04part3_model_Experiments

February 19, 2024

[1]:
```
import os
```

[2]:
```
%pwd
```

[2]:
```
'D:\\Desktop\\Deep Learning\\Lab 4\\Main MNSIT-MLPClassifer\\Research'
```

[3]:
```
os.chdir("../")
```

[4]:
```
%pwd
```

[4]:
```
'D:\\Desktop\\Deep Learning\\Lab 4\\Main MNSIT-MLPClassifer'
```

[5]:
```
import warnings

# Disable all warnings
warnings.filterwarnings("ignore")
```

[6]:
```
import warnings

# Disable specific TensorFlow and Keras warnings
warnings.filterwarnings("ignore", message="From .*: The name tf.
 ↪get_default_graph is deprecated.")
warnings.filterwarnings("ignore", message="From .*: The name tf.train.Optimizer␣
 ↪is deprecated.")
warnings.filterwarnings("ignore", message="From .*: The name tf.ragged.
 ↪RaggedTensorValue is deprecated.")
warnings.filterwarnings("ignore", message="From .*: The name tf.
 ↪executing_eagerly_outside_functions is deprecated.")
```

[11]:
```
import logging
import os
import time
from dataclasses import dataclass
from pathlib import Path
import numpy as np
import pandas as pd
import tensorflow as tf
from tensorflow.keras.models import Sequential
```

```
from tensorflow.keras.layers import Dense, Conv2D, MaxPooling2D, Flatten
from tensorflow.keras.utils import to_categorical
from sklearn.preprocessing import LabelEncoder, StandardScaler
import matplotlib.pyplot as plt

# Configure logging
logging.basicConfig(level=logging.INFO, format='%(asctime)s - %(levelname)s -␣
 ↪%(message)s')

# Your existing ExperimentConfig and ConfigurationManager classes go here
@dataclass(frozen=True)
class ExperimentConfig:
    root_dir: Path
    X_train_file: Path
    y_train_file: Path
    X_test_file: Path
    y_test_file: Path
    experiment_results_dir: Path
    log_file: Path
    scaler_file: Path
    label_encoder_file: Path

class ConfigurationManager:
    def __init__(self):
        self.root_dir = Path(os.getcwd())
        self.X_train_file = self.root_dir / "dataset/Modeltraining/X_train.csv"
        self.y_train_file = self.root_dir / "dataset/Modeltraining/y_train.csv"
        self.X_test_file = self.root_dir / "dataset/Modeltraining/X_test.csv"
        self.y_test_file = self.root_dir / "dataset/Modeltraining/y_test.csv"
        self.experiment_results_dir = self.root_dir / "ModelExperiments"
        self.log_file = self.experiment_results_dir / "experiment_log.txt"

        # Update the paths below to ensure they point to valid directories
        self.scaler_file = self.experiment_results_dir / "scaler.pkl"  #␣
 ↪Adjusted path
        self.label_encoder_file = self.experiment_results_dir / "label_encoder.
 ↪pkl"  # Adjusted path

        # Ensure the directories exist
        os.makedirs(self.experiment_results_dir, exist_ok=True)

    def get_experiment_config(self) -> ExperimentConfig:
        return ExperimentConfig(
            root_dir=self.root_dir,
            X_train_file=self.X_train_file,
            y_train_file=self.y_train_file,
            X_test_file=self.X_test_file,
```

```
            y_test_file=self.y_test_file,
            experiment_results_dir=self.experiment_results_dir,
            log_file=self.log_file,
            scaler_file=self.scaler_file,
            label_encoder_file=self.label_encoder_file
        )


class ExperimentRunner:
    def __init__(self, config: ExperimentConfig):
        self.config = config
        if not self.config.experiment_results_dir.exists():
            self.config.experiment_results_dir.mkdir(parents=True)

    def run_experiments(self):
        with open(self.config.log_file, 'w', encoding='utf-8') as f:
            f.write("Starting experiments...\n")
            logging.info("Starting experiments...\n")
            X_train = pd.read_csv(self.config.X_train_file).values.reshape(-1,␣
 ↪28, 28, 1) / 255.0
            y_train = pd.read_csv(self.config.y_train_file).values
            X_test = pd.read_csv(self.config.X_test_file).values.reshape(-1,␣
 ↪28, 28, 1) / 255.0
            y_test = pd.read_csv(self.config.y_test_file).values

            f.write("Loaded data...\n")
            logging.info("Loaded data...\n")

            filter_counts = [(32, 64, 64), (64, 128, 128)]
            kernel_sizes = [(3, 3), (5, 5)]  # Adjusted to ensure compatibility
            activation_functions = ['relu', 'tanh']

            for filters in filter_counts:
                for kernel_size in kernel_sizes:
                    for activation in activation_functions:
                        self.run_experiment(filters, kernel_size, activation,␣
 ↪X_train, y_train, X_test, y_test, epochs=10, file=f)

            f.write("Experiments completed.\n")

    def run_experiment(self, filters, kernel_size, activation, X_train,␣
 ↪y_train, X_test, y_test, epochs, file):
        file.write(f"Running experiment with Filters: {filters}, Kernel Size:␣
 ↪{kernel_size}, Activation: {activation}, Epochs: {epochs}\n")
        logging.info(f"Running experiment with Filters: {filters}, Kernel Size:␣
 ↪{kernel_size}, Activation: {activation}, Epochs: {epochs}\n")
```

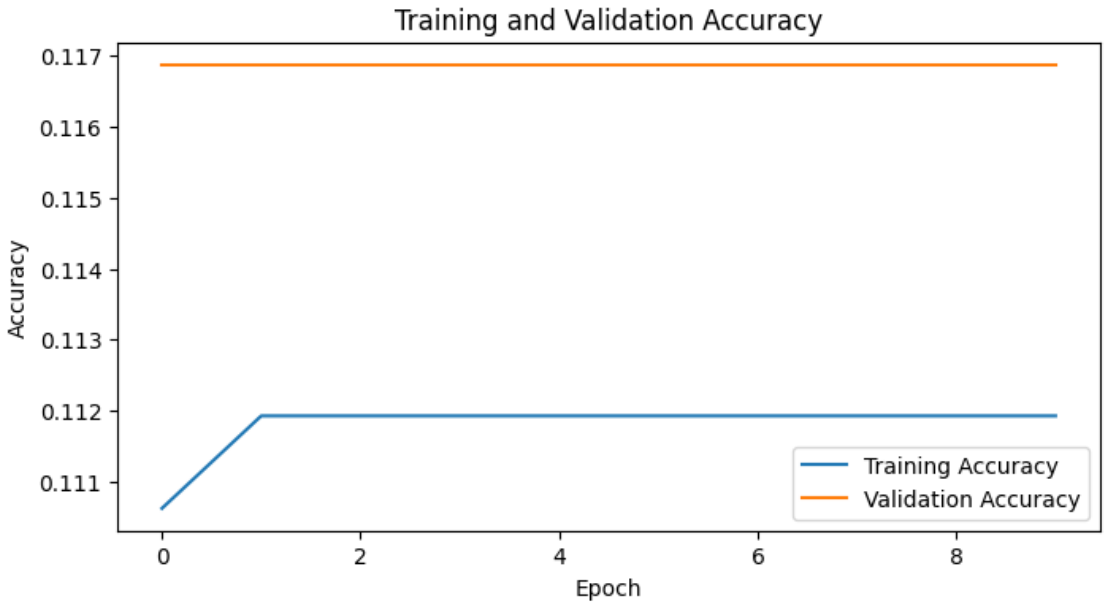
```
        model = Sequential()
        model.add(Conv2D(filters[0], kernel_size, activation=activation,␣
↪input_shape=(28, 28, 1), padding='same'))
        model.add(MaxPooling2D((2, 2)))
        for f in filters[1:]:
            model.add(Conv2D(f, kernel_size, activation=activation,␣
↪padding='same'))
            model.add(MaxPooling2D((2, 2)))
        model.add(Flatten())
        model.add(Dense(64, activation=activation))
        model.add(Dense(10, activation='softmax'))

        model.compile(optimizer='adam', loss='categorical_crossentropy',␣
↪metrics=['accuracy'])

        model.summary(print_fn=lambda x: file.write(x + '\n'))
        model.summary(print_fn=logging.info)

        start_time = time.time()
        history = model.fit(X_train, y_train, epochs=epochs, batch_size=64,␣
↪validation_split=0.2, verbose=1)
        training_time = time.time() - start_time

        # Plotting training/validation accuracy
        plt.figure(figsize=(8, 4))
        plt.plot(history.history['accuracy'], label='Training Accuracy')
        plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
        plt.xlabel('Epoch')
        plt.ylabel('Accuracy')
        plt.title('Training and Validation Accuracy')
        plt.legend()
        plt.show()

        # Evaluate the model
        test_loss, test_acc = model.evaluate(X_test, y_test, verbose=1)

        file.write(f"Filters: {filters}, Kernel Size: {kernel_size}, Activation:
↪ {activation}, Epochs: {epochs}, Test Accuracy: {test_acc}, Training Time:␣
↪{training_time}s\n")
        logging.info(f"Filters: {filters}, Kernel Size: {kernel_size},␣
↪Activation: {activation}, Epochs: {epochs}, Test Accuracy: {test_acc},␣
↪Training Time: {training_time}s\n")
```

```
        model_save_path = self.config.experiment_results_dir /␣
↪f"model_filters_{'_'.join(map(str,␣
↪filters))}_kernel_{kernel_size[0]}_activation_{activation}_epochs_{epochs}.
↪h5"
        model.save(model_save_path)
        file.write(f"Model saved to {model_save_path}\n")
        logging.info(f"Model saved to {model_save_path}\n")


# Your main function goes here
def main():
    try:
        logging.info("Starting the program...")
        config_manager = ConfigurationManager()
        experiment_config = config_manager.get_experiment_config()
        experiment_runner = ExperimentRunner(experiment_config)

        experiment_runner.run_experiments()
        logging.info("Program completed successfully.")
    except Exception as e:
        logging.error(f"Error occurred: {e}", exc_info=True)
        raise

if __name__ == "__main__":
    main()
```

```
2024-02-19 15:02:16,790 - INFO - Starting the program…
2024-02-19 15:02:16,792 - INFO - Starting experiments…

2024-02-19 15:02:21,017 - INFO - Loaded data…

2024-02-19 15:02:21,018 - INFO - Running experiment with Filters: (32, 64, 64),
Kernel Size: (3, 3), Activation: relu, Epochs: 10

2024-02-19 15:02:21,075 - INFO - Model: "sequential_5"
2024-02-19 15:02:21,076 - INFO -
_________________________________________________________________
2024-02-19 15:02:21,077 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:02:21,077 - INFO -
=================================================================
2024-02-19 15:02:21,078 - INFO -  conv2d_12 (Conv2D)          (None, 28, 28, 32)
320
2024-02-19 15:02:21,078 - INFO -
2024-02-19 15:02:21,078 - INFO -  max_pooling2d_11 (MaxPooli  (None, 14, 14, 32)
0
2024-02-19 15:02:21,078 - INFO -  ng2D)
2024-02-19 15:02:21,079 - INFO -
```

```
2024-02-19 15:02:21,079 - INFO -  conv2d_13 (Conv2D)          (None, 14, 14, 64)
18496
2024-02-19 15:02:21,079 - INFO -
2024-02-19 15:02:21,081 - INFO -  max_pooling2d_12 (MaxPooli  (None, 7, 7, 64)
0
2024-02-19 15:02:21,081 - INFO -  ng2D)
2024-02-19 15:02:21,081 - INFO -
2024-02-19 15:02:21,082 - INFO -  conv2d_14 (Conv2D)          (None, 7, 7, 64)
36928
2024-02-19 15:02:21,082 - INFO -
2024-02-19 15:02:21,083 - INFO -  max_pooling2d_13 (MaxPooli  (None, 3, 3, 64)
0
2024-02-19 15:02:21,083 - INFO -  ng2D)
2024-02-19 15:02:21,084 - INFO -
2024-02-19 15:02:21,084 - INFO -  flatten_3 (Flatten)         (None, 576)
0
2024-02-19 15:02:21,085 - INFO -
2024-02-19 15:02:21,085 - INFO -  dense_6 (Dense)             (None, 64)
36928
2024-02-19 15:02:21,086 - INFO -
2024-02-19 15:02:21,086 - INFO -  dense_7 (Dense)             (None, 10)
650
2024-02-19 15:02:21,087 - INFO -
2024-02-19 15:02:21,088 - INFO -
=================================================================
2024-02-19 15:02:21,088 - INFO - Total params: 93322 (364.54 KB)
2024-02-19 15:02:21,089 - INFO - Trainable params: 93322 (364.54 KB)
2024-02-19 15:02:21,090 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:02:21,090 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 7s 10ms/step - loss: 2.3017 -
accuracy: 0.1106 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 2/10
600/600 [==============================] - 6s 11ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3012 - val_accuracy: 0.1169
Epoch 3/10
600/600 [==============================] - 6s 10ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 4/10
600/600 [==============================] - 6s 10ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3010 - val_accuracy: 0.1169
Epoch 5/10
600/600 [==============================] - 6s 11ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3010 - val_accuracy: 0.1169
Epoch 6/10
600/600 [==============================] - 6s 10ms/step - loss: 2.3014 -
```

```
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 7/10
600/600 [==============================] - 6s 10ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3011 - val_accuracy: 0.1169
Epoch 8/10
600/600 [==============================] - 6s 11ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3012 - val_accuracy: 0.1169
Epoch 9/10
600/600 [==============================] - 7s 11ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3010 - val_accuracy: 0.1169
Epoch 10/10
600/600 [==============================] - 6s 10ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
```




```
375/375 [==============================] - 1s 3ms/step - loss: 2.3016 -
accuracy: 0.1102
```

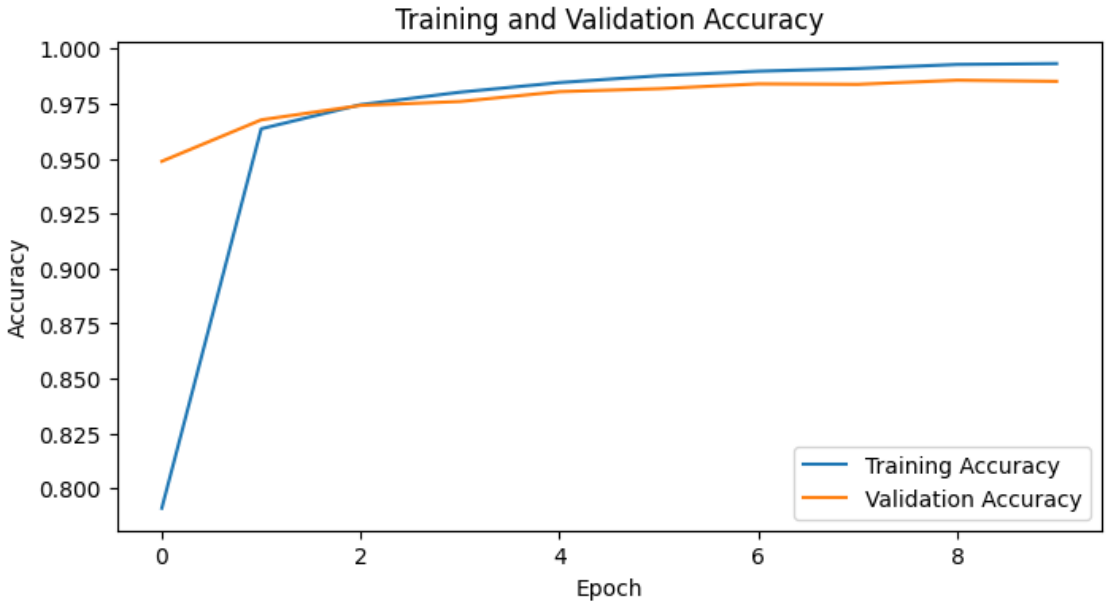
```
2024-02-19 15:03:25,434 - INFO - Filters: (32, 64, 64), Kernel Size: (3, 3),
Activation: relu, Epochs: 10, Test Accuracy: 0.11016666889190674, Training Time:
62.91858911514282s
```

```
2024-02-19 15:03:25,508 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_32_64_64_kernel_3_activ
ation_relu_epochs_10.h5
```

```
2024-02-19 15:03:25,509 - INFO - Running experiment with Filters: (32, 64, 64),
Kernel Size: (3, 3), Activation: tanh, Epochs: 10
```

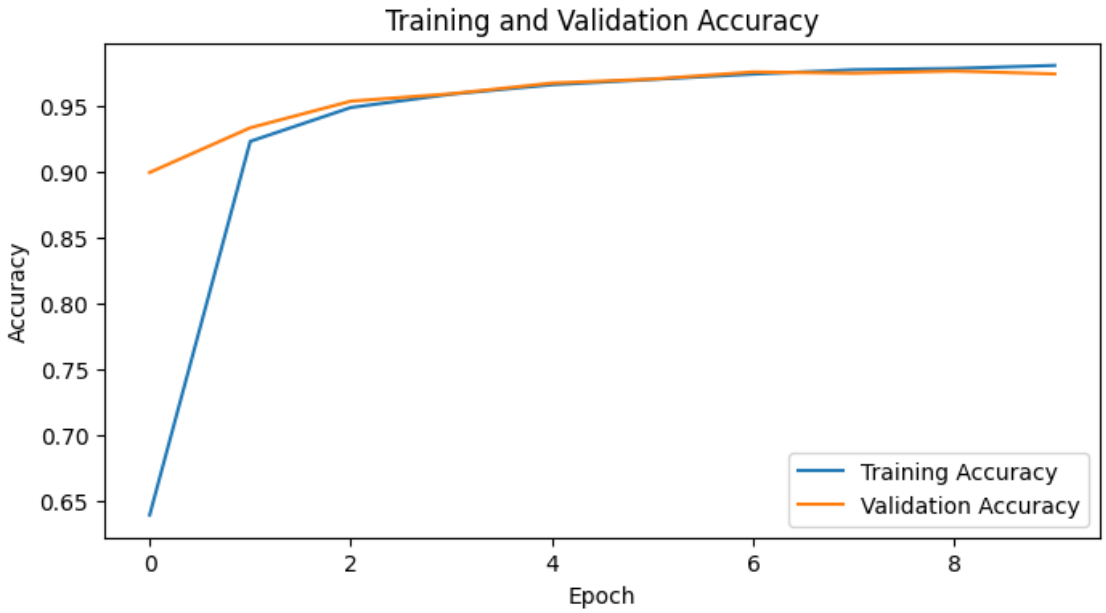
```
2024-02-19 15:03:25,582 - INFO - Model: "sequential_6"
2024-02-19 15:03:25,582 - INFO -
_________________________________________________________________
2024-02-19 15:03:25,583 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:03:25,583 - INFO -
=================================================================
2024-02-19 15:03:25,583 - INFO -  conv2d_15 (Conv2D)          (None, 28, 28, 32)
320
2024-02-19 15:03:25,584 - INFO -
2024-02-19 15:03:25,585 - INFO -  max_pooling2d_14 (MaxPooli  (None, 14, 14, 32)
0
2024-02-19 15:03:25,585 - INFO -  ng2D)
2024-02-19 15:03:25,586 - INFO -
2024-02-19 15:03:25,586 - INFO -  conv2d_16 (Conv2D)          (None, 14, 14, 64)
18496
2024-02-19 15:03:25,586 - INFO -
2024-02-19 15:03:25,587 - INFO -  max_pooling2d_15 (MaxPooli  (None, 7, 7, 64)
0
2024-02-19 15:03:25,588 - INFO -  ng2D)
2024-02-19 15:03:25,588 - INFO -
2024-02-19 15:03:25,588 - INFO -  conv2d_17 (Conv2D)          (None, 7, 7, 64)
36928
2024-02-19 15:03:25,589 - INFO -
2024-02-19 15:03:25,589 - INFO -  max_pooling2d_16 (MaxPooli  (None, 3, 3, 64)
0
2024-02-19 15:03:25,591 - INFO -  ng2D)
2024-02-19 15:03:25,591 - INFO -
2024-02-19 15:03:25,592 - INFO -  flatten_4 (Flatten)         (None, 576)
0
2024-02-19 15:03:25,592 - INFO -
2024-02-19 15:03:25,593 - INFO -  dense_8 (Dense)             (None, 64)
36928
2024-02-19 15:03:25,593 - INFO -
2024-02-19 15:03:25,594 - INFO -  dense_9 (Dense)             (None, 10)
650
2024-02-19 15:03:25,594 - INFO -
2024-02-19 15:03:25,595 - INFO -
=================================================================
2024-02-19 15:03:25,596 - INFO - Total params: 93322 (364.54 KB)
2024-02-19 15:03:25,596 - INFO - Trainable params: 93322 (364.54 KB)
2024-02-19 15:03:25,597 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:03:25,597 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 7s 10ms/step - loss: 0.6170 -
accuracy: 0.7911 - val_loss: 0.1596 - val_accuracy: 0.9488
```

```
Epoch 2/10
600/600 [==============================] - 6s 9ms/step - loss: 0.1186 -
accuracy: 0.9635 - val_loss: 0.1041 - val_accuracy: 0.9676
Epoch 3/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0809 -
accuracy: 0.9745 - val_loss: 0.0823 - val_accuracy: 0.9742
Epoch 4/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0634 -
accuracy: 0.9802 - val_loss: 0.0782 - val_accuracy: 0.9759
Epoch 5/10
600/600 [==============================] - 6s 11ms/step - loss: 0.0502 -
accuracy: 0.9845 - val_loss: 0.0563 - val_accuracy: 0.9804
Epoch 6/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0409 -
accuracy: 0.9877 - val_loss: 0.0570 - val_accuracy: 0.9818
Epoch 7/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0340 -
accuracy: 0.9897 - val_loss: 0.0494 - val_accuracy: 0.9840
Epoch 8/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0287 -
accuracy: 0.9909 - val_loss: 0.0514 - val_accuracy: 0.9837
Epoch 9/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0236 -
accuracy: 0.9928 - val_loss: 0.0461 - val_accuracy: 0.9856
Epoch 10/10
600/600 [==============================] - 6s 10ms/step - loss: 0.0206 -
accuracy: 0.9932 - val_loss: 0.0480 - val_accuracy: 0.9851
```



```
375/375 [==============================] - 1s 3ms/step - loss: 0.0488 -
accuracy: 0.9862

2024-02-19 15:04:28,340 - INFO - Filters: (32, 64, 64), Kernel Size: (3, 3),
Activation: tanh, Epochs: 10, Test Accuracy: 0.9862499833106995, Training Time:
61.333725690841675s

2024-02-19 15:04:28,374 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_32_64_64_kernel_3_activ
ation_tanh_epochs_10.h5

2024-02-19 15:04:28,375 - INFO - Running experiment with Filters: (32, 64, 64),
Kernel Size: (5, 5), Activation: relu, Epochs: 10

2024-02-19 15:04:28,429 - INFO - Model: "sequential_7"
2024-02-19 15:04:28,430 - INFO -
_________________________________________________________________
2024-02-19 15:04:28,431 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:04:28,431 - INFO -
=================================================================
2024-02-19 15:04:28,432 - INFO -  conv2d_18 (Conv2D)          (None, 28, 28, 32)
832
2024-02-19 15:04:28,432 - INFO -
2024-02-19 15:04:28,433 - INFO -  max_pooling2d_17 (MaxPooli  (None, 14, 14, 32)
0
2024-02-19 15:04:28,433 - INFO -  ng2D)
2024-02-19 15:04:28,434 - INFO -
2024-02-19 15:04:28,434 - INFO -  conv2d_19 (Conv2D)          (None, 14, 14, 64)
51264
2024-02-19 15:04:28,435 - INFO -
2024-02-19 15:04:28,435 - INFO -  max_pooling2d_18 (MaxPooli  (None, 7, 7, 64)
0
2024-02-19 15:04:28,436 - INFO -  ng2D)
2024-02-19 15:04:28,436 - INFO -
2024-02-19 15:04:28,436 - INFO -  conv2d_20 (Conv2D)          (None, 7, 7, 64)
102464
2024-02-19 15:04:28,437 - INFO -
2024-02-19 15:04:28,438 - INFO -  max_pooling2d_19 (MaxPooli  (None, 3, 3, 64)
0
2024-02-19 15:04:28,438 - INFO -  ng2D)
2024-02-19 15:04:28,439 - INFO -
2024-02-19 15:04:28,439 - INFO -  flatten_5 (Flatten)         (None, 576)
0
2024-02-19 15:04:28,440 - INFO -
2024-02-19 15:04:28,441 - INFO -  dense_10 (Dense)           (None, 64)
36928
2024-02-19 15:04:28,442 - INFO -
```

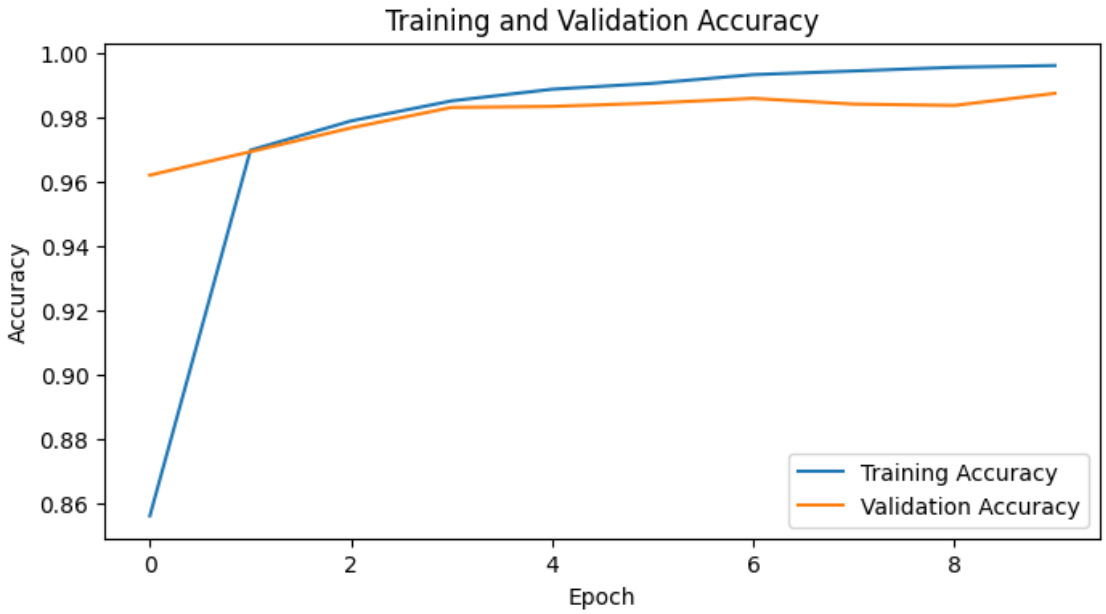
```
2024-02-19 15:04:28,442 - INFO -  dense_11 (Dense)            (None, 10)
650
2024-02-19 15:04:28,443 - INFO -
2024-02-19 15:04:28,443 - INFO -
=================================================================
2024-02-19 15:04:28,445 - INFO - Total params: 192138 (750.54 KB)
2024-02-19 15:04:28,445 - INFO - Trainable params: 192138 (750.54 KB)
2024-02-19 15:04:28,446 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:04:28,446 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 9s 15ms/step - loss: 1.0230 -
accuracy: 0.6395 - val_loss: 0.3320 - val_accuracy: 0.8998
Epoch 2/10
600/600 [==============================] - 9s 15ms/step - loss: 0.2455 -
accuracy: 0.9234 - val_loss: 0.2079 - val_accuracy: 0.9337
Epoch 3/10
600/600 [==============================] - 9s 16ms/step - loss: 0.1623 -
accuracy: 0.9491 - val_loss: 0.1453 - val_accuracy: 0.9540
Epoch 4/10
600/600 [==============================] - 8s 14ms/step - loss: 0.1270 -
accuracy: 0.9593 - val_loss: 0.1178 - val_accuracy: 0.9596
Epoch 5/10
600/600 [==============================] - 9s 14ms/step - loss: 0.1067 -
accuracy: 0.9664 - val_loss: 0.0986 - val_accuracy: 0.9677
Epoch 6/10
600/600 [==============================] - 9s 14ms/step - loss: 0.0919 -
accuracy: 0.9705 - val_loss: 0.0892 - val_accuracy: 0.9707
Epoch 7/10
600/600 [==============================] - 8s 14ms/step - loss: 0.0807 -
accuracy: 0.9746 - val_loss: 0.0755 - val_accuracy: 0.9761
Epoch 8/10
600/600 [==============================] - 8s 14ms/step - loss: 0.0697 -
accuracy: 0.9778 - val_loss: 0.0764 - val_accuracy: 0.9752
Epoch 9/10
600/600 [==============================] - 8s 14ms/step - loss: 0.0633 -
accuracy: 0.9788 - val_loss: 0.0712 - val_accuracy: 0.9769
Epoch 10/10
600/600 [==============================] - 8s 14ms/step - loss: 0.0580 -
accuracy: 0.9811 - val_loss: 0.0761 - val_accuracy: 0.9747
```




```
375/375 [==============================] - 2s 4ms/step - loss: 0.0758 -
accuracy: 0.9772

2024-02-19 15:05:57,381 - INFO - Filters: (32, 64, 64), Kernel Size: (5, 5),
Activation: relu, Epochs: 10, Test Accuracy: 0.9772499799728394, Training Time:
87.18041944503784s

2024-02-19 15:05:57,442 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_32_64_64_kernel_5_activ
ation_relu_epochs_10.h5

2024-02-19 15:05:57,443 - INFO - Running experiment with Filters: (32, 64, 64),
Kernel Size: (5, 5), Activation: tanh, Epochs: 10

2024-02-19 15:05:57,516 - INFO - Model: "sequential_8"
2024-02-19 15:05:57,516 - INFO -
_________________________________________________________________
2024-02-19 15:05:57,517 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:05:57,517 - INFO -
=================================================================
2024-02-19 15:05:57,518 - INFO -  conv2d_21 (Conv2D)          (None, 28, 28, 32)
832
2024-02-19 15:05:57,518 - INFO -
2024-02-19 15:05:57,519 - INFO -  max_pooling2d_20 (MaxPooli  (None, 14, 14, 32)
0
2024-02-19 15:05:57,519 - INFO -  ng2D)
```

```
2024-02-19 15:05:57,520 - INFO -
2024-02-19 15:05:57,520 - INFO -  conv2d_22 (Conv2D)          (None, 14, 14, 64)
51264
2024-02-19 15:05:57,521 - INFO -
2024-02-19 15:05:57,521 - INFO -  max_pooling2d_21 (MaxPooli  (None, 7, 7, 64)
0
2024-02-19 15:05:57,521 - INFO -  ng2D)
2024-02-19 15:05:57,522 - INFO -
2024-02-19 15:05:57,522 - INFO -  conv2d_23 (Conv2D)          (None, 7, 7, 64)
102464
2024-02-19 15:05:57,522 - INFO -
2024-02-19 15:05:57,522 - INFO -  max_pooling2d_22 (MaxPooli  (None, 3, 3, 64)
0
2024-02-19 15:05:57,523 - INFO -  ng2D)
2024-02-19 15:05:57,523 - INFO -
2024-02-19 15:05:57,524 - INFO -  flatten_6 (Flatten)         (None, 576)
0
2024-02-19 15:05:57,524 - INFO -
2024-02-19 15:05:57,525 - INFO -  dense_12 (Dense)           (None, 64)
36928
2024-02-19 15:05:57,526 - INFO -
2024-02-19 15:05:57,526 - INFO -  dense_13 (Dense)           (None, 10)
650
2024-02-19 15:05:57,527 - INFO -
2024-02-19 15:05:57,527 - INFO -
=================================================================
2024-02-19 15:05:57,529 - INFO - Total params: 192138 (750.54 KB)
2024-02-19 15:05:57,530 - INFO - Trainable params: 192138 (750.54 KB)
2024-02-19 15:05:57,530 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:05:57,531 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 9s 15ms/step - loss: 0.4405 -
accuracy: 0.8561 - val_loss: 0.1320 - val_accuracy: 0.9619
Epoch 2/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0999 -
accuracy: 0.9696 - val_loss: 0.0961 - val_accuracy: 0.9692
Epoch 3/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0683 -
accuracy: 0.9787 - val_loss: 0.0678 - val_accuracy: 0.9766
Epoch 4/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0488 -
accuracy: 0.9849 - val_loss: 0.0559 - val_accuracy: 0.9829
Epoch 5/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0376 -
accuracy: 0.9886 - val_loss: 0.0554 - val_accuracy: 0.9832
Epoch 6/10
```

```
600/600 [==============================] - 9s 15ms/step - loss: 0.0317 -
accuracy: 0.9904 - val_loss: 0.0503 - val_accuracy: 0.9843
Epoch 7/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0241 -
accuracy: 0.9931 - val_loss: 0.0446 - val_accuracy: 0.9857
Epoch 8/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0195 -
accuracy: 0.9942 - val_loss: 0.0515 - val_accuracy: 0.9840
Epoch 9/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0157 -
accuracy: 0.9954 - val_loss: 0.0520 - val_accuracy: 0.9835
Epoch 10/10
600/600 [==============================] - 9s 15ms/step - loss: 0.0138 -
accuracy: 0.9959 - val_loss: 0.0436 - val_accuracy: 0.9873
```

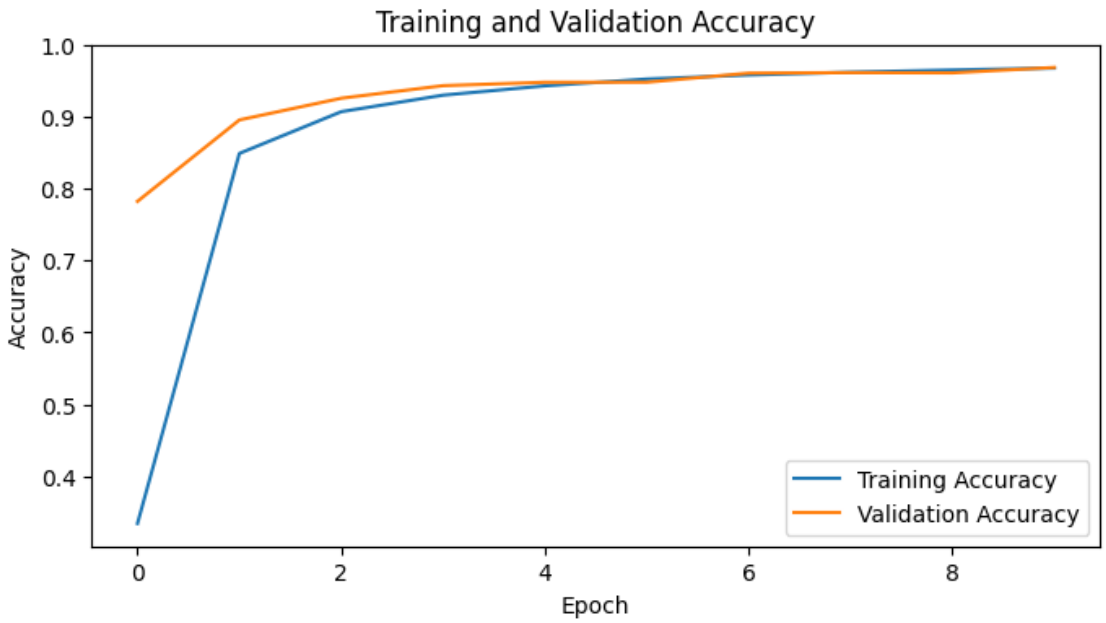



```
375/375 [==============================] - 2s 4ms/step - loss: 0.0461 -
accuracy: 0.9864
```

```
2024-02-19 15:07:29,539 - INFO - Filters: (32, 64, 64), Kernel Size: (5, 5),
Activation: tanh, Epochs: 10, Test Accuracy: 0.9864166378974915, Training Time:
90.1766197681427s

2024-02-19 15:07:29,607 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_32_64_64_kernel_5_activ
ation_tanh_epochs_10.h5

2024-02-19 15:07:29,608 - INFO - Running experiment with Filters: (64, 128,
128), Kernel Size: (3, 3), Activation: relu, Epochs: 10
```

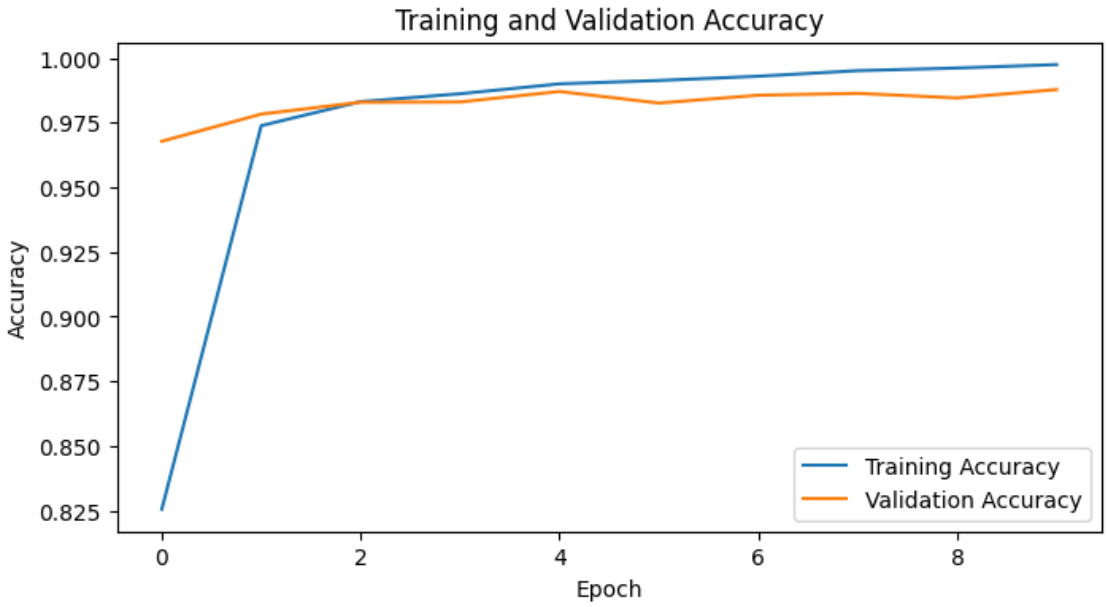
```
2024-02-19 15:07:29,686 - INFO - Model: "sequential_9"
2024-02-19 15:07:29,687 - INFO -
_________________________________________________________________
2024-02-19 15:07:29,687 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:07:29,688 - INFO -
=================================================================
2024-02-19 15:07:29,688 - INFO -  conv2d_24 (Conv2D)          (None, 28, 28, 64)
640
2024-02-19 15:07:29,689 - INFO -
2024-02-19 15:07:29,689 - INFO -  max_pooling2d_23 (MaxPooli  (None, 14, 14, 64)
0
2024-02-19 15:07:29,690 - INFO -  ng2D)
2024-02-19 15:07:29,690 - INFO -
2024-02-19 15:07:29,691 - INFO -  conv2d_25 (Conv2D)          (None, 14, 14,
128)       73856
2024-02-19 15:07:29,691 - INFO -
2024-02-19 15:07:29,692 - INFO -  max_pooling2d_24 (MaxPooli  (None, 7, 7, 128)
0
2024-02-19 15:07:29,692 - INFO -  ng2D)
2024-02-19 15:07:29,693 - INFO -
2024-02-19 15:07:29,694 - INFO -  conv2d_26 (Conv2D)          (None, 7, 7, 128)
147584
2024-02-19 15:07:29,695 - INFO -
2024-02-19 15:07:29,695 - INFO -  max_pooling2d_25 (MaxPooli  (None, 3, 3, 128)
0
2024-02-19 15:07:29,696 - INFO -  ng2D)
2024-02-19 15:07:29,696 - INFO -
2024-02-19 15:07:29,697 - INFO -  flatten_7 (Flatten)         (None, 1152)
0
2024-02-19 15:07:29,697 - INFO -
2024-02-19 15:07:29,698 - INFO -  dense_14 (Dense)            (None, 64)
73792
2024-02-19 15:07:29,699 - INFO -
2024-02-19 15:07:29,700 - INFO -  dense_15 (Dense)            (None, 10)
650
2024-02-19 15:07:29,700 - INFO -
2024-02-19 15:07:29,700 - INFO -
=================================================================
2024-02-19 15:07:29,701 - INFO - Total params: 296522 (1.13 MB)
2024-02-19 15:07:29,702 - INFO - Trainable params: 296522 (1.13 MB)
2024-02-19 15:07:29,702 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:07:29,702 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 12s 20ms/step - loss: 1.7926 -
```

```
accuracy: 0.3343 - val_loss: 0.6573 - val_accuracy: 0.7824
Epoch 2/10
600/600 [==============================] - 12s 20ms/step - loss: 0.4734 -
accuracy: 0.8490 - val_loss: 0.3428 - val_accuracy: 0.8956
Epoch 3/10
600/600 [==============================] - 12s 19ms/step - loss: 0.3003 -
accuracy: 0.9071 - val_loss: 0.2442 - val_accuracy: 0.9258
Epoch 4/10
600/600 [==============================] - 12s 19ms/step - loss: 0.2265 -
accuracy: 0.9301 - val_loss: 0.1852 - val_accuracy: 0.9433
Epoch 5/10
600/600 [==============================] - 12s 19ms/step - loss: 0.1854 -
accuracy: 0.9430 - val_loss: 0.1640 - val_accuracy: 0.9480
Epoch 6/10
600/600 [==============================] - 12s 19ms/step - loss: 0.1582 -
accuracy: 0.9525 - val_loss: 0.1634 - val_accuracy: 0.9481
Epoch 7/10
600/600 [==============================] - 12s 19ms/step - loss: 0.1393 -
accuracy: 0.9581 - val_loss: 0.1264 - val_accuracy: 0.9607
Epoch 8/10
600/600 [==============================] - 12s 20ms/step - loss: 0.1259 -
accuracy: 0.9621 - val_loss: 0.1233 - val_accuracy: 0.9615
Epoch 9/10
600/600 [==============================] - 12s 19ms/step - loss: 0.1157 -
accuracy: 0.9651 - val_loss: 0.1201 - val_accuracy: 0.9611
Epoch 10/10
600/600 [==============================] - 11s 19ms/step - loss: 0.1063 -
accuracy: 0.9678 - val_loss: 0.0984 - val_accuracy: 0.9686
```



```
375/375 [==============================] - 3s 7ms/step - loss: 0.1081 -
accuracy: 0.9675

2024-02-19 15:09:30,223 - INFO - Filters: (64, 128, 128), Kernel Size: (3, 3),
Activation: relu, Epochs: 10, Test Accuracy: 0.9674999713897705, Training Time:
117.62400078773499s

2024-02-19 15:09:30,277 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_64_128_128_kernel_3_act
ivation_relu_epochs_10.h5

2024-02-19 15:09:30,278 - INFO - Running experiment with Filters: (64, 128,
128), Kernel Size: (3, 3), Activation: tanh, Epochs: 10

2024-02-19 15:09:30,334 - INFO - Model: "sequential_10"
2024-02-19 15:09:30,334 - INFO -
_________________________________________________________________
2024-02-19 15:09:30,334 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:09:30,335 - INFO -
=================================================================
2024-02-19 15:09:30,335 - INFO -  conv2d_27 (Conv2D)          (None, 28, 28, 64)
640
2024-02-19 15:09:30,336 - INFO -
2024-02-19 15:09:30,336 - INFO -  max_pooling2d_26 (MaxPooli  (None, 14, 14, 64)
0
2024-02-19 15:09:30,337 - INFO -  ng2D)
2024-02-19 15:09:30,337 - INFO -
2024-02-19 15:09:30,338 - INFO -  conv2d_28 (Conv2D)          (None, 14, 14,
128)       73856
2024-02-19 15:09:30,338 - INFO -
2024-02-19 15:09:30,339 - INFO -  max_pooling2d_27 (MaxPooli  (None, 7, 7, 128)
0
2024-02-19 15:09:30,339 - INFO -  ng2D)
2024-02-19 15:09:30,339 - INFO -
2024-02-19 15:09:30,340 - INFO -  conv2d_29 (Conv2D)          (None, 7, 7, 128)
147584
2024-02-19 15:09:30,340 - INFO -
2024-02-19 15:09:30,341 - INFO -  max_pooling2d_28 (MaxPooli  (None, 3, 3, 128)
0
2024-02-19 15:09:30,341 - INFO -  ng2D)
2024-02-19 15:09:30,342 - INFO -
2024-02-19 15:09:30,343 - INFO -  flatten_8 (Flatten)         (None, 1152)
0
2024-02-19 15:09:30,343 - INFO -
2024-02-19 15:09:30,344 - INFO -  dense_16 (Dense)           (None, 64)
```

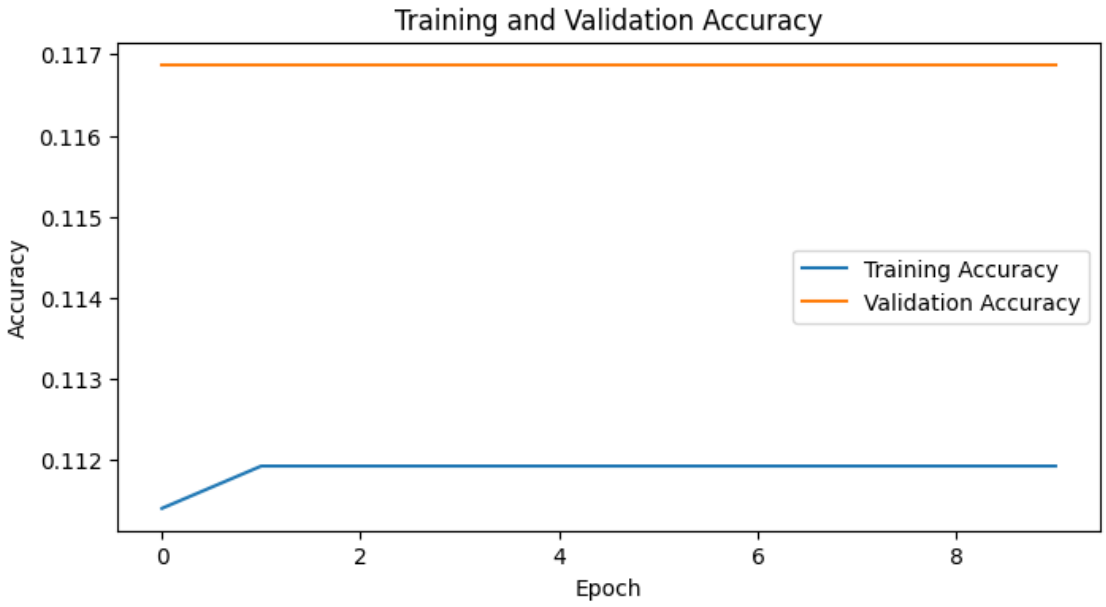
```
73792
2024-02-19 15:09:30,344 - INFO -
2024-02-19 15:09:30,344 - INFO -  dense_17 (Dense)            (None, 10)
650
2024-02-19 15:09:30,345 - INFO -
2024-02-19 15:09:30,346 - INFO -
=================================================================
2024-02-19 15:09:30,346 - INFO - Total params: 296522 (1.13 MB)
2024-02-19 15:09:30,347 - INFO - Trainable params: 296522 (1.13 MB)
2024-02-19 15:09:30,347 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:09:30,348 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 13s 20ms/step - loss: 0.5203 -
accuracy: 0.8256 - val_loss: 0.1048 - val_accuracy: 0.9678
Epoch 2/10
600/600 [==============================] - 11s 19ms/step - loss: 0.0860 -
accuracy: 0.9739 - val_loss: 0.0711 - val_accuracy: 0.9783
Epoch 3/10
600/600 [==============================] - 12s 20ms/step - loss: 0.0556 -
accuracy: 0.9832 - val_loss: 0.0533 - val_accuracy: 0.9829
Epoch 4/10
600/600 [==============================] - 12s 20ms/step - loss: 0.0441 -
accuracy: 0.9862 - val_loss: 0.0511 - val_accuracy: 0.9830
Epoch 5/10
600/600 [==============================] - 12s 19ms/step - loss: 0.0320 -
accuracy: 0.9900 - val_loss: 0.0396 - val_accuracy: 0.9871
Epoch 6/10
600/600 [==============================] - 12s 19ms/step - loss: 0.0259 -
accuracy: 0.9913 - val_loss: 0.0508 - val_accuracy: 0.9826
Epoch 7/10
600/600 [==============================] - 11s 19ms/step - loss: 0.0218 -
accuracy: 0.9930 - val_loss: 0.0444 - val_accuracy: 0.9856
Epoch 8/10
600/600 [==============================] - 12s 19ms/step - loss: 0.0168 -
accuracy: 0.9951 - val_loss: 0.0408 - val_accuracy: 0.9864
Epoch 9/10
600/600 [==============================] - 12s 19ms/step - loss: 0.0129 -
accuracy: 0.9961 - val_loss: 0.0469 - val_accuracy: 0.9846
Epoch 10/10
600/600 [==============================] - 12s 19ms/step - loss: 0.0097 -
accuracy: 0.9975 - val_loss: 0.0422 - val_accuracy: 0.9878
```




```
375/375 [==============================] - 3s 8ms/step - loss: 0.0461 -
accuracy: 0.9866

2024-02-19 15:11:31,347 - INFO - Filters: (64, 128, 128), Kernel Size: (3, 3),
Activation: tanh, Epochs: 10, Test Accuracy: 0.9865833520889282, Training Time:
117.72874402999878s

2024-02-19 15:11:31,413 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_64_128_128_kernel_3_act
ivation_tanh_epochs_10.h5

2024-02-19 15:11:31,414 - INFO - Running experiment with Filters: (64, 128,
128), Kernel Size: (5, 5), Activation: relu, Epochs: 10

2024-02-19 15:11:31,485 - INFO - Model: "sequential_11"
2024-02-19 15:11:31,487 - INFO -
_________________________________________________________________
2024-02-19 15:11:31,487 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:11:31,488 - INFO -
=================================================================
2024-02-19 15:11:31,489 - INFO -  conv2d_30 (Conv2D)          (None, 28, 28, 64)
1664
2024-02-19 15:11:31,490 - INFO -
2024-02-19 15:11:31,490 - INFO -  max_pooling2d_29 (MaxPooli  (None, 14, 14, 64)
0
2024-02-19 15:11:31,491 - INFO -  ng2D)
2024-02-19 15:11:31,491 - INFO -
```

```
2024-02-19 15:11:31,492 - INFO -  conv2d_31 (Conv2D)          (None, 14, 14,
128)       204928
2024-02-19 15:11:31,492 - INFO -
2024-02-19 15:11:31,493 - INFO -  max_pooling2d_30 (MaxPooli  (None, 7, 7, 128)
0
2024-02-19 15:11:31,494 - INFO -  ng2D)
2024-02-19 15:11:31,494 - INFO -
2024-02-19 15:11:31,494 - INFO -  conv2d_32 (Conv2D)          (None, 7, 7, 128)
409728
2024-02-19 15:11:31,496 - INFO -
2024-02-19 15:11:31,496 - INFO -  max_pooling2d_31 (MaxPooli  (None, 3, 3, 128)
0
2024-02-19 15:11:31,497 - INFO -  ng2D)
2024-02-19 15:11:31,498 - INFO -
2024-02-19 15:11:31,499 - INFO -  flatten_9 (Flatten)         (None, 1152)
0
2024-02-19 15:11:31,499 - INFO -
2024-02-19 15:11:31,500 - INFO -  dense_18 (Dense)           (None, 64)
73792
2024-02-19 15:11:31,501 - INFO -
2024-02-19 15:11:31,501 - INFO -  dense_19 (Dense)           (None, 10)
650
2024-02-19 15:11:31,502 - INFO -
2024-02-19 15:11:31,502 - INFO -
=================================================================
2024-02-19 15:11:31,503 - INFO - Total params: 690762 (2.64 MB)
2024-02-19 15:11:31,503 - INFO - Trainable params: 690762 (2.64 MB)
2024-02-19 15:11:31,504 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:11:31,504 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 23s 38ms/step - loss: 2.3018 -
accuracy: 0.1114 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 2/10
600/600 [==============================] - 23s 39ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3008 - val_accuracy: 0.1169
Epoch 3/10
600/600 [==============================] - 26s 44ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 4/10
600/600 [==============================] - 26s 43ms/step - loss: 2.3014 -
accuracy: 0.1119 - val_loss: 2.3010 - val_accuracy: 0.1169
Epoch 5/10
600/600 [==============================] - 23s 39ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3010 - val_accuracy: 0.1169
Epoch 6/10
600/600 [==============================] - 24s 40ms/step - loss: 2.3014 -
```

```
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 7/10
600/600 [==============================] - 23s 39ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 8/10
600/600 [==============================] - 23s 38ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3009 - val_accuracy: 0.1169
Epoch 9/10
600/600 [==============================] - 25s 42ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3011 - val_accuracy: 0.1169
Epoch 10/10
600/600 [==============================] - 27s 45ms/step - loss: 2.3013 -
accuracy: 0.1119 - val_loss: 2.3008 - val_accuracy: 0.1169
```

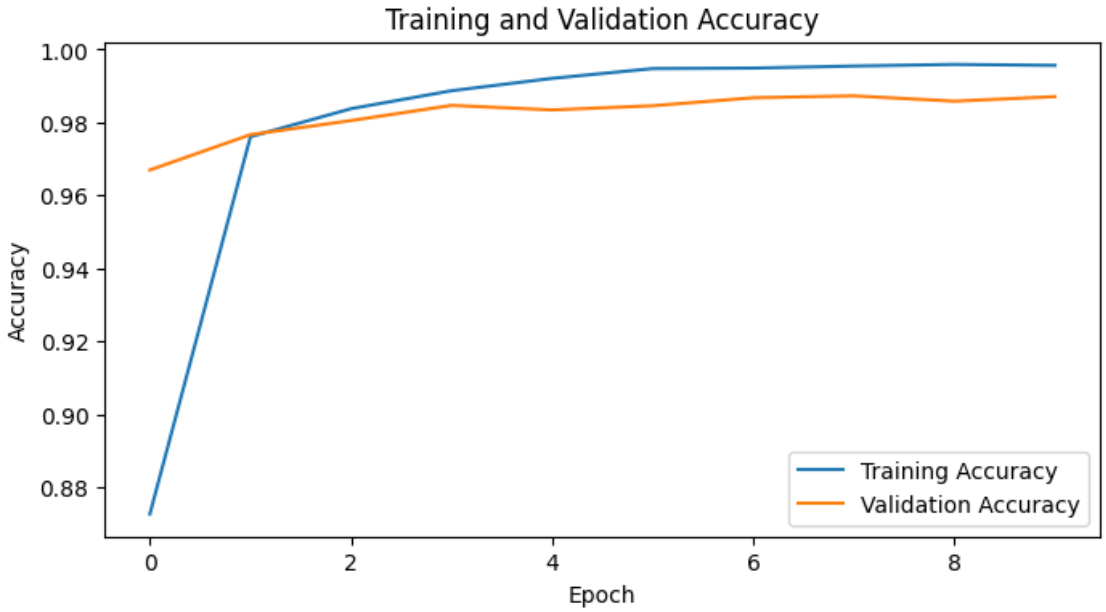



```
375/375 [==============================] - 4s 11ms/step - loss: 2.3015 -
accuracy: 0.1102
```

```
2024-02-19 15:15:39,501 - INFO - Filters: (64, 128, 128), Kernel Size: (5, 5),
Activation: relu, Epochs: 10, Test Accuracy: 0.11016666889190674, Training Time:
243.41449546813965s

2024-02-19 15:15:39,551 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_64_128_128_kernel_5_act
ivation_relu_epochs_10.h5

2024-02-19 15:15:39,552 - INFO - Running experiment with Filters: (64, 128,
128), Kernel Size: (5, 5), Activation: tanh, Epochs: 10
```

```
2024-02-19 15:15:39,608 - INFO - Model: "sequential_12"
2024-02-19 15:15:39,609 - INFO -
_________________________________________________________________
2024-02-19 15:15:39,610 - INFO -  Layer (type)                Output Shape
Param #
2024-02-19 15:15:39,610 - INFO -
=================================================================
2024-02-19 15:15:39,611 - INFO -  conv2d_33 (Conv2D)          (None, 28, 28, 64)
1664
2024-02-19 15:15:39,612 - INFO -
2024-02-19 15:15:39,612 - INFO -  max_pooling2d_32 (MaxPooli  (None, 14, 14, 64)
0
2024-02-19 15:15:39,612 - INFO -  ng2D)
2024-02-19 15:15:39,614 - INFO -
2024-02-19 15:15:39,614 - INFO -  conv2d_34 (Conv2D)          (None, 14, 14,
128)       204928
2024-02-19 15:15:39,614 - INFO -
2024-02-19 15:15:39,615 - INFO -  max_pooling2d_33 (MaxPooli  (None, 7, 7, 128)
0
2024-02-19 15:15:39,615 - INFO -  ng2D)
2024-02-19 15:15:39,616 - INFO -
2024-02-19 15:15:39,616 - INFO -  conv2d_35 (Conv2D)          (None, 7, 7, 128)
409728
2024-02-19 15:15:39,618 - INFO -
2024-02-19 15:15:39,618 - INFO -  max_pooling2d_34 (MaxPooli  (None, 3, 3, 128)
0
2024-02-19 15:15:39,619 - INFO -  ng2D)
2024-02-19 15:15:39,620 - INFO -
2024-02-19 15:15:39,620 - INFO -  flatten_10 (Flatten)        (None, 1152)
0
2024-02-19 15:15:39,620 - INFO -
2024-02-19 15:15:39,621 - INFO -  dense_20 (Dense)            (None, 64)
73792
2024-02-19 15:15:39,903 - INFO -
2024-02-19 15:15:39,904 - INFO -  dense_21 (Dense)            (None, 10)
650
2024-02-19 15:15:39,905 - INFO -
2024-02-19 15:15:39,905 - INFO -
=================================================================
2024-02-19 15:15:39,906 - INFO - Total params: 690762 (2.64 MB)
2024-02-19 15:15:39,907 - INFO - Trainable params: 690762 (2.64 MB)
2024-02-19 15:15:39,908 - INFO - Non-trainable params: 0 (0.00 Byte)
2024-02-19 15:15:39,908 - INFO -
_________________________________________________________________
Epoch 1/10
600/600 [==============================] - 25s 40ms/step - loss: 0.3846 -
accuracy: 0.8727 - val_loss: 0.1017 - val_accuracy: 0.9670
```

```
Epoch 2/10
600/600 [==============================] - 24s 40ms/step - loss: 0.0802 -
accuracy: 0.9761 - val_loss: 0.0725 - val_accuracy: 0.9767
Epoch 3/10
600/600 [==============================] - 23s 39ms/step - loss: 0.0527 -
accuracy: 0.9838 - val_loss: 0.0630 - val_accuracy: 0.9805
Epoch 4/10
600/600 [==============================] - 28s 46ms/step - loss: 0.0365 -
accuracy: 0.9887 - val_loss: 0.0499 - val_accuracy: 0.9847
Epoch 5/10
600/600 [==============================] - 74s 123ms/step - loss: 0.0272 -
accuracy: 0.9921 - val_loss: 0.0518 - val_accuracy: 0.9834
Epoch 6/10
600/600 [==============================] - 85s 141ms/step - loss: 0.0188 -
accuracy: 0.9948 - val_loss: 0.0443 - val_accuracy: 0.9846
Epoch 7/10
600/600 [==============================] - 25s 41ms/step - loss: 0.0180 -
accuracy: 0.9949 - val_loss: 0.0444 - val_accuracy: 0.9868
Epoch 8/10
600/600 [==============================] - 24s 40ms/step - loss: 0.0146 -
accuracy: 0.9955 - val_loss: 0.0407 - val_accuracy: 0.9873
Epoch 9/10
600/600 [==============================] - 29s 48ms/step - loss: 0.0128 -
accuracy: 0.9959 - val_loss: 0.0482 - val_accuracy: 0.9858
Epoch 10/10
600/600 [==============================] - 24s 40ms/step - loss: 0.0138 -
accuracy: 0.9957 - val_loss: 0.0408 - val_accuracy: 0.9871
```



```
375/375 [==============================] - 5s 12ms/step - loss: 0.0440 -
accuracy: 0.9877

2024-02-19 15:21:44,604 - INFO - Filters: (64, 128, 128), Kernel Size: (5, 5),
Activation: tanh, Epochs: 10, Test Accuracy: 0.987666666507721, Training Time:
359.9742214679718s

2024-02-19 15:21:44,675 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
4\Main MNSIT-MLPClassifer\ModelExperiments\model_filters_64_128_128_kernel_5_act
ivation_tanh_epochs_10.h5

2024-02-19 15:21:44,686 - INFO - Program completed successfully.
```

[ ]: