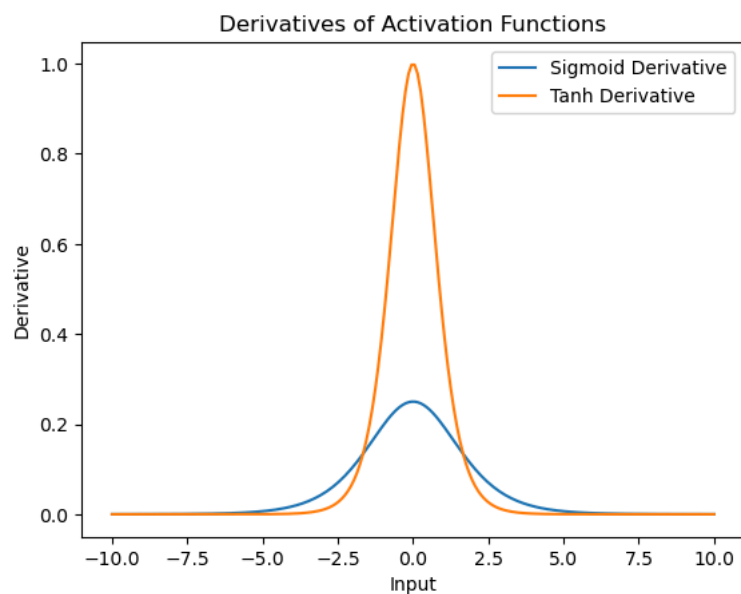
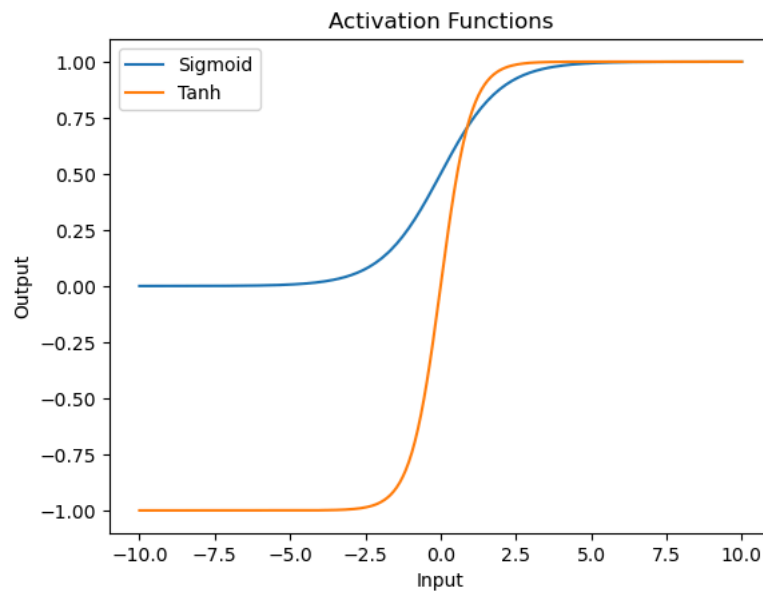
# =====
# PLOTS: ACTIVATION FUNCTIONS
# =====
plt.plot(x, sigmoid, label="Sigmoid")
plt.plot(x, tanh, label="Tanh")
plt.xlabel("Input")
plt.ylabel("Output")
plt.title("Activation Functions")
plt.legend()
plt.show()

# =====
# PLOTS: DERIVATIVES
# =====
plt.plot(x, sigmoid_der, label="Sigmoid Derivative")
plt.plot(x, tanh_der, label="Tanh Derivative")
plt.xlabel("Input")
plt.ylabel("Derivative")
plt.title("Derivatives of Activation Functions")
plt.legend()
plt.show()

# =====
# MSE & MAE CALCULATION
# =====
Y = np.array([1.0, 0.0, 1.0])
Y_hat = np.array([0.8, 0.2, 0.6])

mse = np.mean((Y - Y_hat)**2)
mae = np.mean(np.abs(Y - Y_hat))

print("MSE:", mse)
print("MAE:", mae)
```



MSE: 0.08
MAE: 0.26666666666666666

- # • Calculate and plot all activation functions (Tanh and Relu) for input ranging in (-5, +5)
- # • Calculate and plot Derivative of given Activation function and plot also observe the behaviour of curves.
- # • Consider a target vector Y and prediction vector \hat{Y} . Calculate MSE and MAE.

```
import numpy as np
import matplotlib.pyplot as plt

# =====
# INPUT RANGE
# =====
x = np.linspace(-5, 5, 200)

# =====
# ACTIVATION FUNCTIONS
# =====
tanh = np.tanh(x)
relu = np.maximum(0, x)

# =====
# DERIVATIVES
# =====
tanh_der = 1 - tanh**2
relu_der = np.where(x > 0, 1, 0)

# =====
# PLOTS: ACTIVATION FUNCTIONS
# =====
plt.plot(x, tanh, label="Tanh")
plt.plot(x, relu, label="ReLU")
```

```

plt.xlabel("Input")
plt.ylabel("Output")
plt.title("Activation Functions (Tanh & ReLU)")
plt.legend()
plt.show()

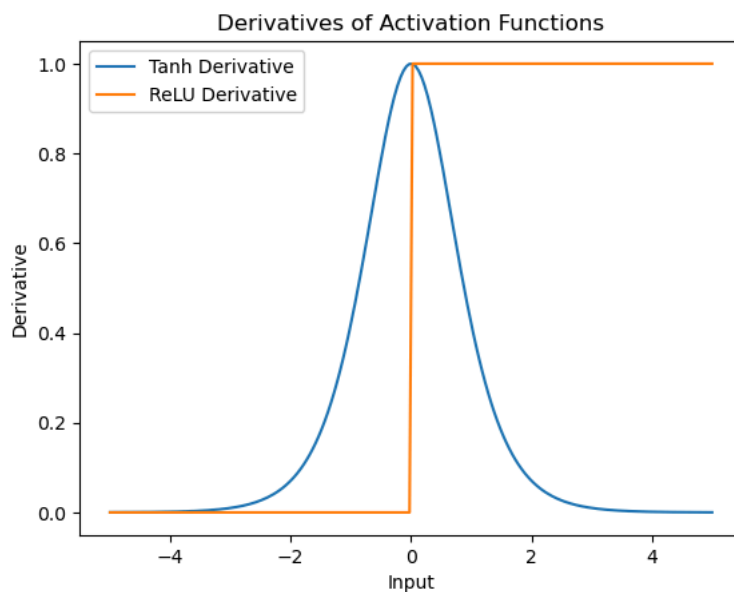
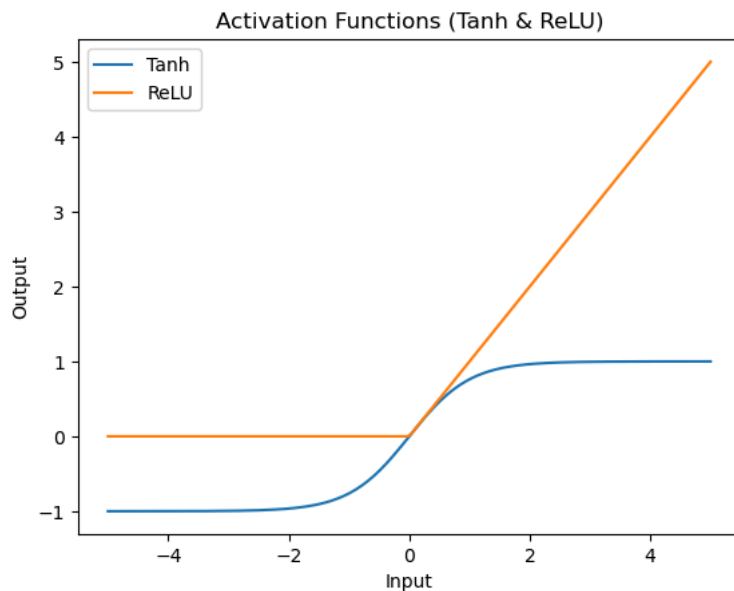
# =====
# PLOTS: DERIVATIVES
# =====
plt.plot(x, tanh_der, label="Tanh Derivative")
plt.plot(x, relu_der, label="ReLU Derivative")
plt.xlabel("Input")
plt.ylabel("Derivative")
plt.title("Derivatives of Activation Functions")
plt.legend()
plt.show()

# =====
# MSE & MAE CALCULATION
# =====
Y = np.array([1.0, 0.0, 1.0])
Y_hat = np.array([0.7, 0.3, 0.6])

mse = np.mean((Y - Y_hat)**2)
mae = np.mean(np.abs(Y - Y_hat))

print("MSE:", mse)
print("MAE:", mae)

```



MSE: 0.11333333333333336
MAE: 0.3333333333333333

- # 1. Calculate and plot all activation functions (Sigmoid, Relu and softmax) for input ranging in (-10 to +10)
- # 2. Calculate and plot Derivative of given Activation function and plot also observe the behaviour of curves
- # 3. Consider a target vector Y and prediction vector \hat{Y} . Calculate MSE and MAE.

```
import numpy as np
import matplotlib.pyplot as plt

# =====
# INPUT RANGE
# =====
x = np.linspace(-10, 10, 200)

# =====
# ACTIVATION FUNCTIONS
# =====
sigmoid = 1 / (1 + np.exp(-x))
relu = np.maximum(0, x)

# Softmax (1D demonstration)
exp_x = np.exp(x)
softmax = exp_x / np.sum(exp_x)

# =====
# DERIVATIVES (EXAM-SAFE)
# =====
sigmoid_der = sigmoid * (1 - sigmoid)
relu_der = np.where(x > 0, 1, 0)
softmax_der = softmax * (1 - softmax) # simplified (diagonal term)

# =====
# PLOT: ACTIVATION FUNCTIONS
# =====
plt.plot(x, sigmoid, label="Sigmoid")
plt.plot(x, relu, label="ReLU")
plt.plot(x, softmax, label="Softmax")
plt.xlabel("Input")
plt.ylabel("Output")
plt.title("Activation Functions")
plt.legend()
plt.show()

# =====
# PLOT: DERIVATIVES
# =====
plt.plot(x, sigmoid_der, label="Sigmoid Derivative")
plt.plot(x, relu_der, label="ReLU Derivative")
plt.plot(x, softmax_der, label="Softmax Derivative")
plt.xlabel("Input")
plt.ylabel("Derivative")
plt.title("Derivatives of Activation Functions")
plt.legend()
plt.show()

# =====
# MSE & MAE CALCULATION
# =====
Y = np.array([1.0, 0.0, 1.0])
Y_hat = np.array([0.8, 0.3, 0.6])

mse = np.mean((Y - Y_hat) ** 2)
mae = np.mean(np.abs(Y - Y_hat))

print("MSE:", mse)
print("MAE:", mae)
```

- # Implement the AND Boolean logic gate using perceptron Neural Network.
- # Inputs = x_1 , x_2 and bias, weights should be fed into the perceptron with single Output = y .
- # Display final weights and bias of each perceptron.

```
# Inputs
inputs = [
    (0, 0),
    (0, 1),
    (1, 0),
    (1, 1)
]

# Weights and bias (predefined for AND gate)
```

```

w1 = 1
w2 = 1
b = -1.5

def perceptron(x1, x2):
    z = w1 * x1 + w2 * x2 + b
    return 1 if z >= 0 else 0

# Test AND gate
for x1, x2 in inputs:
    print(f"{x1} AND {x2} = {perceptron(x1, x2)}")

print("\nFinal Weights and Bias:")
print("w1 =", w1)
print("w2 =", w2)
print("bias =", b)

```

```

# 1. Use the titanic Dataset
# 2. Create an Auto Encoder and fit it with our data using 3 neurons in the dense layer
# 3. Display new reduced dimension values
# 4. Plot loss for different encoders [ Sparse Autoencoder, Noise Autoencoder]

```

```

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
import tensorflow as tf
from tensorflow.keras.layers import Input, Dense, GaussianNoise
from tensorflow.keras.models import Model
from tensorflow.keras import regularizers

# =====
# DATASET LOADING
# =====

# OPTION 2 LOAD FROM LOCAL PC (RECOMMENDED)
data = pd.read_csv("titanic.csv")

X = data[['Age', 'Fare']].fillna(0).values # simple numeric features

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# data = pd.read_csv(
#     "https://raw.githubusercontent.com/datasciencedojo/datasets/master/titanic.csv")
# X = data[['Age', 'Fare']].fillna(0).values

# Normalize
X = MinMaxScaler().fit_transform(X)

# =====
# SPARSE AUTOENCODER (3 NEURONS)
# =====
input_layer = Input(shape=(X.shape[1],))
encoded_sparse = Dense(
    3, activation='relu',
    activity_regularizer=regularizers.l1(1e-3)
)(input_layer)
decoded_sparse = Dense(X.shape[1], activation='sigmoid')(encoded_sparse)

sparse_autoencoder = Model(input_layer, decoded_sparse)
sparse_autoencoder.compile(optimizer='adam', loss='mse')

hist_sparse = sparse_autoencoder.fit(
    X, X, epochs=50, batch_size=16, verbose=0
)

# =====
# DENOISING AUTOENCODER (3 NEURONS)
# =====
noisy_input = GaussianNoise(0.1)(input_layer)
encoded_noise = Dense(3, activation='relu')(noisy_input)
decoded_noise = Dense(X.shape[1], activation='sigmoid')(encoded_noise)

noise_autoencoder = Model(input_layer, decoded_noise)
noise_autoencoder.compile(optimizer='adam', loss='mse')

hist_noise = noise_autoencoder.fit(
    X, X, epochs=50, batch_size=16, verbose=0
)

# =====

```

```
# REDUCED DIMENSION VALUES
# =====
encoder_model = Model(input_layer, encoded_sparse)
encoded_values = encoder_model.predict(X)

print("Reduced Dimension Values (first 5 rows):")
print(encoded_values[:5])

# =====
# PLOT LOSS COMPARISON
# =====
plt.plot(hist_sparse.history['loss'], label="Sparse Autoencoder")
plt.plot(hist_noise.history['loss'], label="Denoising Autoencoder")
plt.xlabel("Epoch")
plt.ylabel("Loss (MSE)")
plt.title("Loss vs Epochs (Autoencoders)")
plt.legend()
plt.show()
```

```
# Use dataset – MNIST digit classification
# Create a neural network and apply following optimizers
# • SGD
# • SGD + Momentum
# • Adam
# Plot the comparison using ROC curve
```

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, auc
from sklearn.preprocessing import label_binarize

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "fashion_mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# Normalize & reshape
x_train = x_train/255.0
x_test = x_test/255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# Binarize labels for ROC (10 classes)
y_test_bin = label_binarize(y_test, classes=np.arange(10))

# =====
# MODEL
# =====
def build_model(optimizer):
    model = tf.keras.Sequential([
        tf.keras.layers.Flatten(input_shape=(28,28,1)),
        tf.keras.layers.Dense(128, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer=optimizer,
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

optimizers = {
    "SGD": tf.keras.optimizers.SGD(),
    "SGD+Momentum": tf.keras.optimizers.SGD(momentum=0.9),
    "Adam": tf.keras.optimizers.Adam()
}
```

```
plt.figure(figsize=(7,6))

# =====
# TRAIN + ROC
# =====
for name, opt in optimizers.items():
    model = build_model(opt)
    model.fit(x_train, y_train, epochs=5, batch_size=32, verbose=0)

    y_score = model.predict(x_test)
    fpr, tpr, _ = roc_curve(y_test_bin.ravel(), y_score.ravel())
    roc_auc = auc(fpr, tpr)

    plt.plot(fpr, tpr, label=f"{name} (AUC={roc_auc:.2f})")

# =====
# ROC PLOT
# =====
plt.plot([0,1], [0,1], 'k--')
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ROC Curve Comparison - MNIST Optimizers")
plt.legend()
plt.show()
```

- # 1. Use MNIST or IRIS/ Cifar-10 Dataset
- # 2. Train a model with and without data augmentation (horizontal flip, rotation, noise).
- # 3. Compare generalization performance on the validation set. (Accuracy & Error)
- # 4. Observe improvements and plot the graph

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()

# OPTION 2 LOAD FROM LOCAL FOLDER (COMMENTED)
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/train", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "mnist/test", image_size=(28,28),
#     color_mode="grayscale", batch_size=32)
# x_train, y_train = np.concatenate([x for x,y in train_ds]), np.concatenate([y for x,y in train_ds])
# x_test, y_test = np.concatenate([x for x,y in test_ds]), np.concatenate([y for x,y in test_ds])

# iris
# data = pd.read_csv("Iris.csv")

# X = data.iloc[:, :-1].values
# y = data.iloc[:, -1].astype('category').cat.codes.values

# OPTION 1 LOAD FROM LIBRARY (COMMENTED)
# from sklearn.datasets import load_iris
# iris = load_iris()
# X = iris.data
# y = iris.target

# cifar-10
# train_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/train",
#     image_size=(32,32),
#     batch_size=32
# )

# test_ds = tf.keras.preprocessing.image_dataset_from_directory(
#     "cifar10/test",
#     image_size=(32,32),
#     batch_size=32
```

```

# )
# x_train = np.concatenate([x.numpy() for x, y in train_ds])
# y_train = np.concatenate([y.numpy() for x, y in train_ds])

# x_test = np.concatenate([x.numpy() for x, y in test_ds])
# y_test = np.concatenate([y.numpy() for x, y in test_ds])

# Normalize & reshape
x_train = x_train / 255.0
x_test = x_test / 255.0
x_train = x_train[..., np.newaxis]
x_test = x_test[..., np.newaxis]

# =====
# CNN MODEL
# =====
def build_model():
    model = tf.keras.Sequential([
        tf.keras.layers.Conv2D(16, 3, activation='relu', input_shape=(28,28,1)),
        tf.keras.layers.MaxPooling2D(),
        tf.keras.layers.Flatten(),
        tf.keras.layers.Dense(64, activation='relu'),
        tf.keras.layers.Dense(10, activation='softmax')
    ])
    model.compile(
        optimizer='adam',
        loss='sparse_categorical_crossentropy',
        metrics=['accuracy']
    )
    return model

# =====
# WITHOUT AUGMENTATION
# =====
model_no_aug = build_model()
hist_no_aug = model_no_aug.fit(
    x_train, y_train,
    validation_split=0.2,
    epochs=5,
    batch_size=32,
    verbose=0
)

# =====
# DATA AUGMENTATION
# =====
datagen = tf.keras.preprocessing.image.ImageDataGenerator(
    rotation_range=20,
    horizontal_flip=True
)

# Add noise manually
x_train_noise = x_train + 0.05 * np.random.normal(size=x_train.shape)

# =====
# WITH AUGMENTATION
# =====
model_aug = build_model()
hist_aug = model_aug.fit(
    datagen.flow(x_train_noise, y_train, batch_size=32),
    validation_data=(x_test, y_test),
    epochs=5,
    verbose=0
)

# =====
# PLOT ACCURACY
# =====
plt.plot(hist_no_aug.history['val_accuracy'], label="No Aug")
plt.plot(hist_aug.history['val_accuracy'], label="With Aug")
plt.xlabel("Epoch")
plt.ylabel("Validation Accuracy")
plt.title("Validation Accuracy Comparison")
plt.legend()
plt.show()

# =====
# PLOT LOSS (ERROR)
# =====
plt.plot(hist_no_aug.history['val_loss'], label="No Aug")

```

```
plt.plot(hist_aug.history['val_loss'], label="With Aug")
plt.xlabel("Epoch")
plt.ylabel("Validation Loss")
plt.title("Validation Loss Comparison")
plt.legend()
plt.show()
```

```
# • Load California Housing dataset, select 2 features (e.g., Median Income, House Age) and 1 target (Median Hou
# • Normalize inputs and initialize a single-layer neural network with random weights and bias.
# • Perform forward propagation and calculate prediction error, Squared Error, and MSE.
# • Update weights and bias using gradient descent.
# • Visualize or analyze how loss changes with weight and bias and observe the error surface.
```

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import fetch_california_housing
from sklearn.preprocessing import MinMaxScaler

# =====
# DATASET LOADING
# =====

# OPTION 1 LOAD FROM LIBRARY (USE THIS)
data = fetch_california_housing()
X = data.data[:, [0, 1]]      # MedInc, HouseAge
y = data.target.reshape(-1,1) # Median House Value

# OPTION 2 LOAD FROM LOCAL PC (COMMENTED)
# import pandas as pd
# df = pd.read_csv("california_housing.csv")
# X = df[['MedInc', 'HouseAge']].values
# y = df[['MedHouseVal']].values

# Normalize
X = MinMaxScaler().fit_transform(X)
y = MinMaxScaler().fit_transform(y)

# =====
# NN INITIALIZATION
# =====
np.random.seed(1)
w = np.random.rand(2,1)
b = np.random.rand()
lr = 0.1
epochs = 20

mse_list = []

# =====
# GRADIENT DESCENT
# =====
for _ in range(epochs):

    # Forward propagation
    y_pred = np.dot(X, w) + b

    # Error, SE, MSE
    error = y - y_pred
    se = error ** 2
    mse = np.mean(se)
    mse_list.append(mse)

    # Gradients
    dw = -2 * np.mean(X * error, axis=0).reshape(2,1)
    db = -2 * np.mean(error)

    # Update
    w = w - lr * dw
    b = b - lr * db

print("Final Weights:", w.flatten())
print("Final Bias:", b)
print("Final MSE:", mse_list[-1])

# =====
# LOSS SURFACE (WEIGHT vs BIAS)
# =====
W, B = np.meshgrid(np.linspace(0,1,30), np.linspace(0,1,30))
Z = []
```