EXPERIMENT 6 : Building and Implementing Neural Networks:

Feedforward and Convolutional Neural Networks

AIM:

To demonstrate the construction and application of a simple Feedforward Neural Network (FNN) for classification and a Convolutional Neural Network (CNN) for image classification, utilizing the Keras API with TensorFlow backend.

SOURCE CODE:

```
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.datasets import mnist, fashion_mnist
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import classification_report, confusion_matrix
import seaborn as sns
tf.keras.utils.disable_interactive_logging()
print("--- Part 1: Building a Simple Feedforward Neural Network ---")
(x_train_fnn, y_train_fnn), (x_test_fnn, y_test_fnn) = fashion_mnist.load_data()
print(f"\nOriginal FNN training data shape: {x_train_fnn.shape}")
print(f"Original FNN test data shape: {x_test_fnn.shape}")
x_train_fnn_flat = x_train_fnn.reshape(-1, 28 * 28)
x_test_fnn_flat = x_test_fnn.reshape(-1, 28 * 28)
x_train_fnn_norm = x_train_fnn_flat / 255.0
x_test_fnn_norm = x_test_fnn_flat / 255.0
print(f"Flattened and Normalized FNN training data shape: {x_train_fnn_norm.shape}")
print(f"Flattened and Normalized FNN test data shape: {x_test_fnn_norm.shape}")
model_fnn = keras.Sequential([
layers.Dense(128, activation='relu', input_shape=(784,)),
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layers.Dropout(0.2),
layers.Dense(64, activation='relu'),
layers.Dense(10, activation='softmax')
])
model_fnn.compile(optimizer='adam',
loss='sparse_categorical_crossentropy',
metrics=['accuracy'])
print("\n--- FNN Model Summary ---")
model_fnn.summary()
print("\n--- Training FNN Model ---")
history_fnn = model_fnn.fit(x_train_fnn_norm, y_train_fnn, epochs=10,
validation_split=0.1,
verbose=1)
print("\n--- Evaluating FNN Model on Test Data ---")
loss_fnn, accuracy_fnn = model_fnn.evaluate(x_test_fnn_norm, y_test_fnn, verbose=0)
print(f"FNN Test Loss: {loss_fnn:.4f}")
print(f"FNN Test Accuracy: {accuracy_fnn:.4f}")
y_pred_fnn = np.argmax(model_fnn.predict(x_test_fnn_norm), axis=-1)
print("\n--- FNN Classification Report ---")
print(classification_report(y_test_fnn, y_pred_fnn))
print("\n--- FNN Confusion Matrix ---")
cm_fnn = confusion_matrix(y_test_fnn, y_pred_fnn)
plt.figure(figsize=(10, 8))
sns.heatmap(cm_fnn, annot=True, fmt="d", cmap="Blues", cbar=False)
plt.title("FNN Confusion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.sho
plt.figure(figsize=(12, 5))
plt.subplot(1, 2, 1)
plt.plot(history_fnn.history['accuracy'], label='Training Accuracy')
plt.plot(history_fnn.history['val_accuracy'], label='Validation Accuracy')
```

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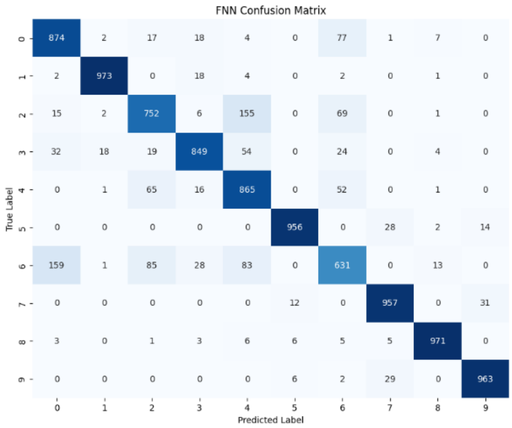
plt.title('FNN Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.grid(True)
plt.subplot(1, 2, 2)
plt.plot(history_fnn.history['loss'], label='Training Loss')
plt.plot(history_fnn.history['val_loss'], label='Validation Loss')
plt.title('FNN Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
print("\n--- Part 2: Implementing a Convolutional Neural Network (CNN) ---")
(x_train_cnn, y_train_cnn), (x_test_cnn, y_test_cnn) = mnist.load_data()
print(f"\nOriginal CNN training data shape: {x_train_cnn.shape}")
print(f"Original CNN test data shape: {x_test_cnn.shape}")
x_train_cnn = x_train_cnn.reshape(x_train_cnn.shape[0], 28, 28, 1)
x_test_cnn = x_test_cnn.reshape(x_test_cnn.shape[0], 28, 28, 1)
x_train_cnn = x_train_cnn.astype('float32') / 255.0
x_test_cnn = x_test_cnn.astype('float32') / 255.0
print(f"Reshaped and Normalized CNN training data shape: {x_train_cnn.shape}")
print(f"Reshaped and Normalized CNN test data shape: {x_test_cnn.shape}")
num_classes_cnn = 10
model_cnn = keras.Sequential([
layers.Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)),
layers.MaxPooling2D((2, 2)),
layers.Conv2D(64, (3, 3), activation='relu'),
layers.MaxPooling2D((2, 2)),
layers.Flatten(),
```

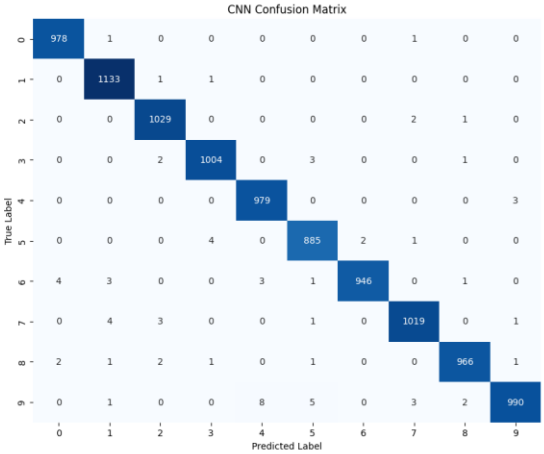
```
layers.Dense(128, activation='relu'),
layers.Dropout(0.5),
layers.Dense(num_classes_cnn, activation='softmax')
])
model_cnn.compile(optimizer='adam',
loss='sparse_categorical_crossentropy',
metrics=['accuracy'])
print("\n--- CNN Model Summary ---")
model_cnn.summary()
print("\n--- Training CNN Model ---")
history_cnn = model_cnn.fit(x_train_cnn, y_train_cnn, epochs=10,
validation_split=0.1,
verbose=1)
print("\n--- Evaluating CNN Model on Test Data ---")
loss_cnn, accuracy_cnn = model_cnn.evaluate(x_test_cnn, y_test_cnn, verbose=0)
print(f"CNN Test Loss: {loss_cnn:.4f}")
print(f"CNN Test Accuracy: {accuracy_cnn:.4f}")
y_pred_cnn = np.argmax(model_cnn.predict(x_test_cnn), axis=-1)
print("\n--- CNN Classification Report ---")
print(classification_report(y_test_cnn, y_pred_cnn))
print("\n--- CNN Confusion Matrix ---")
cm_cnn = confusion_matrix(y_test_cnn, y_pred_cnn)
plt.figure(figsize=(10, 8))
sns.heatmap(cm_cnn, annot=True, fmt="d", cmap="Blues", cbar=False)
plt.title("CNN Confusion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
plt.figure(figsize=(12, 5))
plt.subplot(1, 2, 1)
plt.plot(history_cnn.history['accuracy'], label='Training Accuracy')
plt.plot(history_cnn.history['val_accuracy'], label='Validation Accuracy')
```

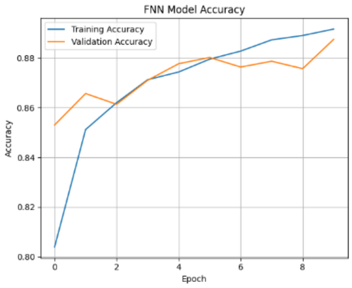
```
plt.title('CNN Model Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.legend()
plt.grid(True)
plt.subplot(1, 2, 2)
plt.plot(history_cnn.history['loss'], label='Training Loss')plt.plot(history_cnn.history['val_loss'],
label='Validation Loss')
plt.title('CNN Model Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
print("\n--- Sample CNN Predictions ---")
class_names_mnist = [str(i) for i in range(10)]

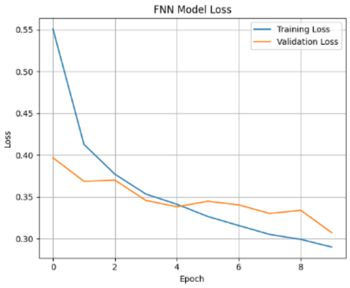
plt.figure(figsize=(10, 10))
for i in range(25):
  plt.subplot(5, 5, i + 1)
  plt.xticks([])
  plt.yticks([])
  plt.grid(False)
  plt.imshow(x_test_cnn[i].reshape(28, 28), cmap=plt.cm.binary)
  true_label = y_test_cnn[i]
  predicted_label = y_pred_cnn[i]
  color = 'green' if true_label == predicted_label else 'red'
  plt.xlabel(f"True: {class_names_mnist[true_label]}\nPred: {class_names_mnist[predicted_label]}",
  color=color)
plt.suptitle("Sample CNN Predictions (Green: Correct, Red: Incorrect)", y=1.02, fontsize=16)
plt.tight_layout(rect=[0, 0, 1, 0.98])
plt.show()
```

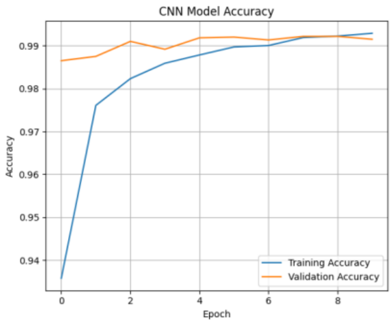
OUTPUT:

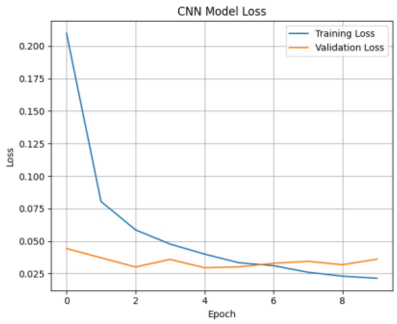

FNN Confusion Matrix
True Label
Predicted Label


CNN Confusion Matrix
True Label
Predicted Label


FNN Model Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch


FNN Model Loss
Training Loss
Validation Loss
Loss
Epoch


CNN Model Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch


CNN Model Loss
Training Loss
Validation Loss
Loss
Epoch


Sample CNN Predictions (Green: Correct, Red: Incorrect)