06_model_Experiments

February 12, 2024

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

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

[2]:
```
'D:\\Desktop\\Deep Learning\\Lab 3\\Main MNSIT-MLPClassifer\\Research'
```

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

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

[4]:
```
'D:\\Desktop\\Deep Learning\\Lab 3\\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.")
```

[8]:
```
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
from sklearn.preprocessing import LabelEncoder, StandardScaler
from tensorflow_addons.metrics import F1Score
from joblib import dump
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):
        # Use the status file to write validation details
        with open(self.config.log_file, 'w', encoding='utf-8') as f:
            f.write("Starting experiments...\n")
            logging.info("Starting experiments...\n")
            # Load data

            X_train = pd.read_csv(self.config.X_train_file).values
            y_train = pd.read_csv(self.config.y_train_file).values.ravel()
            X_test = pd.read_csv(self.config.X_test_file).values
            y_test = pd.read_csv(self.config.y_test_file).values.ravel()
            f.write("Loaded data...\n")
            logging.info("Loaded data...\n")

            # Standardize the input data
            scaler = StandardScaler()
            X_train_scaled = scaler.fit_transform(X_train)
            X_test_scaled = scaler.transform(X_test)  # Ensure to scale the␣
 ↪test set in the same way

            # Save the scaler for later use
            dump(scaler, self.config.scaler_file)
            f.write(f"Scaler saved to {self.config.scaler_file}\n")

            # Ensure labels are encoded starting from 0
            label_encoder = LabelEncoder()
            y_train_encoded = label_encoder.fit_transform(y_train)
            y_test_encoded = label_encoder.transform(y_test)  # Transform test␣
 ↪labels with the same encoder

            # Save the label encoder for later use
            dump(label_encoder, self.config.label_encoder_file)
```

```
            logging.info(f"Label Encoder saved to {self.config.
↪label_encoder_file}")

            # Log the mapping of original labels to encoded labels
            label_mapping = dict(zip(label_encoder.classes_, label_encoder.
↪transform(label_encoder.classes_)))
            f.write(f"Label Encoding Mapping: {label_mapping}\n")
            logging.info(f"Label Encoding Mapping: {label_mapping}\n")

            # Check unique labels to ensure they are in the range [0,␣
↪n_classes-1]
            unique_labels = np.unique(y_train_encoded)
            f.write(f"Unique labels after encoding: {unique_labels}\n")
            logging.info(f"Unique labels after encoding: {unique_labels}\n")

            # Define your experiments here
            node_counts = [4, 32, 64, 128, 512, 2056]
            layer_counts = [4, 5, 6, 8, 16]

            for node_count in node_counts:
                self.run_experiment(node_count, 1, X_train_scaled,␣
↪y_train_encoded, X_test_scaled, y_test_encoded, epochs=10, file=f)

            for layer_count in layer_counts:
                self.run_experiment(64, layer_count, X_train_scaled,␣
↪y_train_encoded, X_test_scaled, y_test_encoded, epochs=10, file=f)
                self.run_experiment(64, layer_count, X_train_scaled,␣
↪y_train_encoded, X_test_scaled, y_test_encoded, epochs=30, file=f)

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



  def run_experiment(self, node_count, layer_count, X_train, y_train, X_test,␣
↪y_test, epochs, file):
      file.write(f"Running experiment with Nodes: {node_count}, Layers:␣
↪{layer_count}, Epochs: {epochs}\n")
      logging.info(f"Running experiment with Nodes: {node_count}, Layers:␣
↪{layer_count}, Epochs: {epochs}\n")

      unique_labels = len(np.unique(y_train))  # Define unique_labels based␣
↪on y_train within the method

      model = Sequential()
      model.add(Dense(node_count, activation='relu', input_shape=(X_train.
↪shape[1],)))
```

```
        for _ in range(1, layer_count):
            model.add(Dense(node_count, activation='relu'))
        model.add(Dense(unique_labels, activation='softmax'))

        model.compile(optimizer='adam',
                      loss='sparse_categorical_crossentropy',
                      metrics=['accuracy', F1Score(num_classes=unique_labels,␣
↪average='micro')])

        logging.info(model.summary())
        file.write(str(model.summary()))

        start_time = time.time()
        history = model.fit(X_train, y_train, epochs=epochs,␣
↪validation_data=(X_test, y_test), verbose=1)
        training_time = time.time() - start_time

        # Plotting training/validation loss, accuracy, and F1 score
        plt.figure(figsize=(8, 16))

        # Plot Training and Validation Loss
        plt.subplot(3, 1, 1)
        plt.plot(history.history['loss'], label='Training Loss')
        plt.plot(history.history['val_loss'], label='Validation Loss')
        plt.xlabel('Epoch')
        plt.ylabel('Loss')
        plt.title('Training and Validation Loss')
        plt.legend()

        # Plot Training and Validation Accuracy
        plt.subplot(3, 1, 2)
        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()

        # Plot Training and Validation F1 Score
        plt.subplot(3, 1, 3)
        plt.plot(history.history['f1_score'], label='Training F1 Score')
        plt.plot(history.history['val_f1_score'], label='Validation F1 Score')
        plt.xlabel('Epoch')
        plt.ylabel('F1 Score')
        plt.title('Training and Validation F1 Score')
        plt.legend()
```

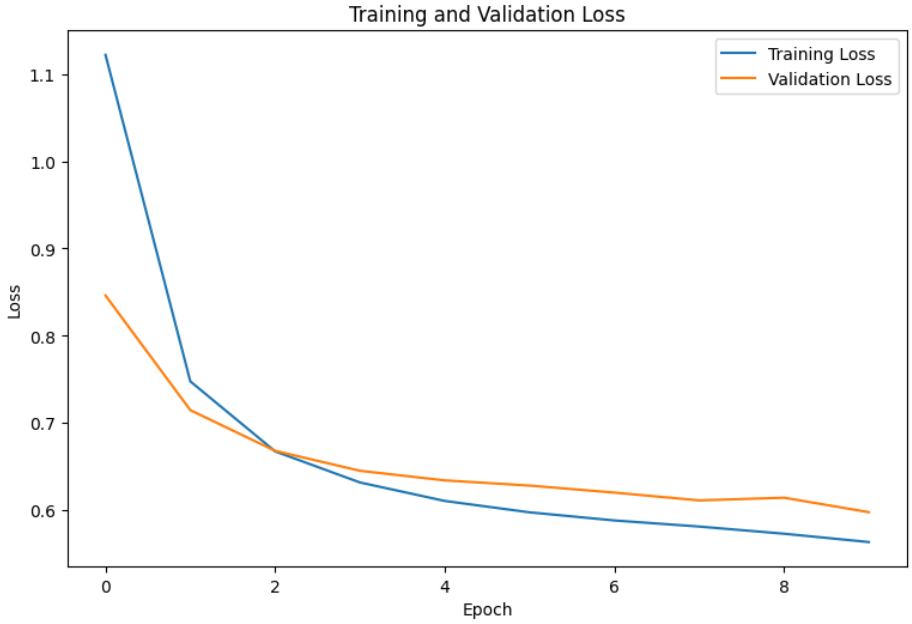
```
        plt.tight_layout()
        plt.show()

        # Evaluate the model to get the F1 score along with loss and accuracy
        results = model.evaluate(X_test, y_test, verbose=1)
        test_loss, test_acc, test_f1 = results  # Assuming the third returned␣
 ↪value is the F1 score

        file.write(f"Nodes: {node_count}, Layers: {layer_count}, Epochs:␣
 ↪{epochs}, Test Accuracy: {test_acc}, F1 Score: {test_f1}, Training Time:␣
 ↪{training_time}s\n")
        logging.info(f"Nodes: {node_count}, Layers: {layer_count}, Epochs:␣
 ↪{epochs}, Test Accuracy: {test_acc}, F1 Score: {test_f1}, Training Time:␣
 ↪{training_time}s\n")

        # Save the model
        model_save_path = str(self.config.experiment_results_dir /␣
 ↪f"model_nodes_{node_count}_layers_{layer_count}_epochs_{epochs}.keras")
        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()
```

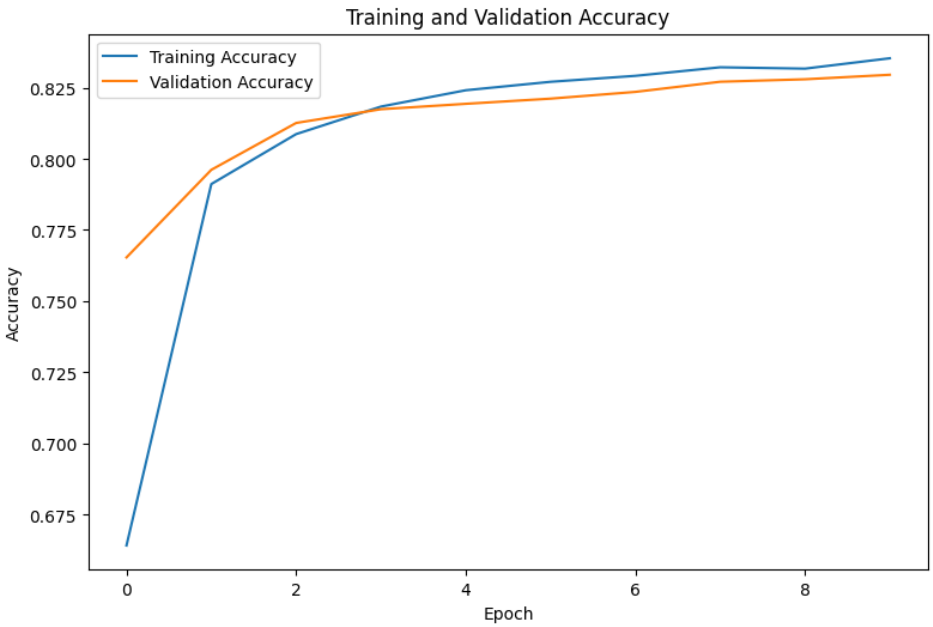
```
WARNING:tensorflow:From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\losses.py:2976: The name
tf.losses.sparse_softmax_cross_entropy is deprecated. Please use
tf.compat.v1.losses.sparse_softmax_cross_entropy instead.


2024-02-12 20:10:24,365 - INFO - Starting the program…
2024-02-12 20:10:24,368 - INFO - Starting experiments…
```

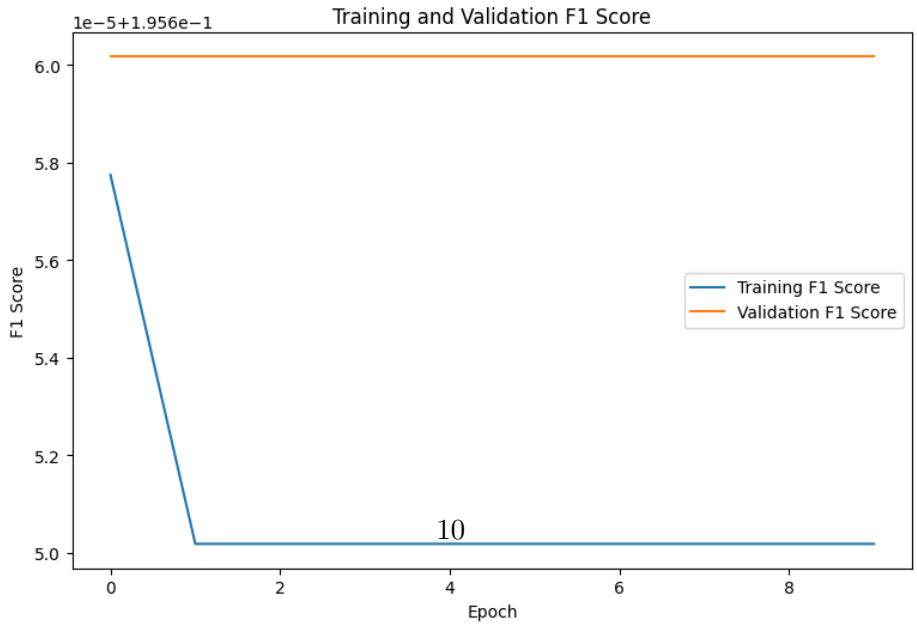
```
2024-02-12 20:10:32,362 - INFO - Loaded data…

2024-02-12 20:10:33,482 - INFO - Label Encoder saved to D:\Desktop\Deep
Learning\Lab 3\Main MNSIT-MLPClassifer\ModelExperiments\label_encoder.pkl
2024-02-12 20:10:33,484 - INFO - Label Encoding Mapping: {0.0: 0, 1.0: 1, 2.0:
2, 3.0: 3, 4.0: 4, 5.0: 5, 6.0: 6, 7.0: 7, 8.0: 8, 9.0: 9}

2024-02-12 20:10:33,487 - INFO - Unique labels after encoding: [0 1 2 3 4 5 6 7
8 9]

2024-02-12 20:10:33,489 - INFO - Running experiment with Nodes: 4, Layers: 1,
Epochs: 10


WARNING:tensorflow:From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\backend.py:873: The name
tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph
instead.


2024-02-12 20:10:34,267 - WARNING - From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\backend.py:873: The name
tf.get_default_graph is deprecated. Please use tf.compat.v1.get_default_graph
instead.


WARNING:tensorflow:From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\optimizers\__init__.py:309: The
name tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer
instead.


2024-02-12 20:10:34,989 - WARNING - From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\optimizers\__init__.py:309: The
name tf.train.Optimizer is deprecated. Please use tf.compat.v1.train.Optimizer
instead.


Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 4)                 3140

 dense_1 (Dense)             (None, 10)                50

=================================================================
Total params: 3190 (12.46 KB)
Trainable params: 3190 (12.46 KB)
```

```
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:10:35,036 - INFO - None
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 4)                 3140

 dense_1 (Dense)             (None, 10)                50

=================================================================
Total params: 3190 (12.46 KB)
Trainable params: 3190 (12.46 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
WARNING:tensorflow:From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\utils\tf_utils.py:492: The name
tf.ragged.RaggedTensorValue is deprecated. Please use
tf.compat.v1.ragged.RaggedTensorValue instead.

2024-02-12 20:10:36,389 - WARNING - From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\utils\tf_utils.py:492: The name
tf.ragged.RaggedTensorValue is deprecated. Please use
tf.compat.v1.ragged.RaggedTensorValue instead.

WARNING:tensorflow:From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\engine\base_layer_utils.py:384:
The name tf.executing_eagerly_outside_functions is deprecated. Please use
tf.compat.v1.executing_eagerly_outside_functions instead.

2024-02-12 20:10:36,940 - WARNING - From D:\Desktop\Deep Learning\Lab 2\MNSIT-
MLPClassifer\venv\lib\site-packages\keras\src\engine\base_layer_utils.py:384:
The name tf.executing_eagerly_outside_functions is deprecated. Please use
tf.compat.v1.executing_eagerly_outside_functions instead.

1579/1579 [==============================] - 10s 5ms/step - loss: 1.1223 -
accuracy: 0.6640 - f1_score: 0.1957 - val_loss: 0.8459 - val_accuracy: 0.7653 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.7473 -
accuracy: 0.7911 - f1_score: 0.1957 - val_loss: 0.7142 - val_accuracy: 0.7961 -
val_f1_score: 0.1957
Epoch 3/10
```

```
1579/1579 [==============================] - 7s 4ms/step - loss: 0.6668 -
accuracy: 0.8087 - f1_score: 0.1957 - val_loss: 0.6675 - val_accuracy: 0.8126 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.6311 -
accuracy: 0.8184 - f1_score: 0.1957 - val_loss: 0.6445 - val_accuracy: 0.8174 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.6099 -
accuracy: 0.8241 - f1_score: 0.1957 - val_loss: 0.6335 - val_accuracy: 0.8193 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.5968 -
accuracy: 0.8271 - f1_score: 0.1957 - val_loss: 0.6275 - val_accuracy: 0.8212 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.5875 -
accuracy: 0.8292 - f1_score: 0.1957 - val_loss: 0.6195 - val_accuracy: 0.8235 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.5805 -
accuracy: 0.8322 - f1_score: 0.1957 - val_loss: 0.6105 - val_accuracy: 0.8271 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.5722 -
accuracy: 0.8317 - f1_score: 0.1957 - val_loss: 0.6136 - val_accuracy: 0.8280 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.5627 -
accuracy: 0.8354 - f1_score: 0.1957 - val_loss: 0.5970 - val_accuracy: 0.8296 -
val_f1_score: 0.1957
```

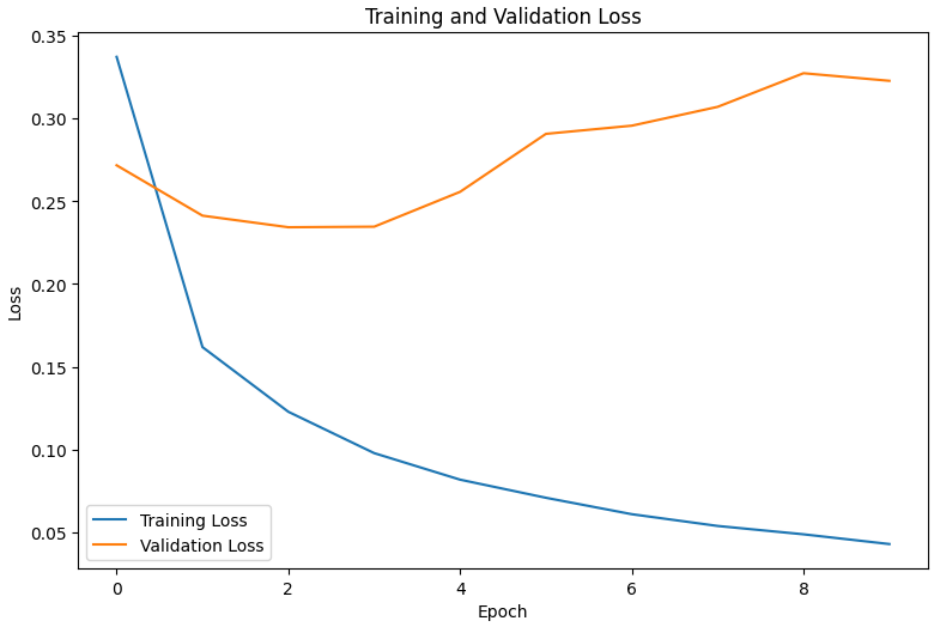

Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
1.1
1.0
0.9
0.8
0.7
0.6
0
2
4
6
8

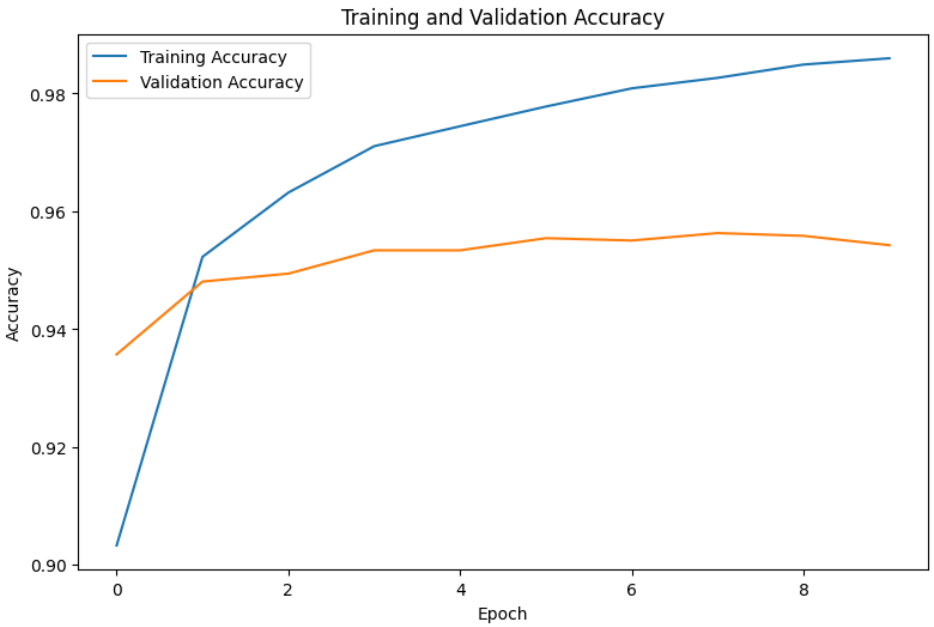

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.825
0.800
0.775
0.750
0.725
0.700
0.675
0
2
4
6
8

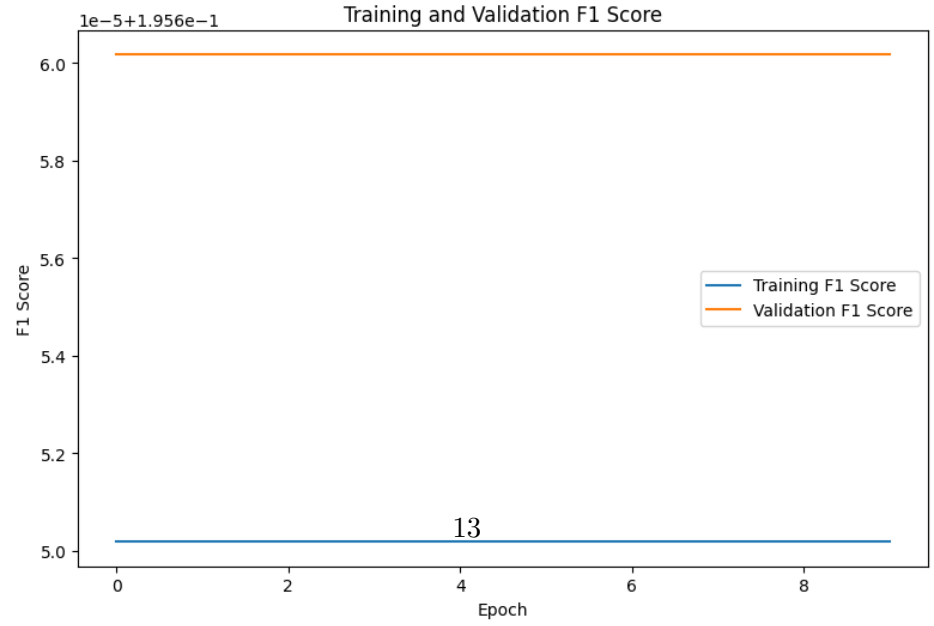

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
6.0
5.8
5.6
5.4
5.2
5.0
0
2
4
6
8

```
395/395 [==============================] - 1s 3ms/step - loss: 0.5970 -
accuracy: 0.8296 - f1_score: 0.1957

2024-02-12 20:11:52,188 - INFO - Nodes: 4, Layers: 1, Epochs: 10, Test Accuracy:
0.8295580744743347, F1 Score: 0.19566017389297485, Training Time:
74.35525441169739s

2024-02-12 20:11:52,267 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_4_layers_1_epochs_10.keras

2024-02-12 20:11:52,269 - INFO - Running experiment with Nodes: 32, Layers: 1,
Epochs: 10


Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_2 (Dense)             (None, 32)                25120

 dense_3 (Dense)             (None, 10)                330

=================================================================
Total params: 25450 (99.41 KB)
Trainable params: 25450 (99.41 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:11:52,372 - INFO - None

Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_2 (Dense)             (None, 32)                25120

 dense_3 (Dense)             (None, 10)                330

=================================================================
Total params: 25450 (99.41 KB)
Trainable params: 25450 (99.41 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.3371 -
accuracy: 0.9032 - f1_score: 0.1957 - val_loss: 0.2716 - val_accuracy: 0.9357 -
```

```
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.1619 -
accuracy: 0.9522 - f1_score: 0.1957 - val_loss: 0.2412 - val_accuracy: 0.9480 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.1228 -
accuracy: 0.9632 - f1_score: 0.1957 - val_loss: 0.2342 - val_accuracy: 0.9494 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0979 -
accuracy: 0.9710 - f1_score: 0.1957 - val_loss: 0.2346 - val_accuracy: 0.9534 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0818 -
accuracy: 0.9744 - f1_score: 0.1957 - val_loss: 0.2556 - val_accuracy: 0.9534 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0709 -
accuracy: 0.9778 - f1_score: 0.1957 - val_loss: 0.2906 - val_accuracy: 0.9554 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0610 -
accuracy: 0.9809 - f1_score: 0.1957 - val_loss: 0.2955 - val_accuracy: 0.9550 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0539 -
accuracy: 0.9826 - f1_score: 0.1957 - val_loss: 0.3069 - val_accuracy: 0.9563 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0489 -
accuracy: 0.9849 - f1_score: 0.1957 - val_loss: 0.3272 - val_accuracy: 0.9558 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 7s 4ms/step - loss: 0.0430 -
accuracy: 0.9860 - f1_score: 0.1957 - val_loss: 0.3226 - val_accuracy: 0.9542 -
val_f1_score: 0.1957
```

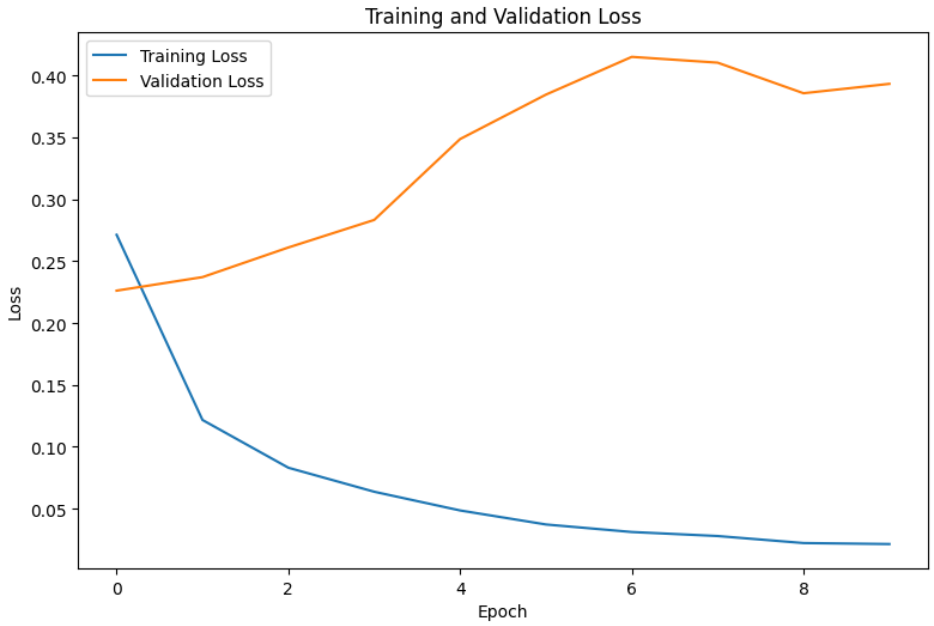

Training and Validation Loss
Loss
Epoch
Training Loss
Validation Loss
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
2
4
6
8

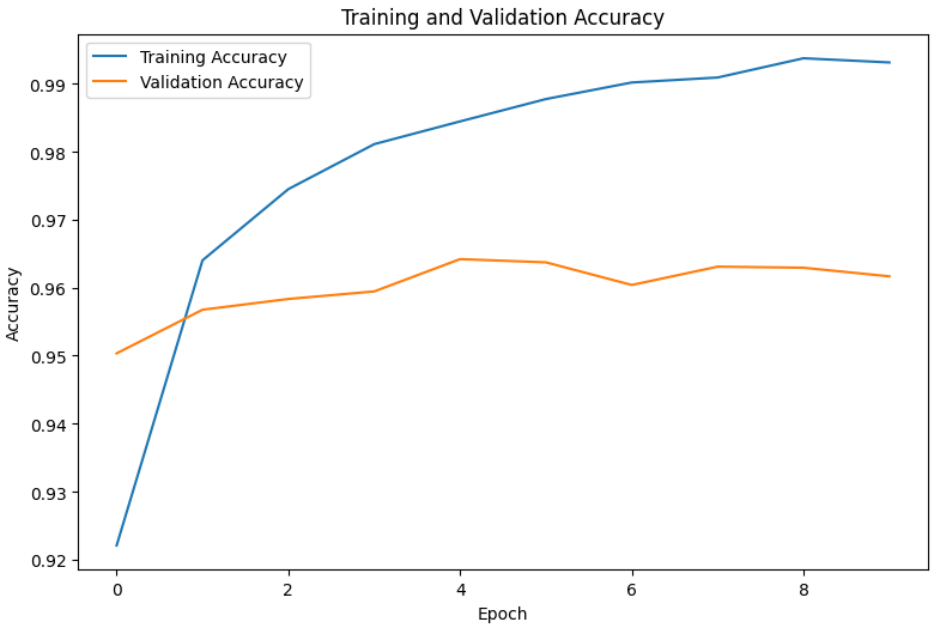

Training and Validation Accuracy
Accuracy
Epoch
Training Accuracy
Validation Accuracy
0.98
0.96
0.94
0.92
0.90
0
2
4
6
8

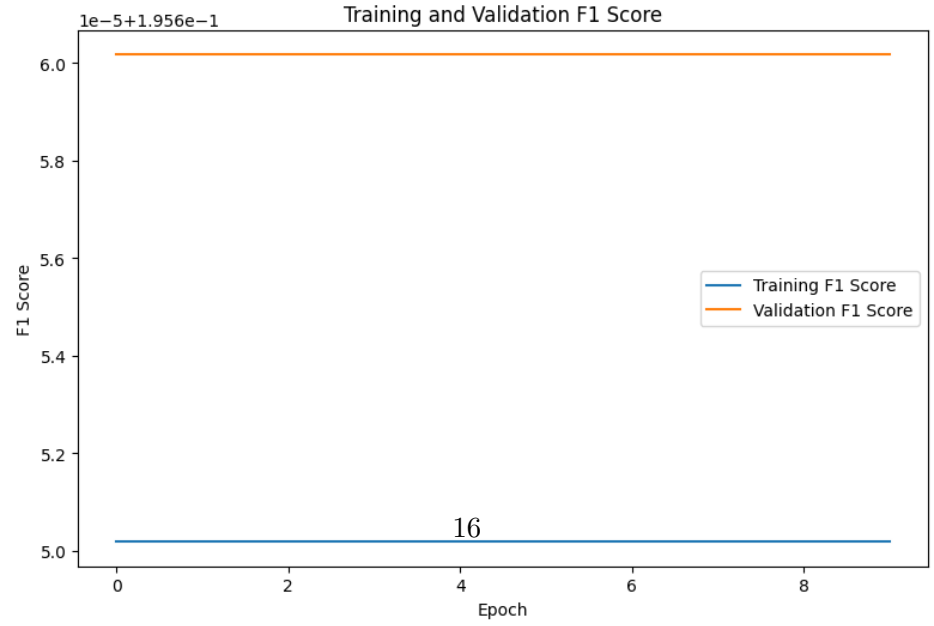

Training and Validation F1 Score
1e−5+1.956e−1
F1 Score
Epoch
Training F1 Score
Validation F1 Score
6.0
5.8
5.6
5.4
5.2
5.0
0
2
4
6
8

```
395/395 [==============================] - 1s 3ms/step - loss: 0.3226 -
accuracy: 0.9542 - f1_score: 0.1957

2024-02-12 20:13:06,859 - INFO - Nodes: 32, Layers: 1, Epochs: 10, Test
Accuracy: 0.9542214274406433, F1 Score: 0.19566017389297485, Training Time:
71.88862752914429s

2024-02-12 20:13:06,922 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_32_layers_1_epochs_10.keras

2024-02-12 20:13:06,923 - INFO - Running experiment with Nodes: 64, Layers: 1,
Epochs: 10


Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_4 (Dense)             (None, 64)                50240

 dense_5 (Dense)             (None, 10)                650

=================================================================
Total params: 50890 (198.79 KB)
Trainable params: 50890 (198.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:13:07,013 - INFO - None

Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_4 (Dense)             (None, 64)                50240

 dense_5 (Dense)             (None, 10)                650

=================================================================
Total params: 50890 (198.79 KB)
Trainable params: 50890 (198.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.2712 -
accuracy: 0.9221 - f1_score: 0.1957 - val_loss: 0.2261 - val_accuracy: 0.9503 -
```

```
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.1216 -
accuracy: 0.9640 - f1_score: 0.1957 - val_loss: 0.2371 - val_accuracy: 0.9568 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0830 -
accuracy: 0.9745 - f1_score: 0.1957 - val_loss: 0.2610 - val_accuracy: 0.9583 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0636 -
accuracy: 0.9811 - f1_score: 0.1957 - val_loss: 0.2833 - val_accuracy: 0.9594 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0485 -
accuracy: 0.9845 - f1_score: 0.1957 - val_loss: 0.3486 - val_accuracy: 0.9642 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0371 -
accuracy: 0.9877 - f1_score: 0.1957 - val_loss: 0.3846 - val_accuracy: 0.9637 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0311 -
accuracy: 0.9902 - f1_score: 0.1957 - val_loss: 0.4151 - val_accuracy: 0.9604 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0278 -
accuracy: 0.9909 - f1_score: 0.1957 - val_loss: 0.4104 - val_accuracy: 0.9631 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0221 -
accuracy: 0.9937 - f1_score: 0.1957 - val_loss: 0.3857 - val_accuracy: 0.9629 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 7s 5ms/step - loss: 0.0213 -
accuracy: 0.9931 - f1_score: 0.1957 - val_loss: 0.3933 - val_accuracy: 0.9617 -
val_f1_score: 0.1957
```

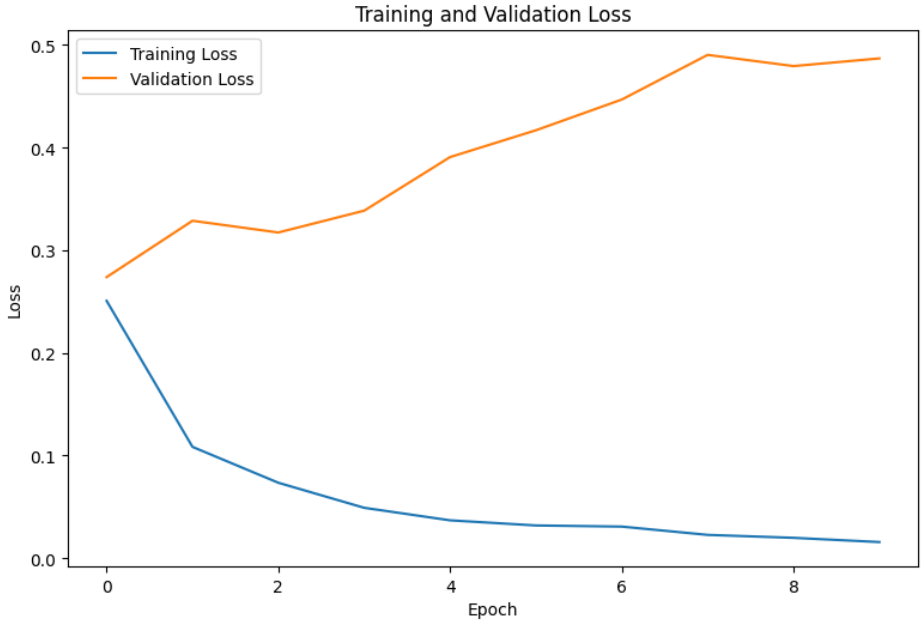

Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch

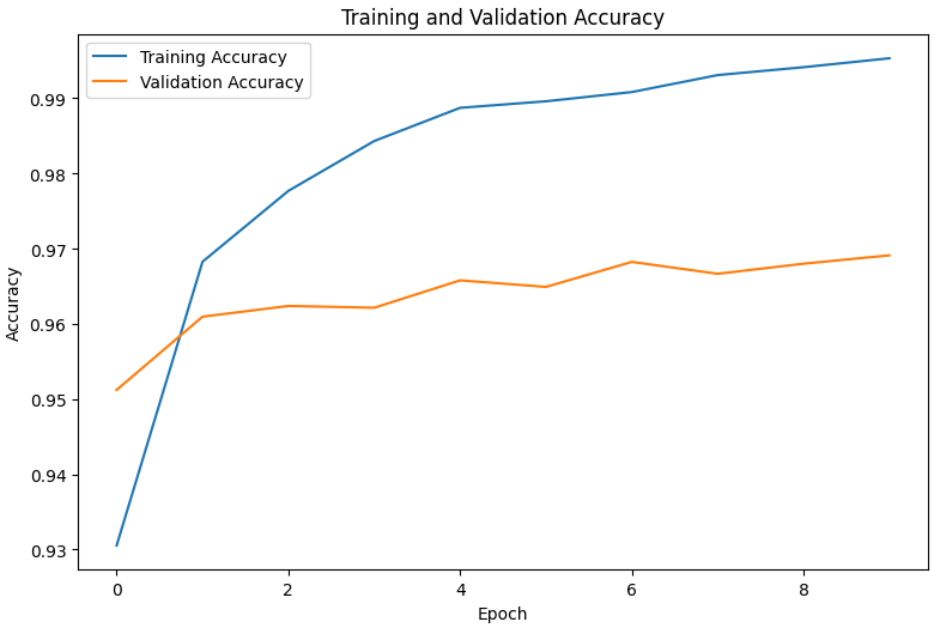

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch

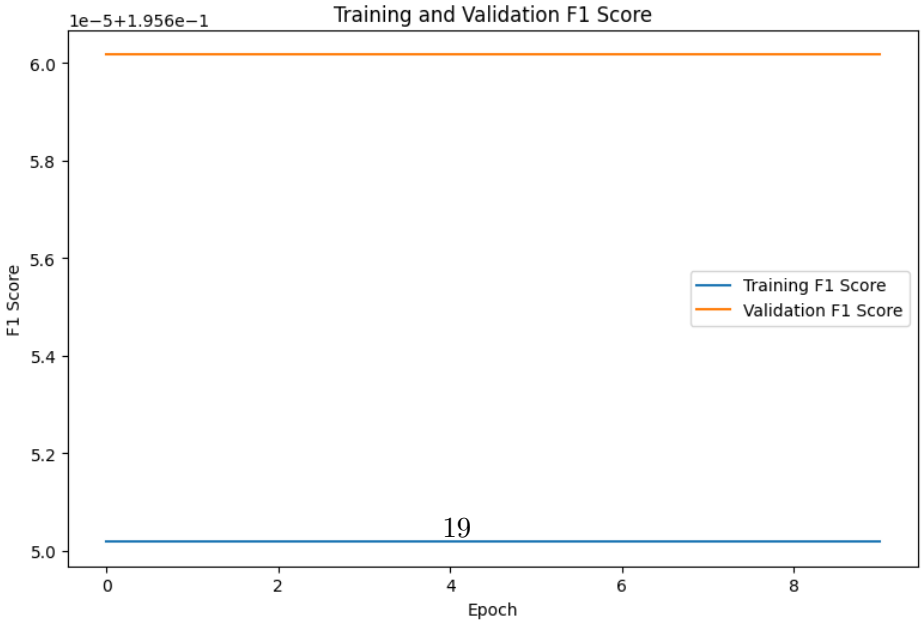

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch

```
395/395 [==============================] - 1s 3ms/step - loss: 0.3933 -
accuracy: 0.9617 - f1_score: 0.1957

2024-02-12 20:14:25,047 - INFO - Nodes: 64, Layers: 1, Epochs: 10, Test
Accuracy: 0.9616664052009583, F1 Score: 0.19566017389297485, Training Time:
75.31173324584961s

2024-02-12 20:14:25,092 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_1_epochs_10.keras

2024-02-12 20:14:25,093 - INFO - Running experiment with Nodes: 128, Layers: 1,
Epochs: 10


Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             (None, 128)               100480

 dense_7 (Dense)             (None, 10)                1290

=================================================================
Total params: 101770 (397.54 KB)
Trainable params: 101770 (397.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

2024-02-12 20:14:25,182 - INFO - None

Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_6 (Dense)             (None, 128)               100480

 dense_7 (Dense)             (None, 10)                1290

=================================================================
Total params: 101770 (397.54 KB)
Trainable params: 101770 (397.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.2508 -
accuracy: 0.9305 - f1_score: 0.1957 - val_loss: 0.2739 - val_accuracy: 0.9512 -
```

```
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.1085 -
accuracy: 0.9683 - f1_score: 0.1957 - val_loss: 0.3288 - val_accuracy: 0.9610 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0736 -
accuracy: 0.9777 - f1_score: 0.1957 - val_loss: 0.3174 - val_accuracy: 0.9624 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0492 -
accuracy: 0.9843 - f1_score: 0.1957 - val_loss: 0.3386 - val_accuracy: 0.9621 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0370 -
accuracy: 0.9887 - f1_score: 0.1957 - val_loss: 0.3908 - val_accuracy: 0.9658 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0320 -
accuracy: 0.9896 - f1_score: 0.1957 - val_loss: 0.4170 - val_accuracy: 0.9649 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0309 -
accuracy: 0.9908 - f1_score: 0.1957 - val_loss: 0.4469 - val_accuracy: 0.9682 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0228 -
accuracy: 0.9931 - f1_score: 0.1957 - val_loss: 0.4904 - val_accuracy: 0.9667 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0199 -
accuracy: 0.9941 - f1_score: 0.1957 - val_loss: 0.4795 - val_accuracy: 0.9680 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0158 -
accuracy: 0.9953 - f1_score: 0.1957 - val_loss: 0.4870 - val_accuracy: 0.9691 -
val_f1_score: 0.1957
```

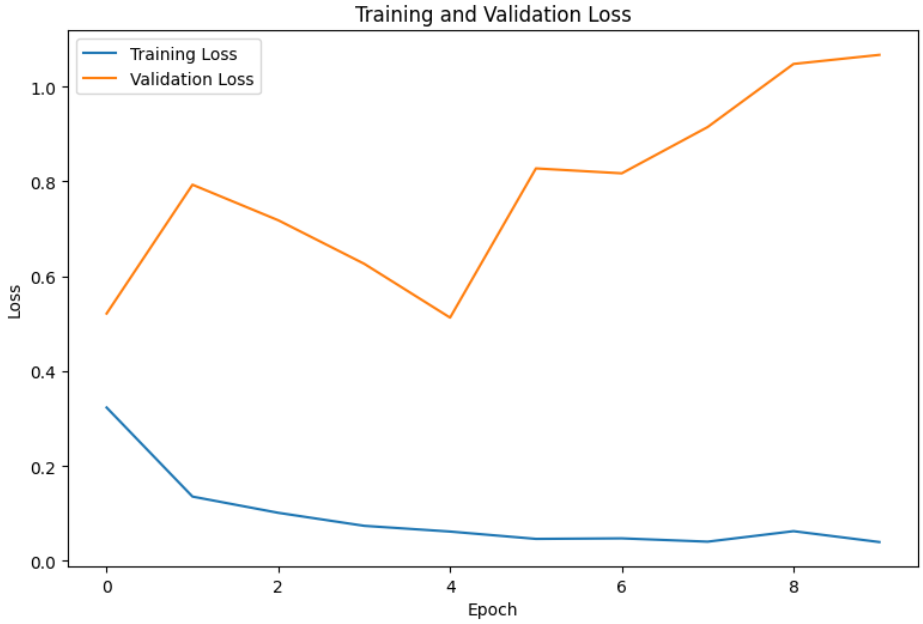

Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8

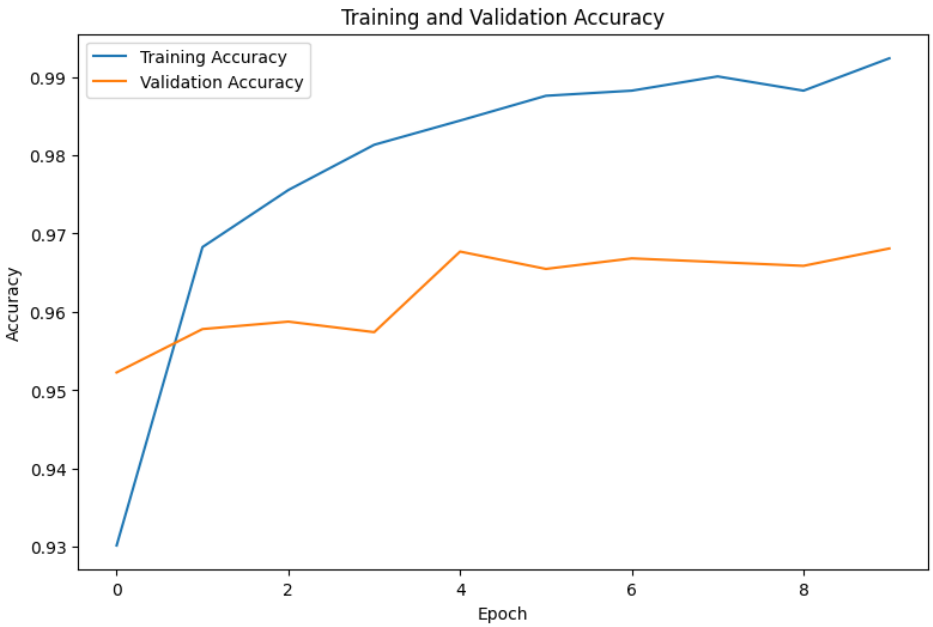

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.93
0.94
0.95
0.96
0.97
0.98
0.99
0
2
4
6
8

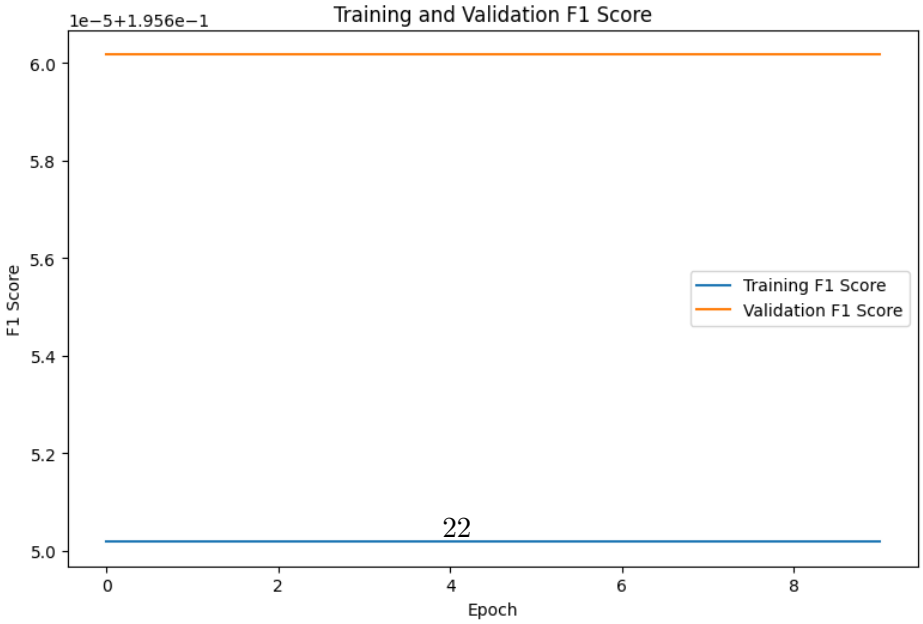

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
2
4
6
8

```
395/395 [==============================] - 1s 3ms/step - loss: 0.4870 -
accuracy: 0.9691 - f1_score: 0.1957

2024-02-12 20:15:56,786 - INFO - Nodes: 128, Layers: 1, Epochs: 10, Test
Accuracy: 0.9691113829612732, F1 Score: 0.19566017389297485, Training Time:
88.62630987167358s

2024-02-12 20:15:56,838 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_128_layers_1_epochs_10.keras

2024-02-12 20:15:56,839 - INFO - Running experiment with Nodes: 512, Layers: 1,
Epochs: 10


Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_8 (Dense)             (None, 512)               401920

 dense_9 (Dense)             (None, 10)                5130

=================================================================
Total params: 407050 (1.55 MB)
Trainable params: 407050 (1.55 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:15:56,946 - INFO - None

Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_8 (Dense)             (None, 512)               401920

 dense_9 (Dense)             (None, 10)                5130

=================================================================
Total params: 407050 (1.55 MB)
Trainable params: 407050 (1.55 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 14s 8ms/step - loss: 0.3230 -
accuracy: 0.9301 - f1_score: 0.1957 - val_loss: 0.5214 - val_accuracy: 0.9522 -
```

```
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1351 -
accuracy: 0.9683 - f1_score: 0.1957 - val_loss: 0.7933 - val_accuracy: 0.9578 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1009 -
accuracy: 0.9755 - f1_score: 0.1957 - val_loss: 0.7182 - val_accuracy: 0.9587 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0734 -
accuracy: 0.9813 - f1_score: 0.1957 - val_loss: 0.6264 - val_accuracy: 0.9574 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0613 -
accuracy: 0.9844 - f1_score: 0.1957 - val_loss: 0.5128 - val_accuracy: 0.9677 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0459 -
accuracy: 0.9876 - f1_score: 0.1957 - val_loss: 0.8277 - val_accuracy: 0.9655 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0470 -
accuracy: 0.9882 - f1_score: 0.1957 - val_loss: 0.8173 - val_accuracy: 0.9668 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 13s 8ms/step - loss: 0.0400 -
accuracy: 0.9901 - f1_score: 0.1957 - val_loss: 0.9150 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0622 -
accuracy: 0.9882 - f1_score: 0.1957 - val_loss: 1.0481 - val_accuracy: 0.9659 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0392 -
accuracy: 0.9924 - f1_score: 0.1957 - val_loss: 1.0673 - val_accuracy: 0.9681 -
val_f1_score: 0.1957
```

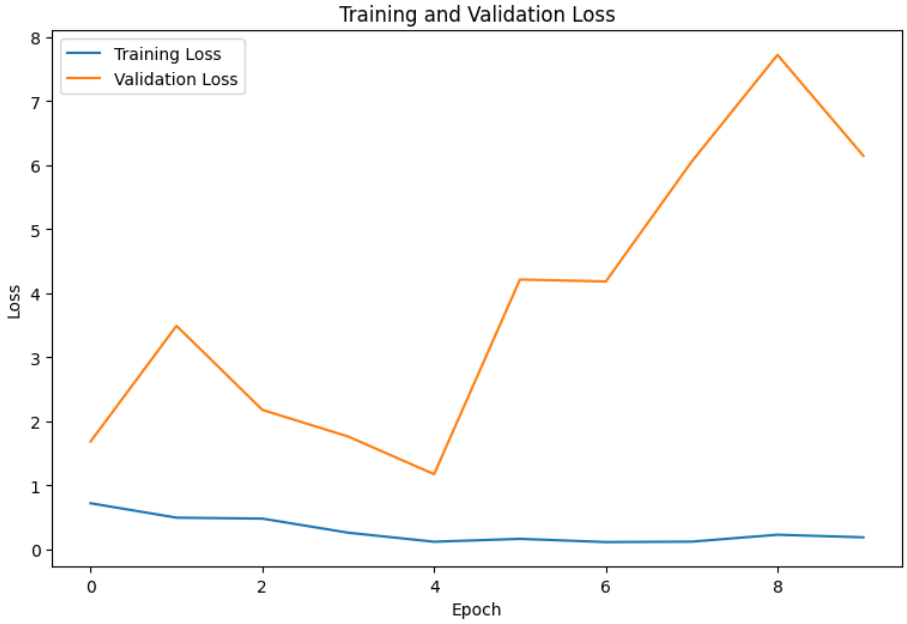

Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8

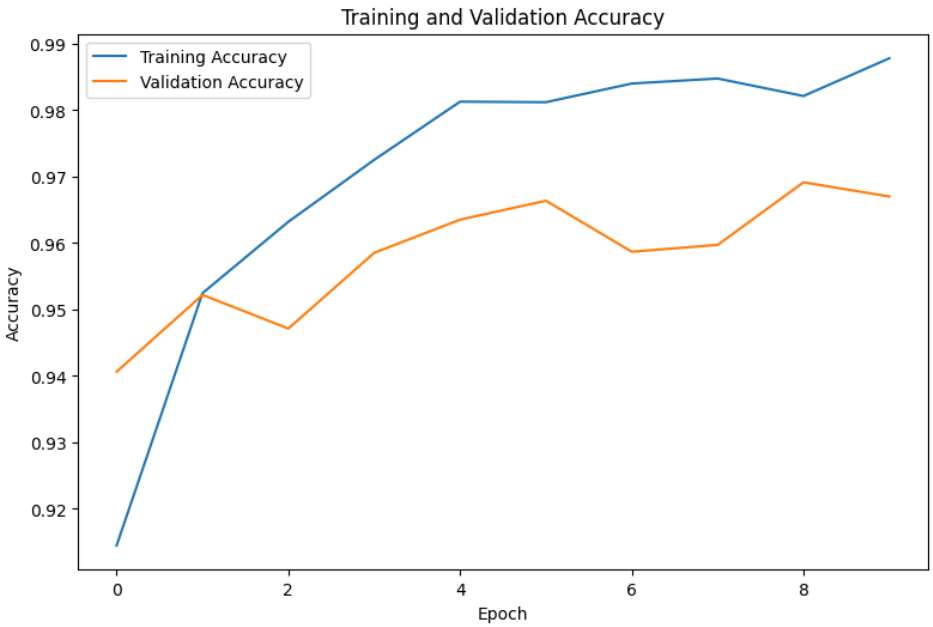

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.93
0.94
0.95
0.96
0.97
0.98
0.99
0
2
4
6
8

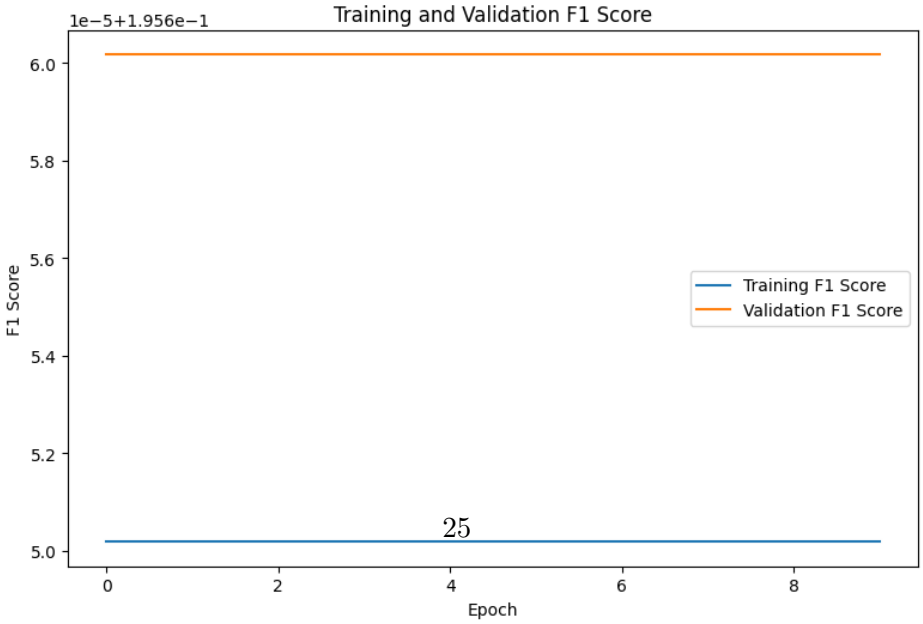

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
2
4
6
8

```
395/395 [==============================] - 2s 5ms/step - loss: 1.0673 -
accuracy: 0.9681 - f1_score: 0.1957

2024-02-12 20:18:06,124 - INFO - Nodes: 512, Layers: 1, Epochs: 10, Test
Accuracy: 0.9680817127227783, F1 Score: 0.19566017389297485, Training Time:
125.9506003856659s

2024-02-12 20:18:06,217 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_512_layers_1_epochs_10.keras

2024-02-12 20:18:06,219 - INFO - Running experiment with Nodes: 2056, Layers: 1,
Epochs: 10


Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_10 (Dense)            (None, 2056)              1613960

 dense_11 (Dense)            (None, 10)                20570

=================================================================
Total params: 1634530 (6.24 MB)
Trainable params: 1634530 (6.24 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:18:06,354 - INFO - None

Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_10 (Dense)            (None, 2056)              1613960

 dense_11 (Dense)            (None, 10)                20570

=================================================================
Total params: 1634530 (6.24 MB)
Trainable params: 1634530 (6.24 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 20s 12ms/step - loss: 0.7207 -
accuracy: 0.9144 - f1_score: 0.1957 - val_loss: 1.6856 - val_accuracy: 0.9406 -
```

```
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.4959 -
accuracy: 0.9524 - f1_score: 0.1957 - val_loss: 3.4922 - val_accuracy: 0.9522 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.4813 -
accuracy: 0.9632 - f1_score: 0.1957 - val_loss: 2.1796 - val_accuracy: 0.9471 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.2611 -
accuracy: 0.9725 - f1_score: 0.1957 - val_loss: 1.7630 - val_accuracy: 0.9585 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.1198 -
accuracy: 0.9812 - f1_score: 0.1957 - val_loss: 1.1747 - val_accuracy: 0.9635 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.1652 -
accuracy: 0.9812 - f1_score: 0.1957 - val_loss: 4.2147 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 18s 11ms/step - loss: 0.1150 -
accuracy: 0.9840 - f1_score: 0.1957 - val_loss: 4.1843 - val_accuracy: 0.9587 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.1214 -
accuracy: 0.9847 - f1_score: 0.1957 - val_loss: 6.0559 - val_accuracy: 0.9597 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 18s 11ms/step - loss: 0.2296 -
accuracy: 0.9821 - f1_score: 0.1957 - val_loss: 7.7233 - val_accuracy: 0.9691 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 18s 12ms/step - loss: 0.1890 -
accuracy: 0.9878 - f1_score: 0.1957 - val_loss: 6.1469 - val_accuracy: 0.9670 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch

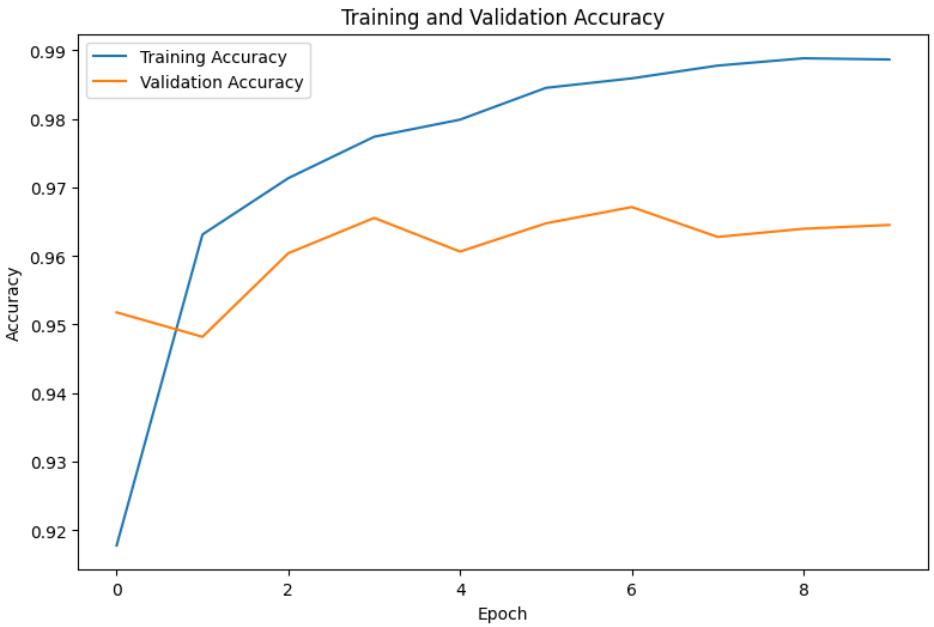

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch

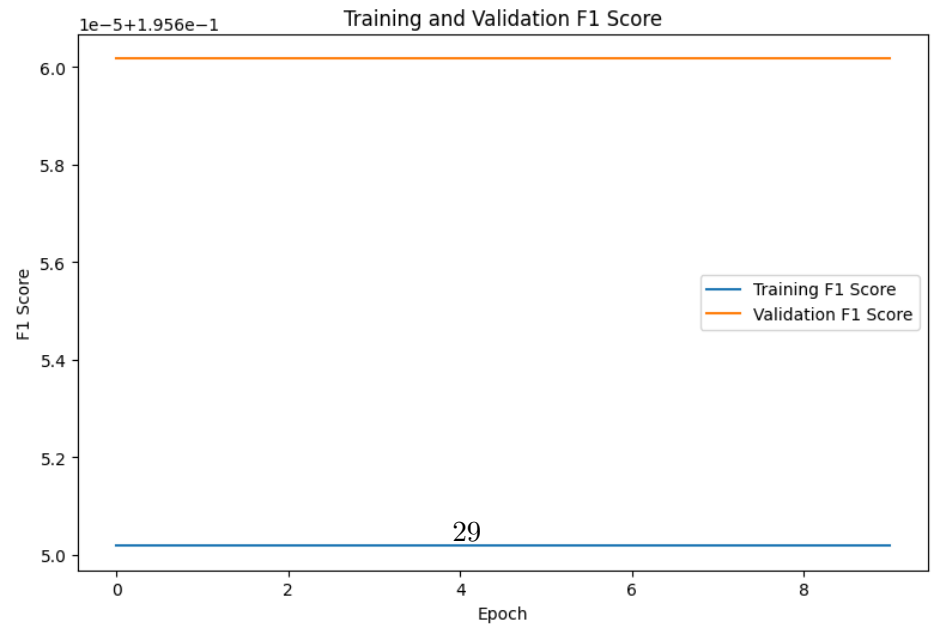
```
395/395 [==============================] - 2s 5ms/step - loss: 6.1469 -
accuracy: 0.9670 - f1_score: 0.1957

2024-02-12 20:21:14,615 - INFO - Nodes: 2056, Layers: 1, Epochs: 10, Test
Accuracy: 0.9669728875160217, F1 Score: 0.19566017389297485, Training Time:
185.04477190971375s

2024-02-12 20:21:14,803 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_2056_layers_1_epochs_10.keras

2024-02-12 20:21:14,805 - INFO - Running experiment with Nodes: 64, Layers: 4,
Epochs: 10


Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_12 (Dense)            (None, 64)                50240

 dense_13 (Dense)            (None, 64)                4160

 dense_14 (Dense)            (None, 64)                4160

 dense_15 (Dense)            (None, 64)                4160

 dense_16 (Dense)            (None, 10)                650

=================================================================
Total params: 63370 (247.54 KB)
Trainable params: 63370 (247.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

2024-02-12 20:21:14,986 - INFO - None

Model: "sequential_6"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_12 (Dense)            (None, 64)                50240

 dense_13 (Dense)            (None, 64)                4160

 dense_14 (Dense)            (None, 64)                4160
```

```
 dense_15 (Dense)            (None, 64)                4160

 dense_16 (Dense)            (None, 10)                650

=================================================================
Total params: 63370 (247.54 KB)
Trainable params: 63370 (247.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 11s 6ms/step - loss: 0.2758 -
accuracy: 0.9178 - f1_score: 0.1957 - val_loss: 0.1855 - val_accuracy: 0.9518 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.1230 -
accuracy: 0.9631 - f1_score: 0.1957 - val_loss: 0.2080 - val_accuracy: 0.9482 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0922 -
accuracy: 0.9713 - f1_score: 0.1957 - val_loss: 0.1579 - val_accuracy: 0.9604 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0713 -
accuracy: 0.9774 - f1_score: 0.1957 - val_loss: 0.1731 - val_accuracy: 0.9655 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0620 -
accuracy: 0.9799 - f1_score: 0.1957 - val_loss: 0.1877 - val_accuracy: 0.9606 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0499 -
accuracy: 0.9845 - f1_score: 0.1957 - val_loss: 0.1798 - val_accuracy: 0.9648 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0447 -
accuracy: 0.9859 - f1_score: 0.1957 - val_loss: 0.2045 - val_accuracy: 0.9671 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0407 -
accuracy: 0.9878 - f1_score: 0.1957 - val_loss: 0.2141 - val_accuracy: 0.9628 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0360 -
accuracy: 0.9888 - f1_score: 0.1957 - val_loss: 0.2161 - val_accuracy: 0.9640 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0372 -
accuracy: 0.9887 - f1_score: 0.1957 - val_loss: 0.2053 - val_accuracy: 0.9645 -
```

```
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.25
0.20
0.15
0.10
0.05
0
2
4
6
8


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0
2
4
6
8

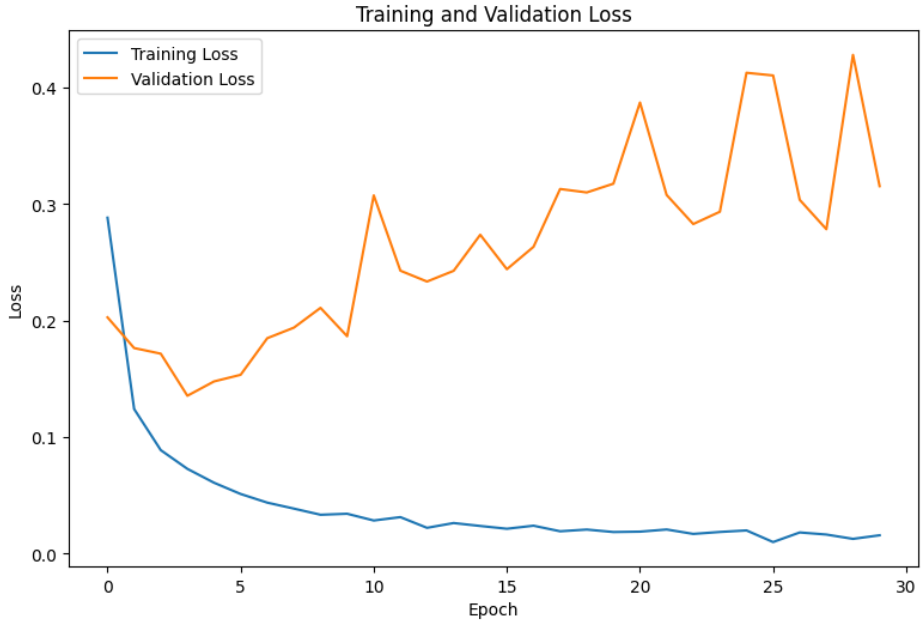

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
6.0
5.8
5.6
5.4
5.2
5.0
0
2
4
6
8

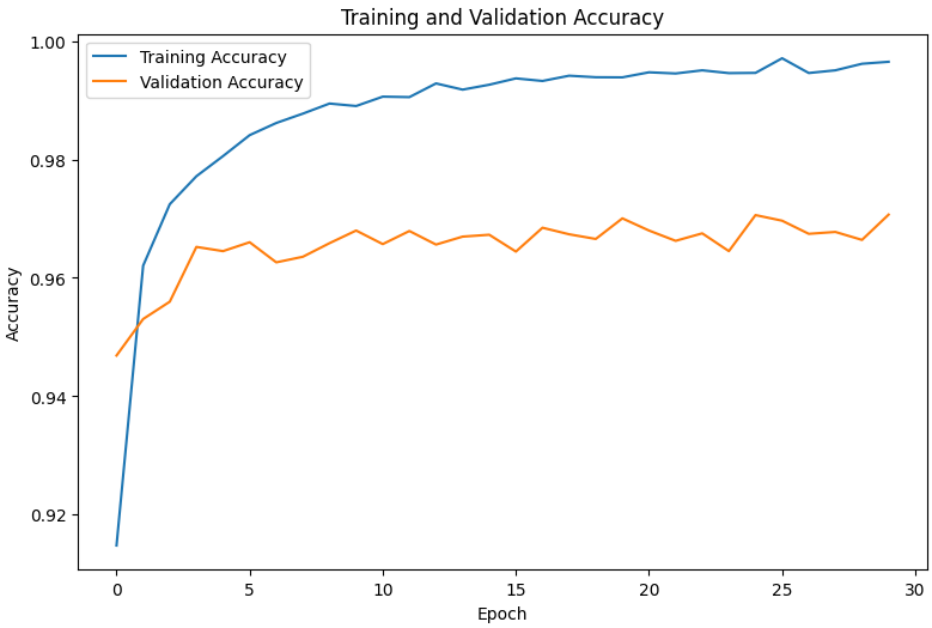
```
395/395 [==============================] - 1s 3ms/step - loss: 0.2053 -
accuracy: 0.9645 - f1_score: 0.1957

2024-02-12 20:22:45,267 - INFO - Nodes: 64, Layers: 4, Epochs: 10, Test
Accuracy: 0.9645176529884338, F1 Score: 0.19566017389297485, Training Time:
87.61051201820374s

2024-02-12 20:22:45,356 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_4_epochs_10.keras

2024-02-12 20:22:45,359 - INFO - Running experiment with Nodes: 64, Layers: 4,
Epochs: 30


Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_17 (Dense)            (None, 64)                50240

 dense_18 (Dense)            (None, 64)                4160

 dense_19 (Dense)            (None, 64)                4160

 dense_20 (Dense)            (None, 64)                4160

 dense_21 (Dense)            (None, 10)                650

=================================================================
Total params: 63370 (247.54 KB)
Trainable params: 63370 (247.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

2024-02-12 20:22:45,498 - INFO - None

Model: "sequential_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_17 (Dense)            (None, 64)                50240

 dense_18 (Dense)            (None, 64)                4160

 dense_19 (Dense)            (None, 64)                4160
```

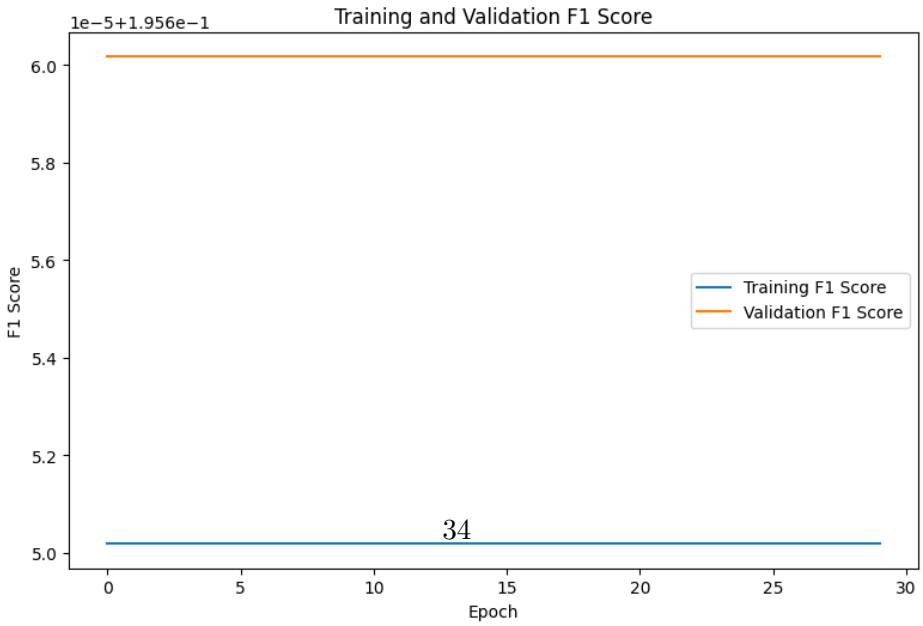
```
 dense_20 (Dense)            (None, 64)                4160

 dense_21 (Dense)            (None, 10)                650

=================================================================
Total params: 63370 (247.54 KB)
Trainable params: 63370 (247.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/30
1579/1579 [==============================] - 11s 6ms/step - loss: 0.2881 -
accuracy: 0.9147 - f1_score: 0.1957 - val_loss: 0.2026 - val_accuracy: 0.9469 -
val_f1_score: 0.1957
Epoch 2/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.1240 -
accuracy: 0.9621 - f1_score: 0.1957 - val_loss: 0.1763 - val_accuracy: 0.9530 -
val_f1_score: 0.1957
Epoch 3/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0888 -
accuracy: 0.9725 - f1_score: 0.1957 - val_loss: 0.1715 - val_accuracy: 0.9560 -
val_f1_score: 0.1957
Epoch 4/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0728 -
accuracy: 0.9772 - f1_score: 0.1957 - val_loss: 0.1354 - val_accuracy: 0.9652 -
val_f1_score: 0.1957
Epoch 5/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0609 -
accuracy: 0.9806 - f1_score: 0.1957 - val_loss: 0.1477 - val_accuracy: 0.9645 -
val_f1_score: 0.1957
Epoch 6/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0512 -
accuracy: 0.9841 - f1_score: 0.1957 - val_loss: 0.1534 - val_accuracy: 0.9660 -
val_f1_score: 0.1957
Epoch 7/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0438 -
accuracy: 0.9862 - f1_score: 0.1957 - val_loss: 0.1848 - val_accuracy: 0.9626 -
val_f1_score: 0.1957
Epoch 8/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0387 -
accuracy: 0.9878 - f1_score: 0.1957 - val_loss: 0.1938 - val_accuracy: 0.9636 -
val_f1_score: 0.1957
Epoch 9/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0334 -
accuracy: 0.9895 - f1_score: 0.1957 - val_loss: 0.2108 - val_accuracy: 0.9659 -
val_f1_score: 0.1957
Epoch 10/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0343 -
accuracy: 0.9891 - f1_score: 0.1957 - val_loss: 0.1864 - val_accuracy: 0.9680 -
```

```
val_f1_score: 0.1957
Epoch 11/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0285 -
accuracy: 0.9907 - f1_score: 0.1957 - val_loss: 0.3072 - val_accuracy: 0.9657 -
val_f1_score: 0.1957
Epoch 12/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0314 -
accuracy: 0.9906 - f1_score: 0.1957 - val_loss: 0.2426 - val_accuracy: 0.9679 -
val_f1_score: 0.1957
Epoch 13/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0222 -
accuracy: 0.9929 - f1_score: 0.1957 - val_loss: 0.2333 - val_accuracy: 0.9656 -
val_f1_score: 0.1957
Epoch 14/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0263 -
accuracy: 0.9918 - f1_score: 0.1957 - val_loss: 0.2425 - val_accuracy: 0.9670 -
val_f1_score: 0.1957
Epoch 15/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0238 -
accuracy: 0.9927 - f1_score: 0.1957 - val_loss: 0.2734 - val_accuracy: 0.9673 -
val_f1_score: 0.1957
Epoch 16/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0214 -
accuracy: 0.9937 - f1_score: 0.1957 - val_loss: 0.2439 - val_accuracy: 0.9644 -
val_f1_score: 0.1957
Epoch 17/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0240 -
accuracy: 0.9933 - f1_score: 0.1957 - val_loss: 0.2631 - val_accuracy: 0.9685 -
val_f1_score: 0.1957
Epoch 18/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0192 -
accuracy: 0.9942 - f1_score: 0.1957 - val_loss: 0.3127 - val_accuracy: 0.9674 -
val_f1_score: 0.1957
Epoch 19/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0207 -
accuracy: 0.9939 - f1_score: 0.1957 - val_loss: 0.3097 - val_accuracy: 0.9666 -
val_f1_score: 0.1957
Epoch 20/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0186 -
accuracy: 0.9939 - f1_score: 0.1957 - val_loss: 0.3172 - val_accuracy: 0.9701 -
val_f1_score: 0.1957
Epoch 21/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0189 -
accuracy: 0.9948 - f1_score: 0.1957 - val_loss: 0.3868 - val_accuracy: 0.9680 -
val_f1_score: 0.1957
Epoch 22/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0208 -
accuracy: 0.9946 - f1_score: 0.1957 - val_loss: 0.3075 - val_accuracy: 0.9663 -
```

```
val_f1_score: 0.1957
Epoch 23/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0170 -
accuracy: 0.9951 - f1_score: 0.1957 - val_loss: 0.2826 - val_accuracy: 0.9675 -
val_f1_score: 0.1957
Epoch 24/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0187 -
accuracy: 0.9946 - f1_score: 0.1957 - val_loss: 0.2932 - val_accuracy: 0.9645 -
val_f1_score: 0.1957
Epoch 25/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0200 -
accuracy: 0.9947 - f1_score: 0.1957 - val_loss: 0.4123 - val_accuracy: 0.9706 -
val_f1_score: 0.1957
Epoch 26/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0100 -
accuracy: 0.9971 - f1_score: 0.1957 - val_loss: 0.4100 - val_accuracy: 0.9697 -
val_f1_score: 0.1957
Epoch 27/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0182 -
accuracy: 0.9947 - f1_score: 0.1957 - val_loss: 0.3034 - val_accuracy: 0.9674 -
val_f1_score: 0.1957
Epoch 28/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0164 -
accuracy: 0.9951 - f1_score: 0.1957 - val_loss: 0.2782 - val_accuracy: 0.9678 -
val_f1_score: 0.1957
Epoch 29/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0127 -
accuracy: 0.9962 - f1_score: 0.1957 - val_loss: 0.4276 - val_accuracy: 0.9664 -
val_f1_score: 0.1957
Epoch 30/30
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0158 -
accuracy: 0.9966 - f1_score: 0.1957 - val_loss: 0.3151 - val_accuracy: 0.9707 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.1
0.2
0.3
0.4
0
5
10
15
20
25
30

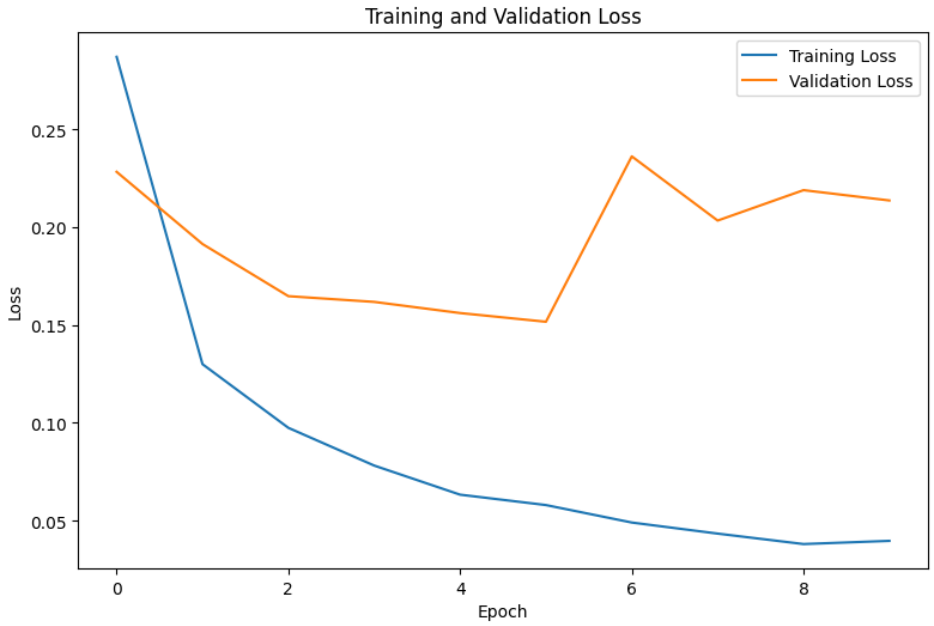

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.92
0.94
0.96
0.98
1.00
0
5
10
15
20
25
30

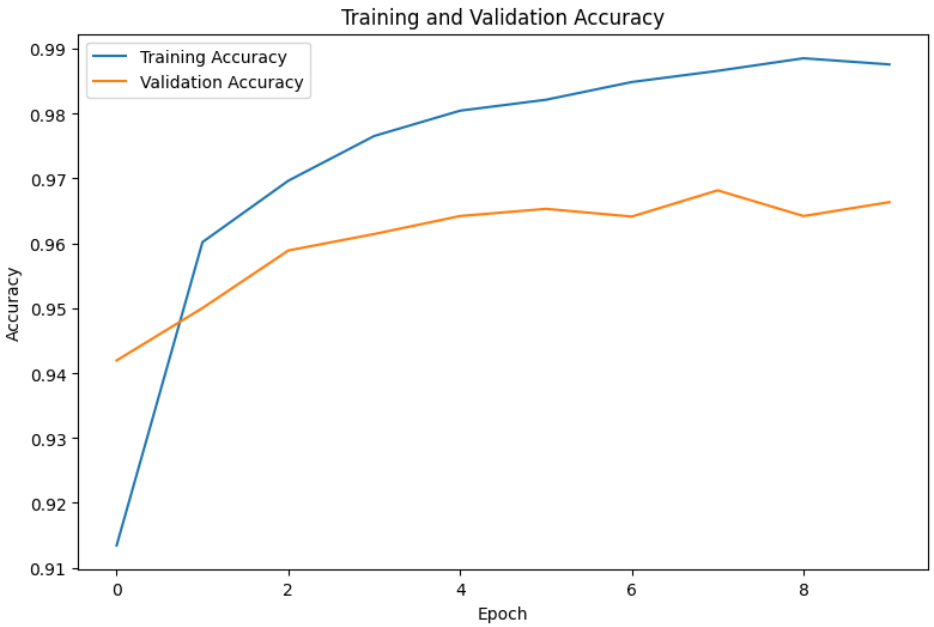

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
5
10
15
20
25
30

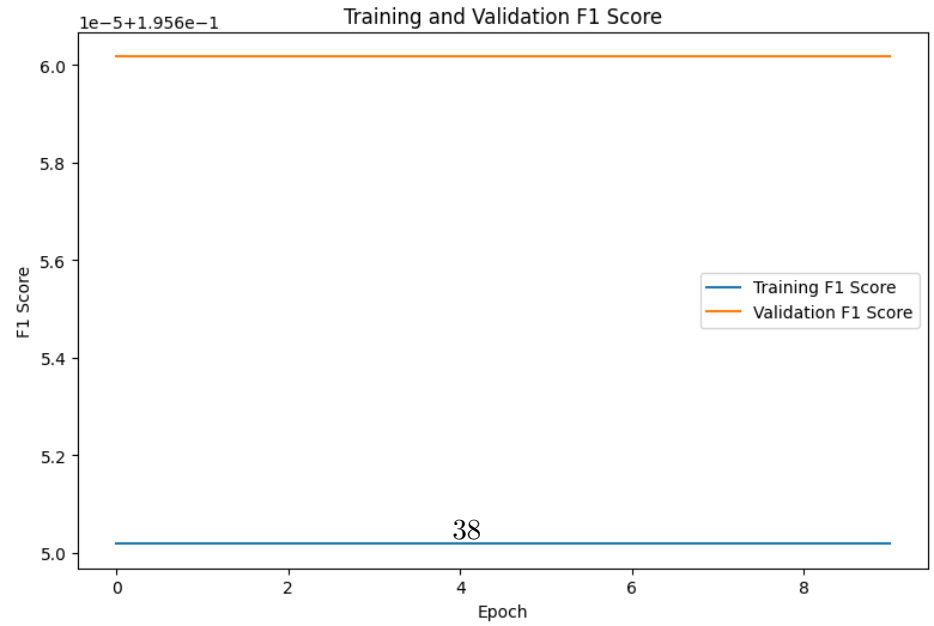
```
395/395 [==============================] - 1s 3ms/step - loss: 0.3151 -
accuracy: 0.9707 - f1_score: 0.1957

2024-02-12 20:27:04,167 - INFO - Nodes: 64, Layers: 4, Epochs: 30, Test
Accuracy: 0.9706953763961792, F1 Score: 0.19566017389297485, Training Time:
255.99460887908936s

2024-02-12 20:27:04,219 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_4_epochs_30.keras

2024-02-12 20:27:04,221 - INFO - Running experiment with Nodes: 64, Layers: 5,
Epochs: 10


Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_22 (Dense)            (None, 64)                50240

 dense_23 (Dense)            (None, 64)                4160

 dense_24 (Dense)            (None, 64)                4160

 dense_25 (Dense)            (None, 64)                4160

 dense_26 (Dense)            (None, 64)                4160

 dense_27 (Dense)            (None, 10)                650

=================================================================
Total params: 67530 (263.79 KB)
Trainable params: 67530 (263.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:27:04,446 - INFO - None

Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_22 (Dense)            (None, 64)                50240

 dense_23 (Dense)            (None, 64)                4160
```

```
 dense_24 (Dense)            (None, 64)                4160

 dense_25 (Dense)            (None, 64)                4160

 dense_26 (Dense)            (None, 64)                4160

 dense_27 (Dense)            (None, 10)                650

=================================================================
Total params: 67530 (263.79 KB)
Trainable params: 67530 (263.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 11s 6ms/step - loss: 0.2870 -
accuracy: 0.9134 - f1_score: 0.1957 - val_loss: 0.2283 - val_accuracy: 0.9419 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.1300 -
accuracy: 0.9602 - f1_score: 0.1957 - val_loss: 0.1914 - val_accuracy: 0.9500 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0974 -
accuracy: 0.9696 - f1_score: 0.1957 - val_loss: 0.1647 - val_accuracy: 0.9589 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0782 -
accuracy: 0.9765 - f1_score: 0.1957 - val_loss: 0.1618 - val_accuracy: 0.9614 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0633 -
accuracy: 0.9804 - f1_score: 0.1957 - val_loss: 0.1561 - val_accuracy: 0.9642 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0580 -
accuracy: 0.9821 - f1_score: 0.1957 - val_loss: 0.1516 - val_accuracy: 0.9653 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0491 -
accuracy: 0.9849 - f1_score: 0.1957 - val_loss: 0.2362 - val_accuracy: 0.9641 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0434 -
accuracy: 0.9866 - f1_score: 0.1957 - val_loss: 0.2034 - val_accuracy: 0.9682 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0381 -
accuracy: 0.9885 - f1_score: 0.1957 - val_loss: 0.2189 - val_accuracy: 0.9642 -
```

```
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 8s 5ms/step - loss: 0.0397 -
accuracy: 0.9876 - f1_score: 0.1957 - val_loss: 0.2136 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
0.25
0.20
0.15
0.10
0.05
0
2
4
6
8
Epoch


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0
2
4
6
8
Epoch

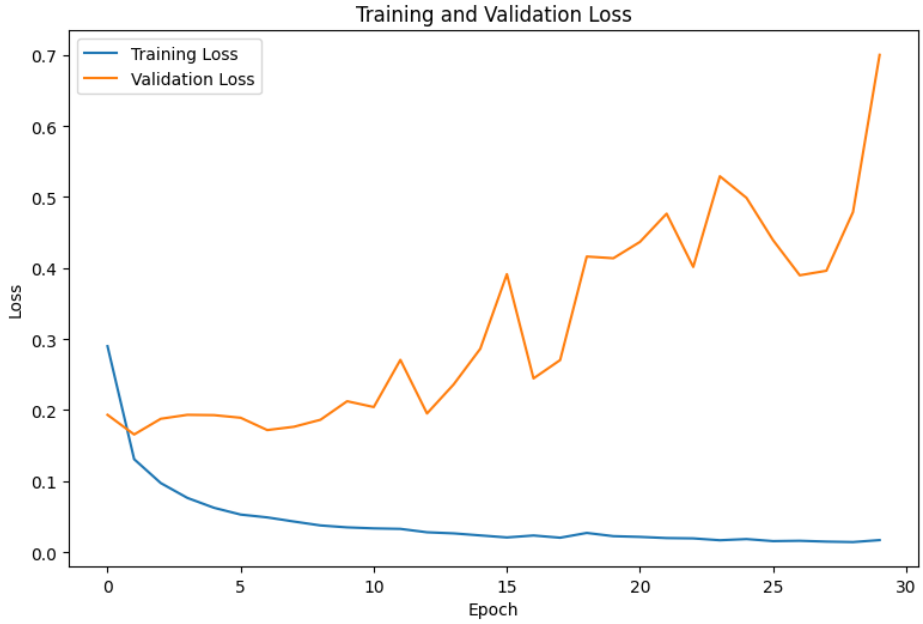

Training and Validation F1 Score
1e−5+1.956e−1
F1 Score
6.0
5.8
5.6
5.4
5.2
5.0
Training F1 Score
Validation F1 Score
0
2
4
6
8
Epoch

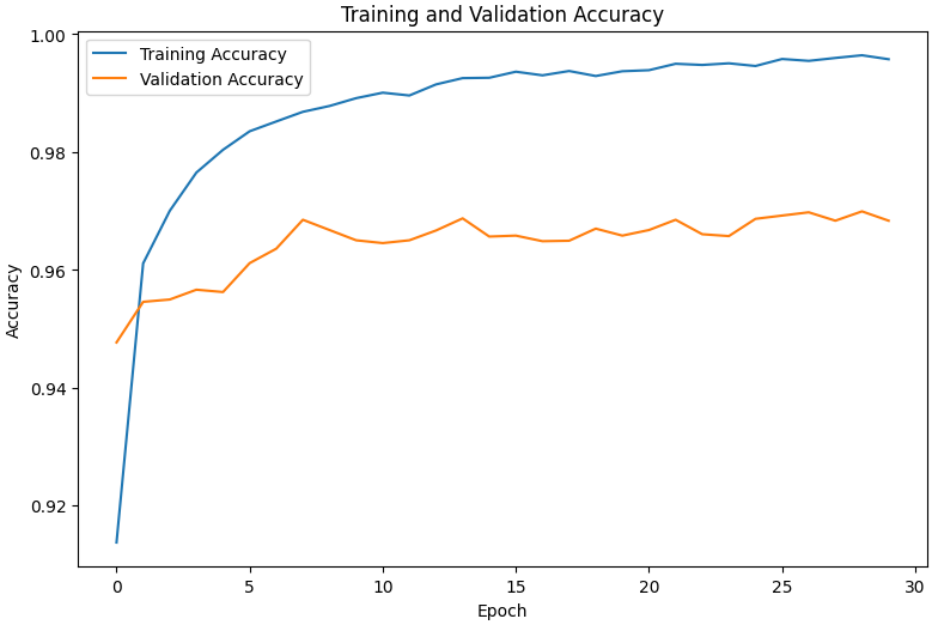
```
395/395 [==============================] - 2s 4ms/step - loss: 0.2136 -
accuracy: 0.9663 - f1_score: 0.1957

2024-02-12 20:28:37,056 - INFO - Nodes: 64, Layers: 5, Epochs: 10, Test
Accuracy: 0.9663392901420593, F1 Score: 0.19566017389297485, Training Time:
89.38357043266296s

2024-02-12 20:28:37,161 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_5_epochs_10.keras

2024-02-12 20:28:37,163 - INFO - Running experiment with Nodes: 64, Layers: 5,
Epochs: 30


Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_28 (Dense)            (None, 64)                50240

 dense_29 (Dense)            (None, 64)                4160

 dense_30 (Dense)            (None, 64)                4160

 dense_31 (Dense)            (None, 64)                4160

 dense_32 (Dense)            (None, 64)                4160

 dense_33 (Dense)            (None, 10)                650

=================================================================
Total params: 67530 (263.79 KB)
Trainable params: 67530 (263.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:28:37,398 - INFO - None

Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_28 (Dense)            (None, 64)                50240

 dense_29 (Dense)            (None, 64)                4160
```

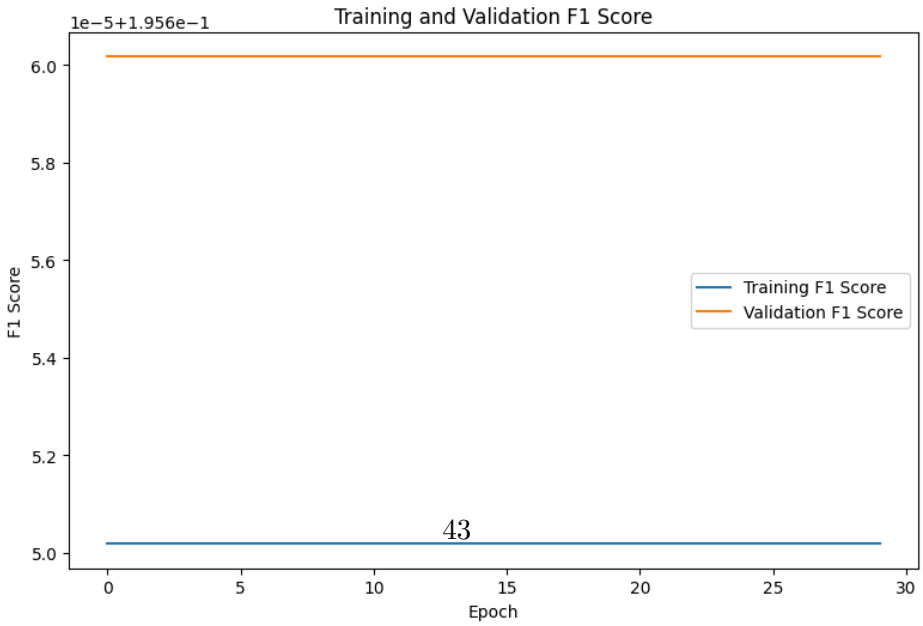
```
 dense_30 (Dense)            (None, 64)                4160

 dense_31 (Dense)            (None, 64)                4160

 dense_32 (Dense)            (None, 64)                4160

 dense_33 (Dense)            (None, 10)                650

=================================================================
Total params: 67530 (263.79 KB)
Trainable params: 67530 (263.79 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/30
1579/1579 [==============================] - 11s 6ms/step - loss: 0.2899 -
accuracy: 0.9137 - f1_score: 0.1957 - val_loss: 0.1933 - val_accuracy: 0.9476 -
val_f1_score: 0.1957
Epoch 2/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.1309 -
accuracy: 0.9611 - f1_score: 0.1957 - val_loss: 0.1657 - val_accuracy: 0.9545 -
val_f1_score: 0.1957
Epoch 3/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0973 -
accuracy: 0.9700 - f1_score: 0.1957 - val_loss: 0.1878 - val_accuracy: 0.9549 -
val_f1_score: 0.1957
Epoch 4/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0764 -
accuracy: 0.9765 - f1_score: 0.1957 - val_loss: 0.1933 - val_accuracy: 0.9566 -
val_f1_score: 0.1957
Epoch 5/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0625 -
accuracy: 0.9804 - f1_score: 0.1957 - val_loss: 0.1929 - val_accuracy: 0.9562 -
val_f1_score: 0.1957
Epoch 6/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0529 -
accuracy: 0.9835 - f1_score: 0.1957 - val_loss: 0.1892 - val_accuracy: 0.9611 -
val_f1_score: 0.1957
Epoch 7/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0490 -
accuracy: 0.9852 - f1_score: 0.1957 - val_loss: 0.1719 - val_accuracy: 0.9636 -
val_f1_score: 0.1957
Epoch 8/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0432 -
accuracy: 0.9868 - f1_score: 0.1957 - val_loss: 0.1765 - val_accuracy: 0.9685 -
val_f1_score: 0.1957
Epoch 9/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0376 -
accuracy: 0.9878 - f1_score: 0.1957 - val_loss: 0.1864 - val_accuracy: 0.9667 -
```

```
val_f1_score: 0.1957
Epoch 10/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0349 -
accuracy: 0.9891 - f1_score: 0.1957 - val_loss: 0.2125 - val_accuracy: 0.9650 -
val_f1_score: 0.1957
Epoch 11/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0335 -
accuracy: 0.9901 - f1_score: 0.1957 - val_loss: 0.2043 - val_accuracy: 0.9645 -
val_f1_score: 0.1957
Epoch 12/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0328 -
accuracy: 0.9896 - f1_score: 0.1957 - val_loss: 0.2707 - val_accuracy: 0.9650 -
val_f1_score: 0.1957
Epoch 13/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0280 -
accuracy: 0.9915 - f1_score: 0.1957 - val_loss: 0.1952 - val_accuracy: 0.9667 -
val_f1_score: 0.1957
Epoch 14/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0265 -
accuracy: 0.9925 - f1_score: 0.1957 - val_loss: 0.2361 - val_accuracy: 0.9687 -
val_f1_score: 0.1957
Epoch 15/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0236 -
accuracy: 0.9926 - f1_score: 0.1957 - val_loss: 0.2863 - val_accuracy: 0.9656 -
val_f1_score: 0.1957
Epoch 16/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0208 -
accuracy: 0.9936 - f1_score: 0.1957 - val_loss: 0.3914 - val_accuracy: 0.9658 -
val_f1_score: 0.1957
Epoch 17/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0235 -
accuracy: 0.9930 - f1_score: 0.1957 - val_loss: 0.2446 - val_accuracy: 0.9648 -
val_f1_score: 0.1957
Epoch 18/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0204 -
accuracy: 0.9937 - f1_score: 0.1957 - val_loss: 0.2704 - val_accuracy: 0.9649 -
val_f1_score: 0.1957
Epoch 19/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0271 -
accuracy: 0.9929 - f1_score: 0.1957 - val_loss: 0.4161 - val_accuracy: 0.9670 -
val_f1_score: 0.1957
Epoch 20/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0225 -
accuracy: 0.9937 - f1_score: 0.1957 - val_loss: 0.4137 - val_accuracy: 0.9658 -
val_f1_score: 0.1957
Epoch 21/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0215 -
accuracy: 0.9939 - f1_score: 0.1957 - val_loss: 0.4368 - val_accuracy: 0.9667 -
```

```
val_f1_score: 0.1957
Epoch 22/30
1579/1579 [==============================] - 9s 5ms/step - loss: 0.0199 -
accuracy: 0.9950 - f1_score: 0.1957 - val_loss: 0.4765 - val_accuracy: 0.9685 -
val_f1_score: 0.1957
Epoch 23/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0194 -
accuracy: 0.9948 - f1_score: 0.1957 - val_loss: 0.4015 - val_accuracy: 0.9660 -
val_f1_score: 0.1957
Epoch 24/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0168 -
accuracy: 0.9950 - f1_score: 0.1957 - val_loss: 0.5292 - val_accuracy: 0.9657 -
val_f1_score: 0.1957
Epoch 25/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0184 -
accuracy: 0.9946 - f1_score: 0.1957 - val_loss: 0.4987 - val_accuracy: 0.9686 -
val_f1_score: 0.1957
Epoch 26/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0156 -
accuracy: 0.9958 - f1_score: 0.1957 - val_loss: 0.4391 - val_accuracy: 0.9692 -
val_f1_score: 0.1957
Epoch 27/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0161 -
accuracy: 0.9955 - f1_score: 0.1957 - val_loss: 0.3897 - val_accuracy: 0.9697 -
val_f1_score: 0.1957
Epoch 28/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0149 -
accuracy: 0.9960 - f1_score: 0.1957 - val_loss: 0.3961 - val_accuracy: 0.9683 -
val_f1_score: 0.1957
Epoch 29/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0143 -
accuracy: 0.9964 - f1_score: 0.1957 - val_loss: 0.4787 - val_accuracy: 0.9699 -
val_f1_score: 0.1957
Epoch 30/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0170 -
accuracy: 0.9957 - f1_score: 0.1957 - val_loss: 0.7000 - val_accuracy: 0.9683 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
5
10
15
20
25
30

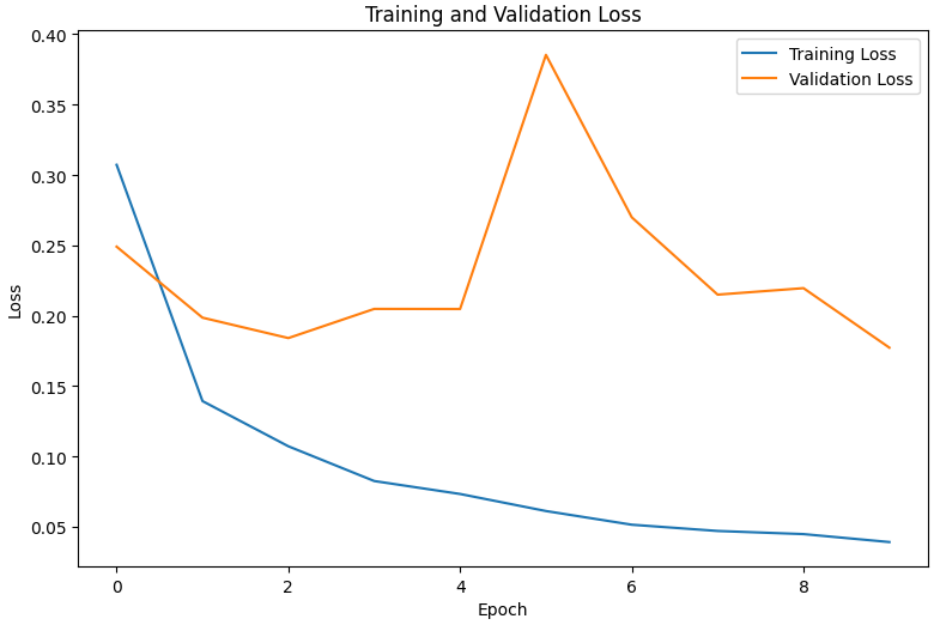

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.92
0.94
0.96
0.98
1.00
0
5
10
15
20
25
30

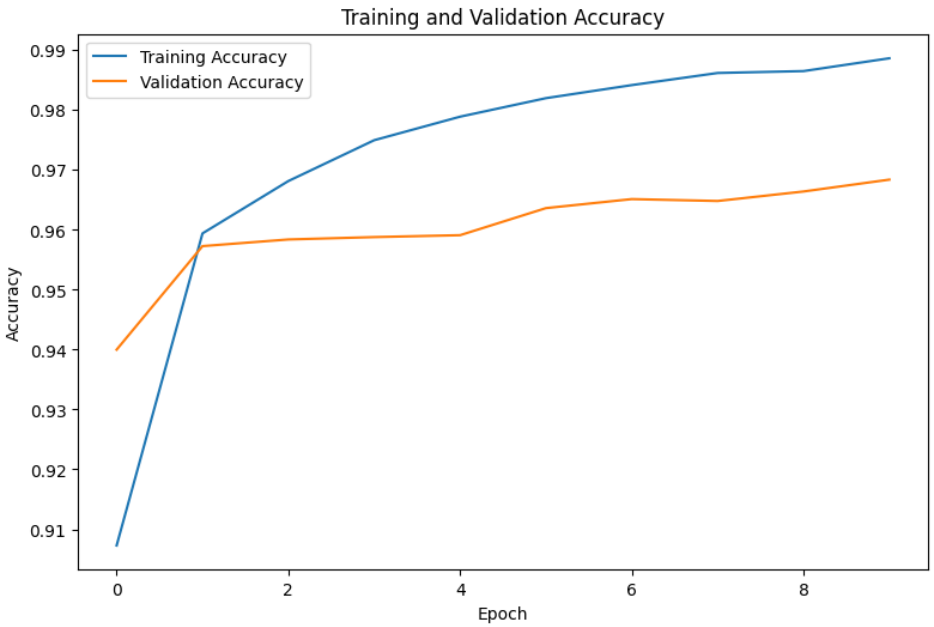

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
5
10
15
20
25
30

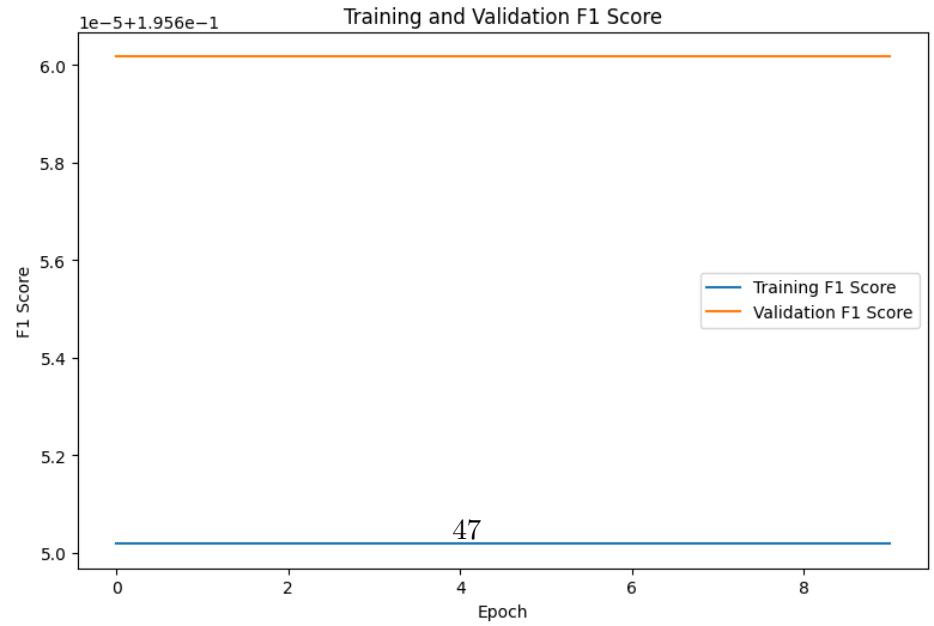
```
395/395 [==============================] - 1s 4ms/step - loss: 0.7000 -
accuracy: 0.9683 - f1_score: 0.1957

2024-02-12 20:33:06,101 - INFO - Nodes: 64, Layers: 5, Epochs: 30, Test
Accuracy: 0.9683193564414978, F1 Score: 0.19566017389297485, Training Time:
266.10791873931885s

2024-02-12 20:33:06,161 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_5_epochs_30.keras

2024-02-12 20:33:06,162 - INFO - Running experiment with Nodes: 64, Layers: 6,
Epochs: 10


Model: "sequential_10"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_34 (Dense)            (None, 64)                50240

 dense_35 (Dense)            (None, 64)                4160

 dense_36 (Dense)            (None, 64)                4160

 dense_37 (Dense)            (None, 64)                4160

 dense_38 (Dense)            (None, 64)                4160

 dense_39 (Dense)            (None, 64)                4160

 dense_40 (Dense)            (None, 10)                650

=================================================================
Total params: 71690 (280.04 KB)
Trainable params: 71690 (280.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

2024-02-12 20:33:06,388 - INFO - None

Model: "sequential_10"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_34 (Dense)            (None, 64)                50240
```

```
 dense_35 (Dense)            (None, 64)                4160

 dense_36 (Dense)            (None, 64)                4160

 dense_37 (Dense)            (None, 64)                4160

 dense_38 (Dense)            (None, 64)                4160

 dense_39 (Dense)            (None, 64)                4160

 dense_40 (Dense)            (None, 10)                650

=================================================================
Total params: 71690 (280.04 KB)
Trainable params: 71690 (280.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 11s 6ms/step - loss: 0.3072 -
accuracy: 0.9073 - f1_score: 0.1957 - val_loss: 0.2490 - val_accuracy: 0.9400 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.1393 -
accuracy: 0.9593 - f1_score: 0.1957 - val_loss: 0.1986 - val_accuracy: 0.9572 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.1071 -
accuracy: 0.9681 - f1_score: 0.1957 - val_loss: 0.1840 - val_accuracy: 0.9583 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0824 -
accuracy: 0.9749 - f1_score: 0.1957 - val_loss: 0.2048 - val_accuracy: 0.9587 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0732 -
accuracy: 0.9788 - f1_score: 0.1957 - val_loss: 0.2047 - val_accuracy: 0.9591 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0611 -
accuracy: 0.9819 - f1_score: 0.1957 - val_loss: 0.3854 - val_accuracy: 0.9636 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0514 -
accuracy: 0.9841 - f1_score: 0.1957 - val_loss: 0.2699 - val_accuracy: 0.9651 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0469 -
accuracy: 0.9861 - f1_score: 0.1957 - val_loss: 0.2149 - val_accuracy: 0.9648 -
```

```
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0447 -
accuracy: 0.9864 - f1_score: 0.1957 - val_loss: 0.2195 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0390 -
accuracy: 0.9886 - f1_score: 0.1957 - val_loss: 0.1772 - val_accuracy: 0.9683 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
2
4
6
8


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0
2
4
6
8

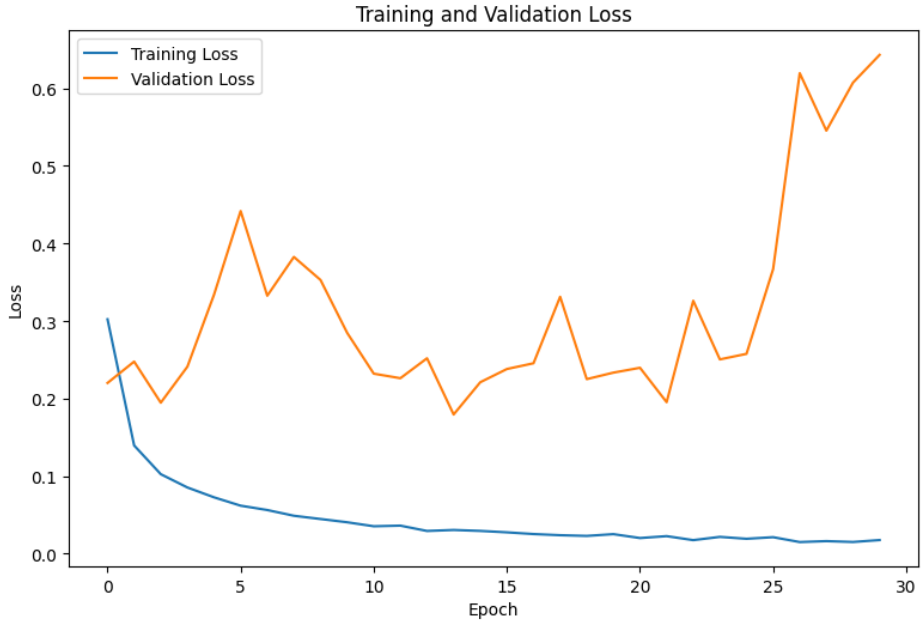

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
6.0
5.8
5.6
5.4
5.2
5.0
0
2
4
6
8

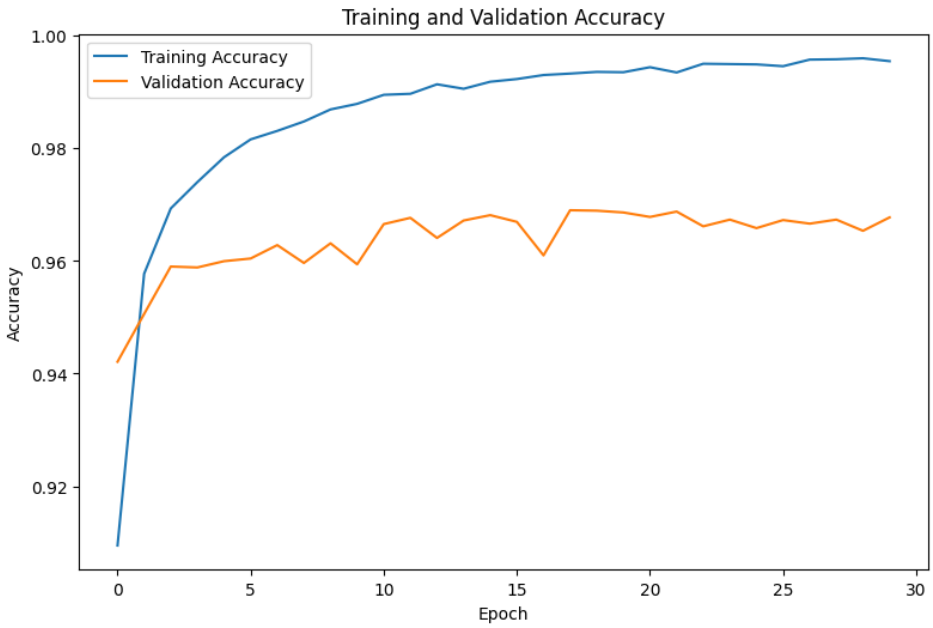
```
395/395 [==============================] - 1s 4ms/step - loss: 0.1772 -
accuracy: 0.9683 - f1_score: 0.1957

2024-02-12 20:34:41,168 - INFO - Nodes: 64, Layers: 6, Epochs: 10, Test
Accuracy: 0.9683193564414978, F1 Score: 0.19566017389297485, Training Time:
91.98444747924805s

2024-02-12 20:34:41,240 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_6_epochs_10.keras

2024-02-12 20:34:41,242 - INFO - Running experiment with Nodes: 64, Layers: 6,
Epochs: 30


Model: "sequential_11"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_41 (Dense)            (None, 64)                50240

 dense_42 (Dense)            (None, 64)                4160

 dense_43 (Dense)            (None, 64)                4160

 dense_44 (Dense)            (None, 64)                4160

 dense_45 (Dense)            (None, 64)                4160

 dense_46 (Dense)            (None, 64)                4160

 dense_47 (Dense)            (None, 10)                650

=================================================================
Total params: 71690 (280.04 KB)
Trainable params: 71690 (280.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________

2024-02-12 20:34:41,456 - INFO - None

Model: "sequential_11"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_41 (Dense)            (None, 64)                50240
```

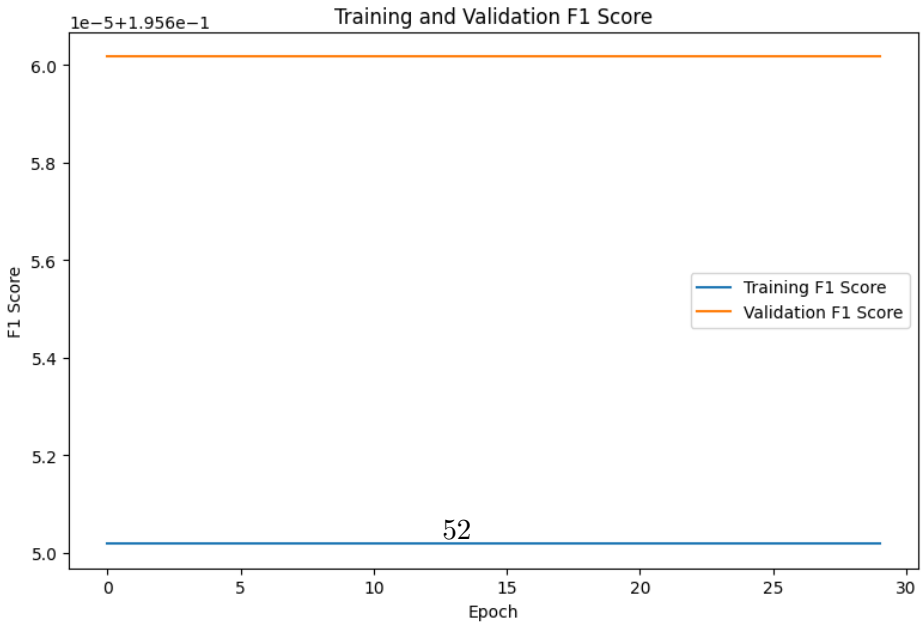
```
 dense_42 (Dense)            (None, 64)                4160

 dense_43 (Dense)            (None, 64)                4160

 dense_44 (Dense)            (None, 64)                4160

 dense_45 (Dense)            (None, 64)                4160

 dense_46 (Dense)            (None, 64)                4160

 dense_47 (Dense)            (None, 10)                650

=================================================================
Total params: 71690 (280.04 KB)
Trainable params: 71690 (280.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/30
1579/1579 [==============================] - 12s 6ms/step - loss: 0.3022 -
accuracy: 0.9096 - f1_score: 0.1957 - val_loss: 0.2201 - val_accuracy: 0.9421 -
val_f1_score: 0.1957
Epoch 2/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.1396 -
accuracy: 0.9577 - f1_score: 0.1957 - val_loss: 0.2477 - val_accuracy: 0.9506 -
val_f1_score: 0.1957
Epoch 3/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.1026 -
accuracy: 0.9693 - f1_score: 0.1957 - val_loss: 0.1947 - val_accuracy: 0.9590 -
val_f1_score: 0.1957
Epoch 4/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0854 -
accuracy: 0.9739 - f1_score: 0.1957 - val_loss: 0.2412 - val_accuracy: 0.9588 -
val_f1_score: 0.1957
Epoch 5/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0728 -
accuracy: 0.9783 - f1_score: 0.1957 - val_loss: 0.3339 - val_accuracy: 0.9599 -
val_f1_score: 0.1957
Epoch 6/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0620 -
accuracy: 0.9815 - f1_score: 0.1957 - val_loss: 0.4417 - val_accuracy: 0.9604 -
val_f1_score: 0.1957
Epoch 7/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0564 -
accuracy: 0.9830 - f1_score: 0.1957 - val_loss: 0.3326 - val_accuracy: 0.9628 -
val_f1_score: 0.1957
Epoch 8/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0490 -
accuracy: 0.9847 - f1_score: 0.1957 - val_loss: 0.3826 - val_accuracy: 0.9596 -
```

```
val_f1_score: 0.1957
Epoch 9/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0448 -
accuracy: 0.9868 - f1_score: 0.1957 - val_loss: 0.3529 - val_accuracy: 0.9631 -
val_f1_score: 0.1957
Epoch 10/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0406 -
accuracy: 0.9878 - f1_score: 0.1957 - val_loss: 0.2848 - val_accuracy: 0.9594 -
val_f1_score: 0.1957
Epoch 11/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0354 -
accuracy: 0.9894 - f1_score: 0.1957 - val_loss: 0.2321 - val_accuracy: 0.9665 -
val_f1_score: 0.1957
Epoch 12/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0363 -
accuracy: 0.9896 - f1_score: 0.1957 - val_loss: 0.2263 - val_accuracy: 0.9676 -
val_f1_score: 0.1957
Epoch 13/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0294 -
accuracy: 0.9913 - f1_score: 0.1957 - val_loss: 0.2520 - val_accuracy: 0.9640 -
val_f1_score: 0.1957
Epoch 14/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0307 -
accuracy: 0.9905 - f1_score: 0.1957 - val_loss: 0.1795 - val_accuracy: 0.9671 -
val_f1_score: 0.1957
Epoch 15/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0295 -
accuracy: 0.9917 - f1_score: 0.1957 - val_loss: 0.2211 - val_accuracy: 0.9681 -
val_f1_score: 0.1957
Epoch 16/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0276 -
accuracy: 0.9922 - f1_score: 0.1957 - val_loss: 0.2381 - val_accuracy: 0.9669 -
val_f1_score: 0.1957
Epoch 17/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0254 -
accuracy: 0.9929 - f1_score: 0.1957 - val_loss: 0.2455 - val_accuracy: 0.9610 -
val_f1_score: 0.1957
Epoch 18/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0239 -
accuracy: 0.9932 - f1_score: 0.1957 - val_loss: 0.3312 - val_accuracy: 0.9690 -
val_f1_score: 0.1957
Epoch 19/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0230 -
accuracy: 0.9935 - f1_score: 0.1957 - val_loss: 0.2251 - val_accuracy: 0.9689 -
val_f1_score: 0.1957
Epoch 20/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0253 -
accuracy: 0.9934 - f1_score: 0.1957 - val_loss: 0.2334 - val_accuracy: 0.9686 -
```

```
val_f1_score: 0.1957
Epoch 21/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0203 -
accuracy: 0.9943 - f1_score: 0.1957 - val_loss: 0.2397 - val_accuracy: 0.9678 -
val_f1_score: 0.1957
Epoch 22/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0227 -
accuracy: 0.9934 - f1_score: 0.1957 - val_loss: 0.1954 - val_accuracy: 0.9687 -
val_f1_score: 0.1957
Epoch 23/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0176 -
accuracy: 0.9949 - f1_score: 0.1957 - val_loss: 0.3261 - val_accuracy: 0.9661 -
val_f1_score: 0.1957
Epoch 24/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0218 -
accuracy: 0.9949 - f1_score: 0.1957 - val_loss: 0.2505 - val_accuracy: 0.9673 -
val_f1_score: 0.1957
Epoch 25/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0193 -
accuracy: 0.9948 - f1_score: 0.1957 - val_loss: 0.2577 - val_accuracy: 0.9658 -
val_f1_score: 0.1957
Epoch 26/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0214 -
accuracy: 0.9945 - f1_score: 0.1957 - val_loss: 0.3668 - val_accuracy: 0.9672 -
val_f1_score: 0.1957
Epoch 27/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0151 -
accuracy: 0.9956 - f1_score: 0.1957 - val_loss: 0.6194 - val_accuracy: 0.9666 -
val_f1_score: 0.1957
Epoch 28/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0163 -
accuracy: 0.9957 - f1_score: 0.1957 - val_loss: 0.5453 - val_accuracy: 0.9673 -
val_f1_score: 0.1957
Epoch 29/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0152 -
accuracy: 0.9959 - f1_score: 0.1957 - val_loss: 0.6071 - val_accuracy: 0.9653 -
val_f1_score: 0.1957
Epoch 30/30
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0177 -
accuracy: 0.9954 - f1_score: 0.1957 - val_loss: 0.6430 - val_accuracy: 0.9677 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
5
10
15
20
25
30

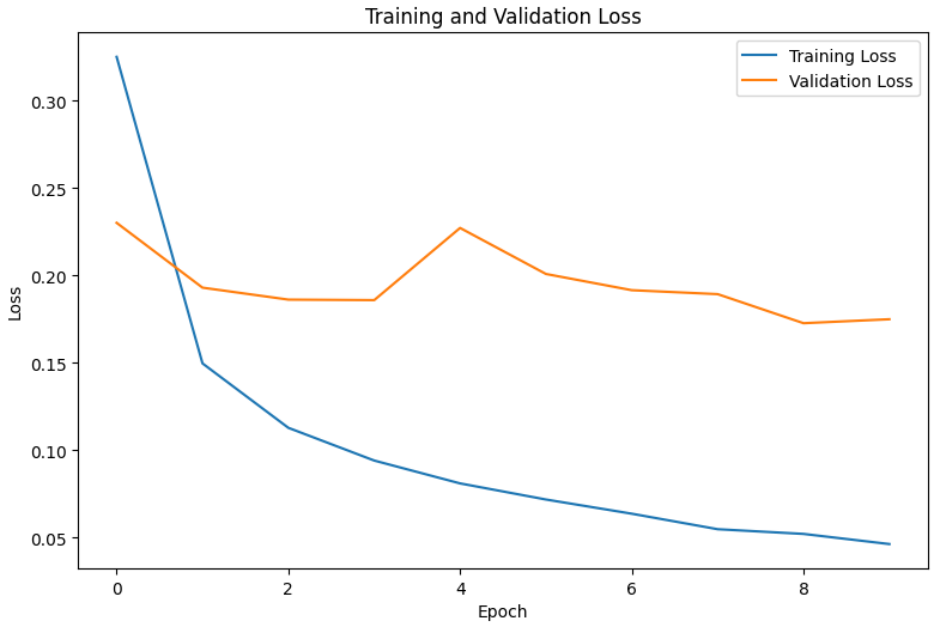

Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.92
0.94
0.96
0.98
1.00
0
5
10
15
20
25
30

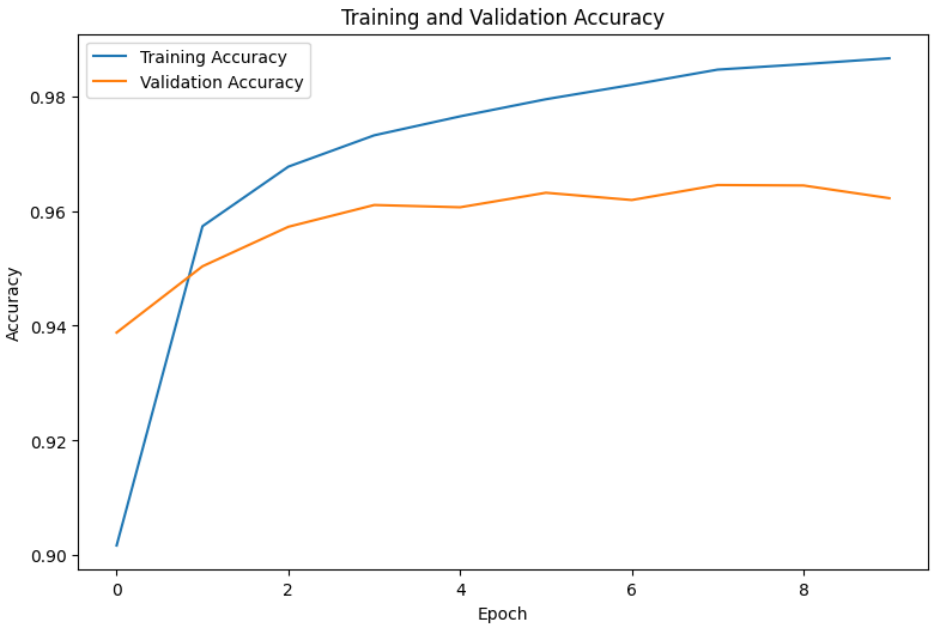

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
5
10
15
20
25
30

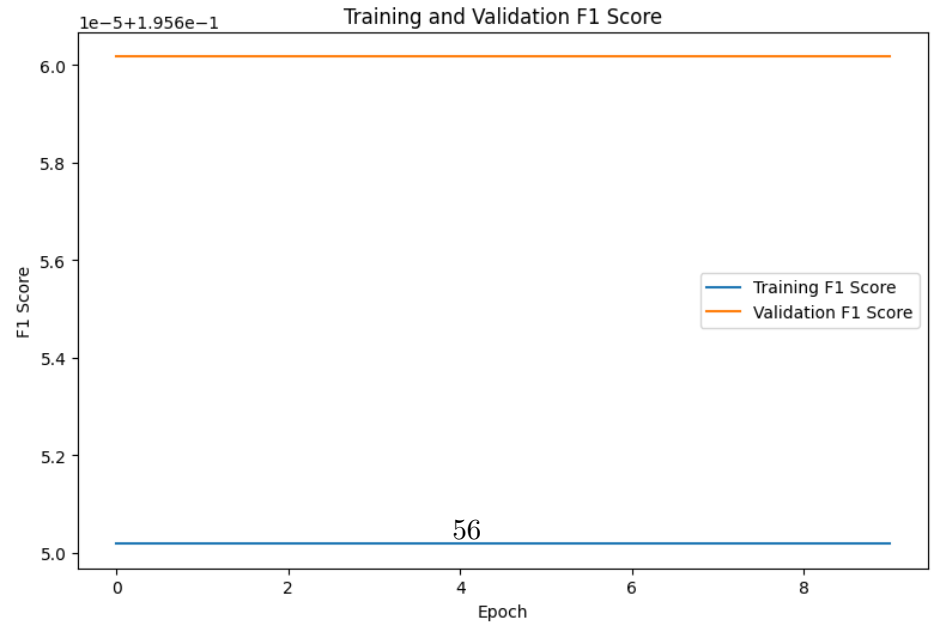
```
395/395 [==============================] - 1s 4ms/step - loss: 0.6430 -
accuracy: 0.9677 - f1_score: 0.1957

2024-02-12 20:39:15,164 - INFO - Nodes: 64, Layers: 6, Epochs: 30, Test
Accuracy: 0.9676856994628906, F1 Score: 0.19566017389297485, Training Time:
270.91913962364197s

2024-02-12 20:39:15,246 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_6_epochs_30.keras

2024-02-12 20:39:15,248 - INFO - Running experiment with Nodes: 64, Layers: 8,
Epochs: 10


Model: "sequential_12"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_48 (Dense)            (None, 64)                50240

 dense_49 (Dense)            (None, 64)                4160

 dense_50 (Dense)            (None, 64)                4160

 dense_51 (Dense)            (None, 64)                4160

 dense_52 (Dense)            (None, 64)                4160

 dense_53 (Dense)            (None, 64)                4160

 dense_54 (Dense)            (None, 64)                4160

 dense_55 (Dense)            (None, 64)                4160

 dense_56 (Dense)            (None, 10)                650

=================================================================
Total params: 80010 (312.54 KB)
Trainable params: 80010 (312.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:39:15,508 - INFO - None

Model: "sequential_12"
_________________________________________________________________
```

```
 Layer (type)                Output Shape              Param #
=================================================================
 dense_48 (Dense)            (None, 64)                50240

 dense_49 (Dense)            (None, 64)                4160

 dense_50 (Dense)            (None, 64)                4160

 dense_51 (Dense)            (None, 64)                4160

 dense_52 (Dense)            (None, 64)                4160

 dense_53 (Dense)            (None, 64)                4160

 dense_54 (Dense)            (None, 64)                4160

 dense_55 (Dense)            (None, 64)                4160

 dense_56 (Dense)            (None, 10)                650

=================================================================
Total params: 80010 (312.54 KB)
Trainable params: 80010 (312.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 13s 6ms/step - loss: 0.3251 -
accuracy: 0.9016 - f1_score: 0.1957 - val_loss: 0.2301 - val_accuracy: 0.9388 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.1496 -
accuracy: 0.9573 - f1_score: 0.1957 - val_loss: 0.1930 - val_accuracy: 0.9503 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.1127 -
accuracy: 0.9677 - f1_score: 0.1957 - val_loss: 0.1861 - val_accuracy: 0.9572 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0940 -
accuracy: 0.9732 - f1_score: 0.1957 - val_loss: 0.1858 - val_accuracy: 0.9610 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0809 -
accuracy: 0.9765 - f1_score: 0.1957 - val_loss: 0.2271 - val_accuracy: 0.9606 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0717 -
accuracy: 0.9795 - f1_score: 0.1957 - val_loss: 0.2008 - val_accuracy: 0.9632 -
```

```
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0635 -
accuracy: 0.9820 - f1_score: 0.1957 - val_loss: 0.1915 - val_accuracy: 0.9619 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0547 -
accuracy: 0.9847 - f1_score: 0.1957 - val_loss: 0.1892 - val_accuracy: 0.9645 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 9s 6ms/step - loss: 0.0520 -
accuracy: 0.9856 - f1_score: 0.1957 - val_loss: 0.1726 - val_accuracy: 0.9644 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0461 -
accuracy: 0.9866 - f1_score: 0.1957 - val_loss: 0.1749 - val_accuracy: 0.9622 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.30
0.25
0.20
0.15
0.10
0.05
0
2
4
6
8


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.98
0.96
0.94
0.92
0.90
0
2
4
6
8


Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
6.0
5.8
5.6
5.4
5.2
5.0
0
2
4
6
8

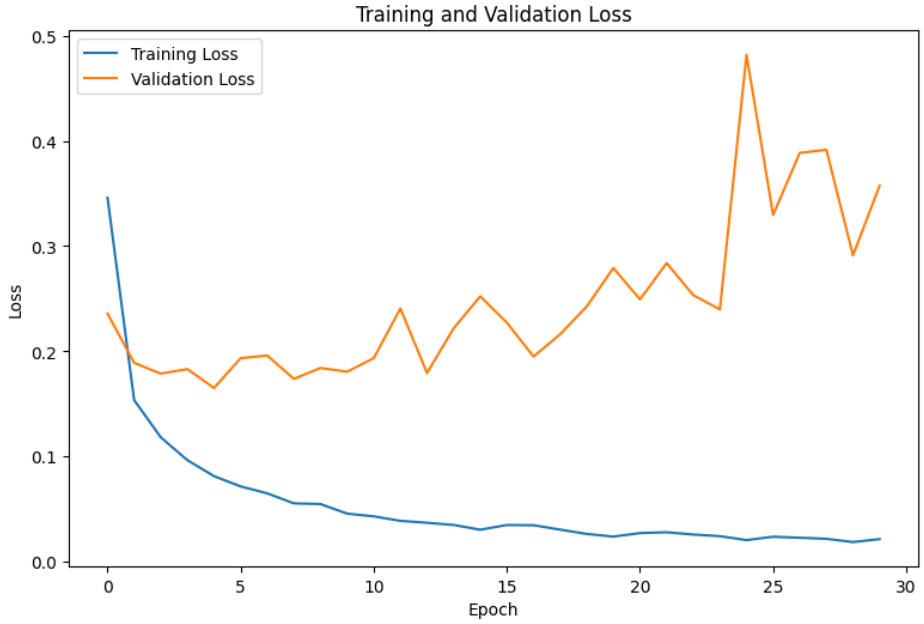
```
395/395 [==============================] - 2s 4ms/step - loss: 0.1749 -
accuracy: 0.9622 - f1_score: 0.1957

2024-02-12 20:40:58,172 - INFO - Nodes: 64, Layers: 8, Epochs: 10, Test
Accuracy: 0.9622207880020142, F1 Score: 0.19566017389297485, Training Time:
99.83066415786743s

2024-02-12 20:40:58,266 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_8_epochs_10.keras

2024-02-12 20:40:58,269 - INFO - Running experiment with Nodes: 64, Layers: 8,
Epochs: 30


Model: "sequential_13"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_57 (Dense)            (None, 64)                50240

 dense_58 (Dense)            (None, 64)                4160

 dense_59 (Dense)            (None, 64)                4160

 dense_60 (Dense)            (None, 64)                4160

 dense_61 (Dense)            (None, 64)                4160

 dense_62 (Dense)            (None, 64)                4160

 dense_63 (Dense)            (None, 64)                4160

 dense_64 (Dense)            (None, 64)                4160

 dense_65 (Dense)            (None, 10)                650

=================================================================
Total params: 80010 (312.54 KB)
Trainable params: 80010 (312.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:40:58,518 - INFO - None

Model: "sequential_13"
_________________________________________________________________
```

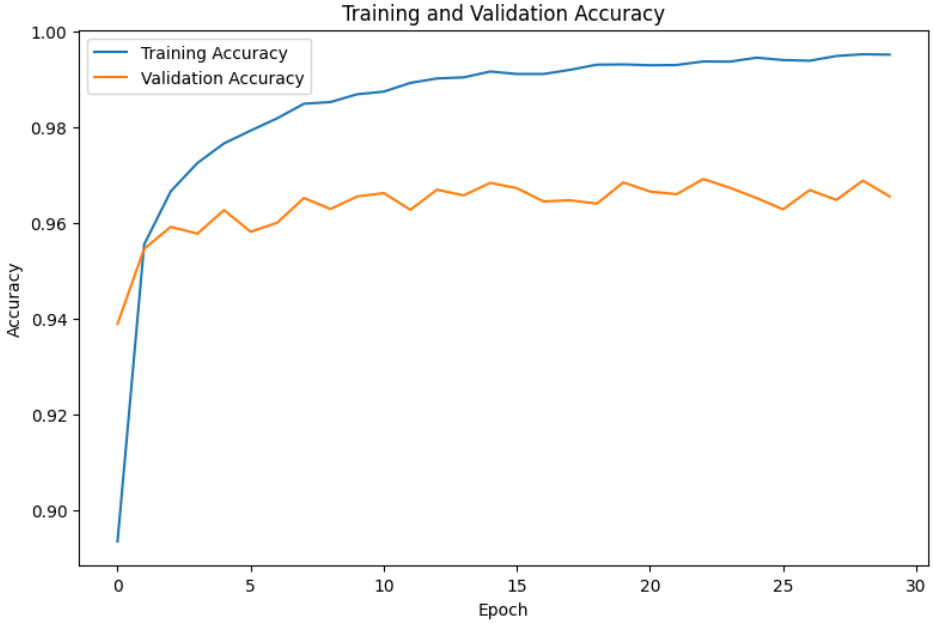
```
 Layer (type)                Output Shape              Param #
=================================================================
 dense_57 (Dense)            (None, 64)                50240

 dense_58 (Dense)            (None, 64)                4160

 dense_59 (Dense)            (None, 64)                4160

 dense_60 (Dense)            (None, 64)                4160

 dense_61 (Dense)            (None, 64)                4160

 dense_62 (Dense)            (None, 64)                4160

 dense_63 (Dense)            (None, 64)                4160

 dense_64 (Dense)            (None, 64)                4160

 dense_65 (Dense)            (None, 10)                650

=================================================================
Total params: 80010 (312.54 KB)
Trainable params: 80010 (312.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/30
1579/1579 [==============================] - 13s 6ms/step - loss: 0.3460 -
accuracy: 0.8934 - f1_score: 0.1957 - val_loss: 0.2357 - val_accuracy: 0.9389 -
val_f1_score: 0.1957
Epoch 2/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.1534 -
accuracy: 0.9554 - f1_score: 0.1957 - val_loss: 0.1888 - val_accuracy: 0.9545 -
val_f1_score: 0.1957
Epoch 3/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.1180 -
accuracy: 0.9666 - f1_score: 0.1957 - val_loss: 0.1786 - val_accuracy: 0.9591 -
val_f1_score: 0.1957
Epoch 4/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0962 -
accuracy: 0.9725 - f1_score: 0.1957 - val_loss: 0.1829 - val_accuracy: 0.9577 -
val_f1_score: 0.1957
Epoch 5/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0809 -
accuracy: 0.9766 - f1_score: 0.1957 - val_loss: 0.1649 - val_accuracy: 0.9626 -
val_f1_score: 0.1957
Epoch 6/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0712 -
accuracy: 0.9792 - f1_score: 0.1957 - val_loss: 0.1933 - val_accuracy: 0.9581 -
```

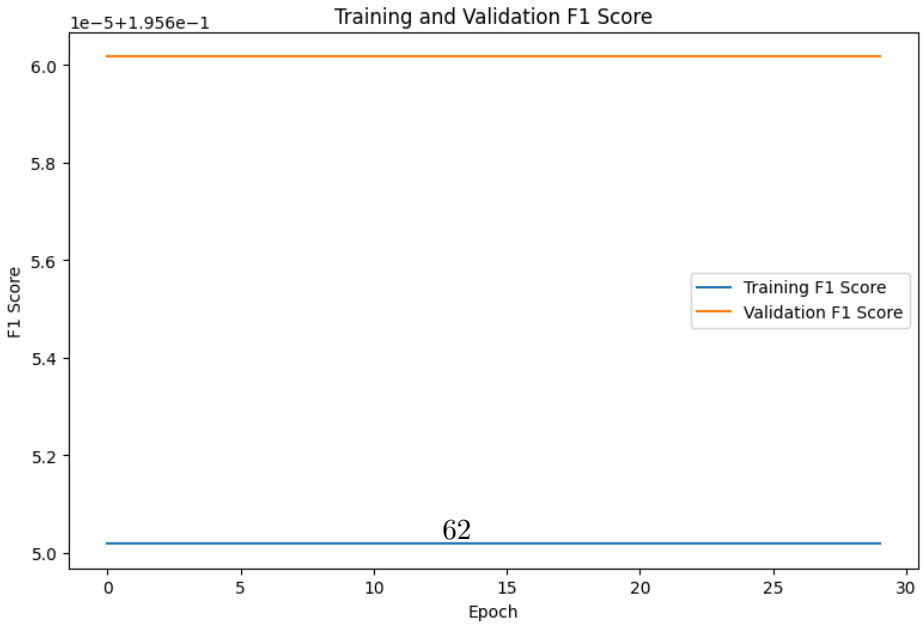
```
val_f1_score: 0.1957
Epoch 7/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0646 -
accuracy: 0.9818 - f1_score: 0.1957 - val_loss: 0.1958 - val_accuracy: 0.9600 -
val_f1_score: 0.1957
Epoch 8/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0550 -
accuracy: 0.9848 - f1_score: 0.1957 - val_loss: 0.1736 - val_accuracy: 0.9652 -
val_f1_score: 0.1957
Epoch 9/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0544 -
accuracy: 0.9852 - f1_score: 0.1957 - val_loss: 0.1839 - val_accuracy: 0.9629 -
val_f1_score: 0.1957
Epoch 10/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0453 -
accuracy: 0.9868 - f1_score: 0.1957 - val_loss: 0.1804 - val_accuracy: 0.9655 -
val_f1_score: 0.1957
Epoch 11/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0427 -
accuracy: 0.9874 - f1_score: 0.1957 - val_loss: 0.1934 - val_accuracy: 0.9662 -
val_f1_score: 0.1957
Epoch 12/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0384 -
accuracy: 0.9892 - f1_score: 0.1957 - val_loss: 0.2406 - val_accuracy: 0.9627 -
val_f1_score: 0.1957
Epoch 13/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0366 -
accuracy: 0.9901 - f1_score: 0.1957 - val_loss: 0.1791 - val_accuracy: 0.9669 -
val_f1_score: 0.1957
Epoch 14/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0345 -
accuracy: 0.9903 - f1_score: 0.1957 - val_loss: 0.2217 - val_accuracy: 0.9657 -
val_f1_score: 0.1957
Epoch 15/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0300 -
accuracy: 0.9916 - f1_score: 0.1957 - val_loss: 0.2522 - val_accuracy: 0.9683 -
val_f1_score: 0.1957
Epoch 16/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0344 -
accuracy: 0.9911 - f1_score: 0.1957 - val_loss: 0.2271 - val_accuracy: 0.9672 -
val_f1_score: 0.1957
Epoch 17/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0342 -
accuracy: 0.9911 - f1_score: 0.1957 - val_loss: 0.1948 - val_accuracy: 0.9644 -
val_f1_score: 0.1957
Epoch 18/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0301 -
accuracy: 0.9919 - f1_score: 0.1957 - val_loss: 0.2160 - val_accuracy: 0.9647 -
```

```
val_f1_score: 0.1957
Epoch 19/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0259 -
accuracy: 0.9930 - f1_score: 0.1957 - val_loss: 0.2426 - val_accuracy: 0.9640 -
val_f1_score: 0.1957
Epoch 20/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0234 -
accuracy: 0.9931 - f1_score: 0.1957 - val_loss: 0.2792 - val_accuracy: 0.9684 -
val_f1_score: 0.1957
Epoch 21/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0268 -
accuracy: 0.9929 - f1_score: 0.1957 - val_loss: 0.2493 - val_accuracy: 0.9665 -
val_f1_score: 0.1957
Epoch 22/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0276 -
accuracy: 0.9929 - f1_score: 0.1957 - val_loss: 0.2839 - val_accuracy: 0.9659 -
val_f1_score: 0.1957
Epoch 23/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0254 -
accuracy: 0.9937 - f1_score: 0.1957 - val_loss: 0.2533 - val_accuracy: 0.9691 -
val_f1_score: 0.1957
Epoch 24/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0238 -
accuracy: 0.9936 - f1_score: 0.1957 - val_loss: 0.2397 - val_accuracy: 0.9673 -
val_f1_score: 0.1957
Epoch 25/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0201 -
accuracy: 0.9945 - f1_score: 0.1957 - val_loss: 0.4821 - val_accuracy: 0.9652 -
val_f1_score: 0.1957
Epoch 26/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0233 -
accuracy: 0.9940 - f1_score: 0.1957 - val_loss: 0.3297 - val_accuracy: 0.9628 -
val_f1_score: 0.1957
Epoch 27/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0223 -
accuracy: 0.9938 - f1_score: 0.1957 - val_loss: 0.3887 - val_accuracy: 0.9668 -
val_f1_score: 0.1957
Epoch 28/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0213 -
accuracy: 0.9948 - f1_score: 0.1957 - val_loss: 0.3917 - val_accuracy: 0.9648 -
val_f1_score: 0.1957
Epoch 29/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0182 -
accuracy: 0.9952 - f1_score: 0.1957 - val_loss: 0.2912 - val_accuracy: 0.9688 -
val_f1_score: 0.1957
Epoch 30/30
1579/1579 [==============================] - 10s 6ms/step - loss: 0.0210 -
accuracy: 0.9951 - f1_score: 0.1957 - val_loss: 0.3576 - val_accuracy: 0.9655 -
```

```
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.0
0.1
0.2
0.3
0.4
0.5
0
5
10
15
20
25
30


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.90
0.92
0.94
0.96
0.98
1.00
0
5
10
15
20
25
30

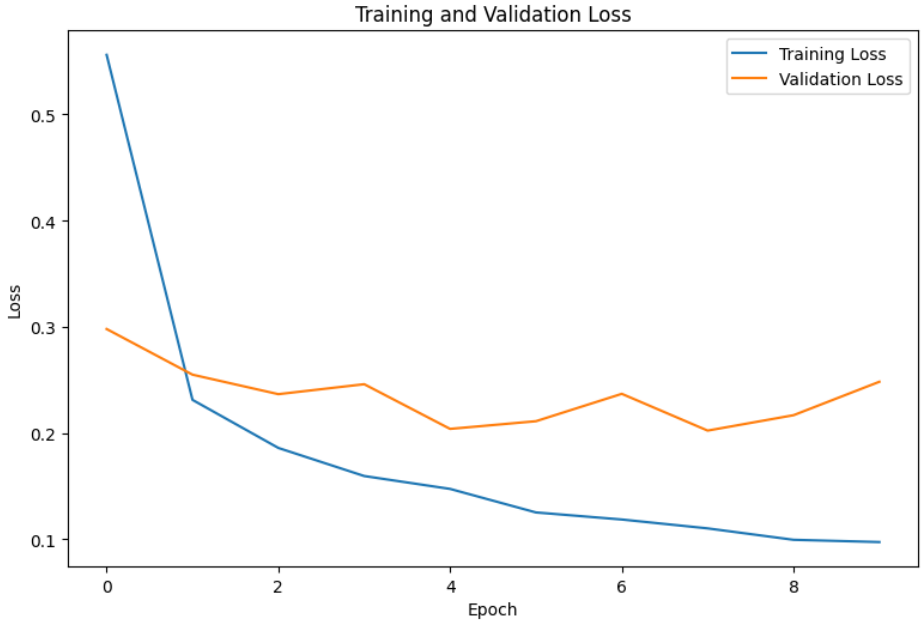

Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
5
10
15
20
25
30

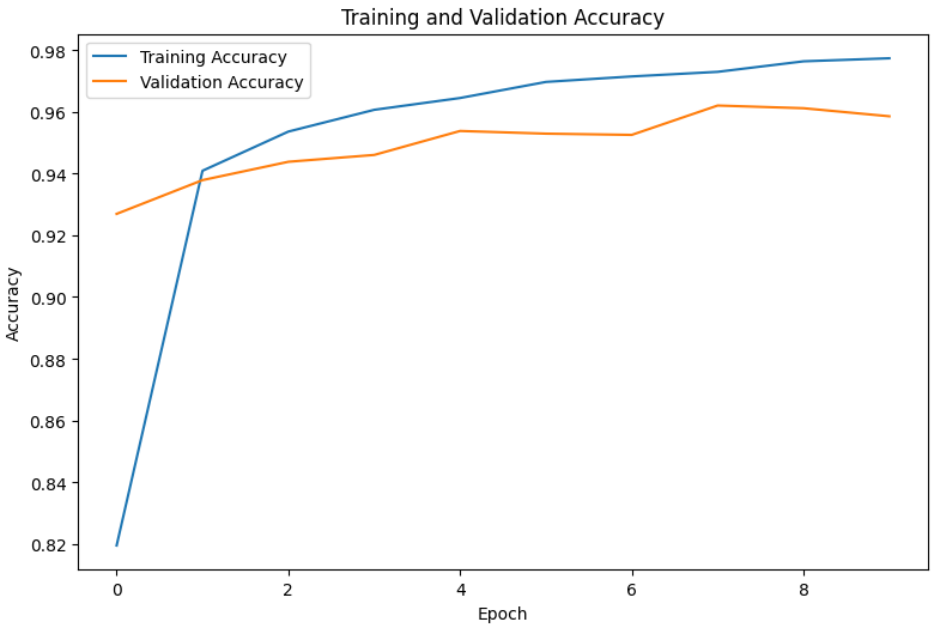
```
395/395 [==============================] - 2s 4ms/step - loss: 0.3576 -
accuracy: 0.9655 - f1_score: 0.1957

2024-02-12 20:46:02,514 - INFO - Nodes: 64, Layers: 8, Epochs: 30, Test
Accuracy: 0.9654681086540222, F1 Score: 0.19566017389297485, Training Time:
301.11518120765686s

2024-02-12 20:46:02,603 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_8_epochs_30.keras

2024-02-12 20:46:02,606 - INFO - Running experiment with Nodes: 64, Layers: 16,
Epochs: 10


Model: "sequential_14"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_66 (Dense)            (None, 64)                50240

 dense_67 (Dense)            (None, 64)                4160

 dense_68 (Dense)            (None, 64)                4160

 dense_69 (Dense)            (None, 64)                4160

 dense_70 (Dense)            (None, 64)                4160

 dense_71 (Dense)            (None, 64)                4160

 dense_72 (Dense)            (None, 64)                4160

 dense_73 (Dense)            (None, 64)                4160

 dense_74 (Dense)            (None, 64)                4160

 dense_75 (Dense)            (None, 64)                4160

 dense_76 (Dense)            (None, 64)                4160

 dense_77 (Dense)            (None, 64)                4160

 dense_78 (Dense)            (None, 64)                4160

 dense_79 (Dense)            (None, 64)                4160
```

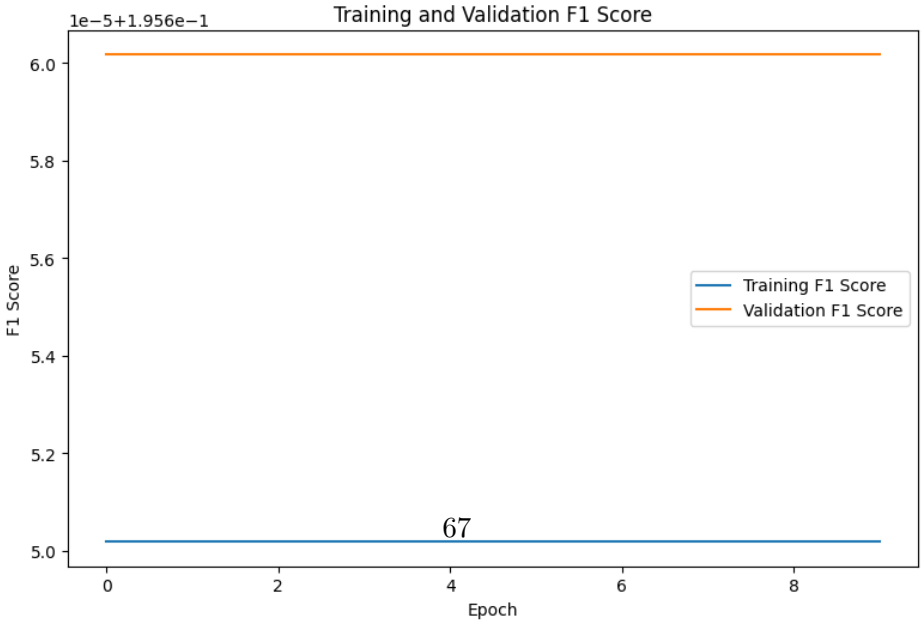
```
 dense_80 (Dense)            (None, 64)                4160

 dense_81 (Dense)            (None, 64)                4160

 dense_82 (Dense)            (None, 10)                650

=================================================================
Total params: 113290 (442.54 KB)
Trainable params: 113290 (442.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:46:03,081 - INFO - None
Model: "sequential_14"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_66 (Dense)            (None, 64)                50240

 dense_67 (Dense)            (None, 64)                4160

 dense_68 (Dense)            (None, 64)                4160

 dense_69 (Dense)            (None, 64)                4160

 dense_70 (Dense)            (None, 64)                4160

 dense_71 (Dense)            (None, 64)                4160

 dense_72 (Dense)            (None, 64)                4160

 dense_73 (Dense)            (None, 64)                4160

 dense_74 (Dense)            (None, 64)                4160

 dense_75 (Dense)            (None, 64)                4160

 dense_76 (Dense)            (None, 64)                4160

 dense_77 (Dense)            (None, 64)                4160

 dense_78 (Dense)            (None, 64)                4160

 dense_79 (Dense)            (None, 64)                4160

 dense_80 (Dense)            (None, 64)                4160
```

```
 dense_81 (Dense)            (None, 64)                4160

 dense_82 (Dense)            (None, 10)                650

=================================================================
Total params: 113290 (442.54 KB)
Trainable params: 113290 (442.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/10
1579/1579 [==============================] - 18s 8ms/step - loss: 0.5559 -
accuracy: 0.8195 - f1_score: 0.1957 - val_loss: 0.2979 - val_accuracy: 0.9269 -
val_f1_score: 0.1957
Epoch 2/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.2312 -
accuracy: 0.9409 - f1_score: 0.1957 - val_loss: 0.2549 - val_accuracy: 0.9378 -
val_f1_score: 0.1957
Epoch 3/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1859 -
accuracy: 0.9535 - f1_score: 0.1957 - val_loss: 0.2365 - val_accuracy: 0.9438 -
val_f1_score: 0.1957
Epoch 4/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1595 -
accuracy: 0.9606 - f1_score: 0.1957 - val_loss: 0.2459 - val_accuracy: 0.9460 -
val_f1_score: 0.1957
Epoch 5/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1473 -
accuracy: 0.9644 - f1_score: 0.1957 - val_loss: 0.2038 - val_accuracy: 0.9537 -
val_f1_score: 0.1957
Epoch 6/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1252 -
accuracy: 0.9696 - f1_score: 0.1957 - val_loss: 0.2111 - val_accuracy: 0.9529 -
val_f1_score: 0.1957
Epoch 7/10
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1186 -
accuracy: 0.9714 - f1_score: 0.1957 - val_loss: 0.2368 - val_accuracy: 0.9525 -
val_f1_score: 0.1957
Epoch 8/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1102 -
accuracy: 0.9729 - f1_score: 0.1957 - val_loss: 0.2022 - val_accuracy: 0.9620 -
val_f1_score: 0.1957
Epoch 9/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.0995 -
accuracy: 0.9763 - f1_score: 0.1957 - val_loss: 0.2167 - val_accuracy: 0.9611 -
val_f1_score: 0.1957
Epoch 10/10
1579/1579 [==============================] - 12s 7ms/step - loss: 0.0973 -
accuracy: 0.9773 - f1_score: 0.1957 - val_loss: 0.2482 - val_accuracy: 0.9585 -
```

```
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.82
0.84
0.86
0.88
0.90
0.92
0.94
0.96
0.98
0
2
4
6
8


Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
5.0
5.2
5.4
5.6
5.8
6.0
0
2
4
6
8

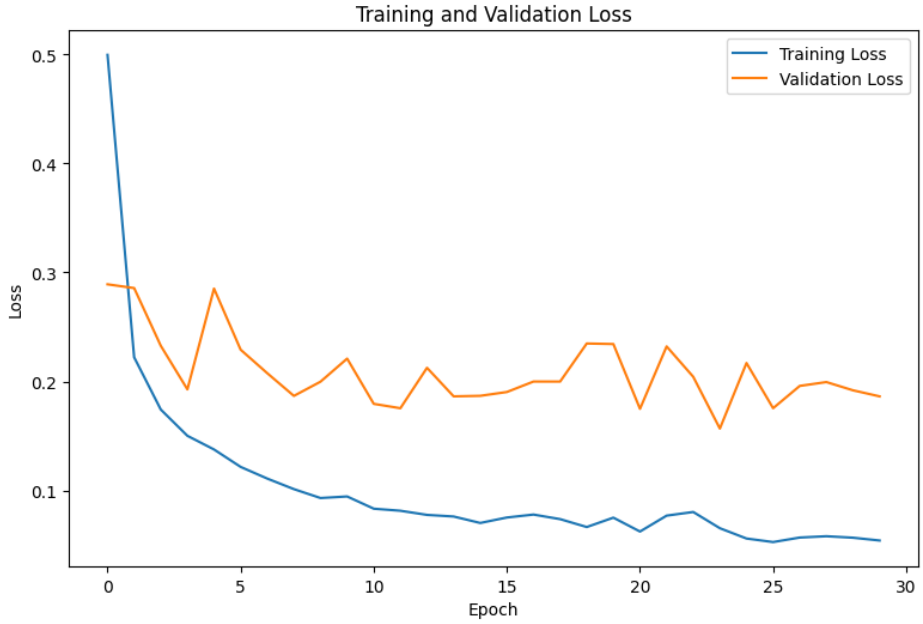
```
395/395 [==============================] - 2s 4ms/step - loss: 0.2482 -
accuracy: 0.9585 - f1_score: 0.1957

2024-02-12 20:48:09,756 - INFO - Nodes: 64, Layers: 16, Epochs: 10, Test
Accuracy: 0.9584983587265015, F1 Score: 0.19566017389297485, Training Time:
123.66581177711487s

2024-02-12 20:48:09,900 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_16_epochs_10.keras

2024-02-12 20:48:09,900 - INFO - Running experiment with Nodes: 64, Layers: 16,
Epochs: 30


Model: "sequential_15"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_83 (Dense)            (None, 64)                50240

 dense_84 (Dense)            (None, 64)                4160

 dense_85 (Dense)            (None, 64)                4160

 dense_86 (Dense)            (None, 64)                4160

 dense_87 (Dense)            (None, 64)                4160

 dense_88 (Dense)            (None, 64)                4160

 dense_89 (Dense)            (None, 64)                4160

 dense_90 (Dense)            (None, 64)                4160

 dense_91 (Dense)            (None, 64)                4160

 dense_92 (Dense)            (None, 64)                4160

 dense_93 (Dense)            (None, 64)                4160

 dense_94 (Dense)            (None, 64)                4160

 dense_95 (Dense)            (None, 64)                4160

 dense_96 (Dense)            (None, 64)                4160
```

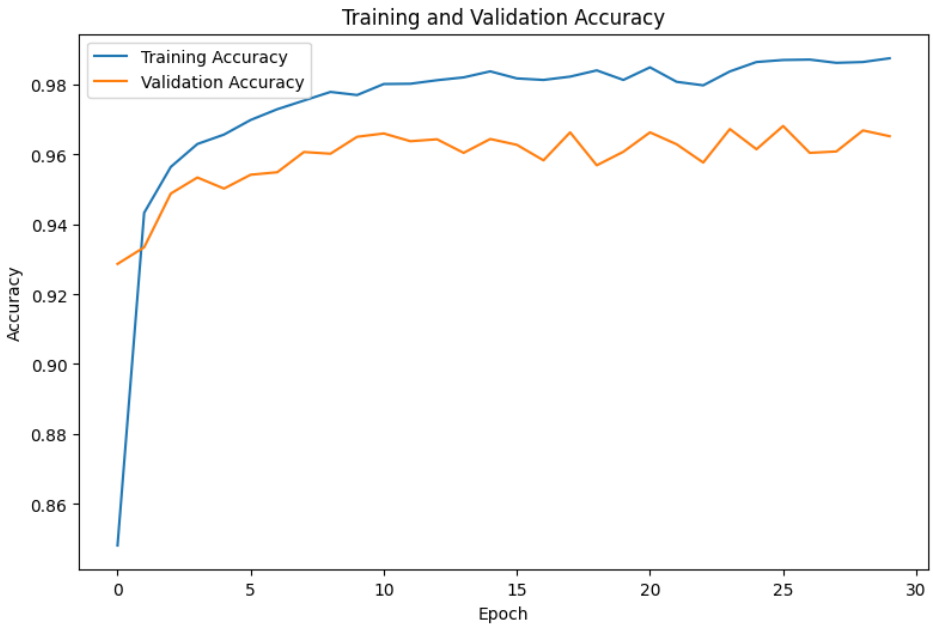
```
 dense_97 (Dense)            (None, 64)                4160

 dense_98 (Dense)            (None, 64)                4160

 dense_99 (Dense)            (None, 10)                650

=================================================================
Total params: 113290 (442.54 KB)
Trainable params: 113290 (442.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
2024-02-12 20:48:10,368 - INFO - None
Model: "sequential_15"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_83 (Dense)            (None, 64)                50240

 dense_84 (Dense)            (None, 64)                4160

 dense_85 (Dense)            (None, 64)                4160

 dense_86 (Dense)            (None, 64)                4160

 dense_87 (Dense)            (None, 64)                4160

 dense_88 (Dense)            (None, 64)                4160

 dense_89 (Dense)            (None, 64)                4160

 dense_90 (Dense)            (None, 64)                4160

 dense_91 (Dense)            (None, 64)                4160

 dense_92 (Dense)            (None, 64)                4160

 dense_93 (Dense)            (None, 64)                4160

 dense_94 (Dense)            (None, 64)                4160

 dense_95 (Dense)            (None, 64)                4160

 dense_96 (Dense)            (None, 64)                4160

 dense_97 (Dense)            (None, 64)                4160
```

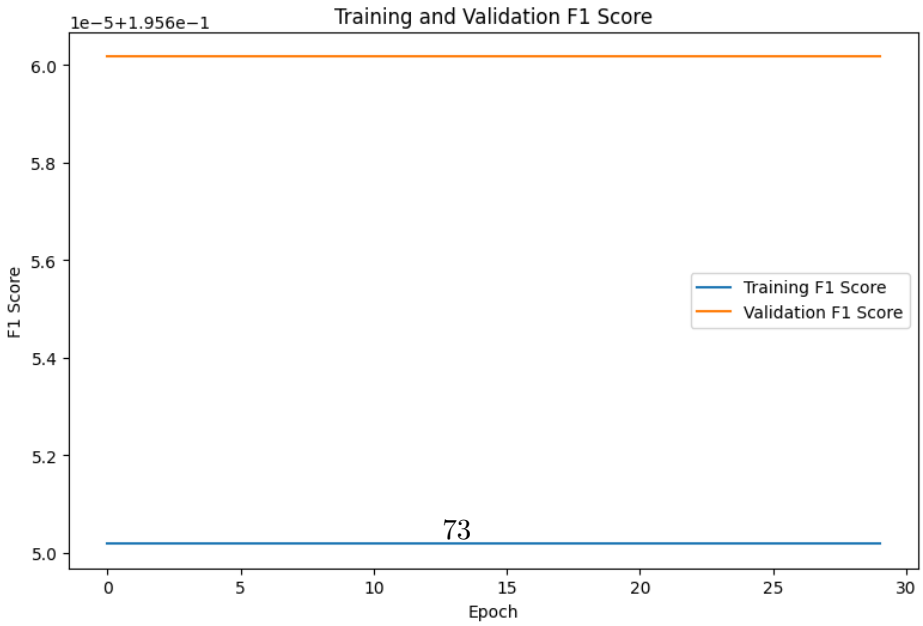
```
 dense_98 (Dense)            (None, 64)                4160

 dense_99 (Dense)            (None, 10)                650

=================================================================
Total params: 113290 (442.54 KB)
Trainable params: 113290 (442.54 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/30
1579/1579 [==============================] - 18s 8ms/step - loss: 0.4994 -
accuracy: 0.8481 - f1_score: 0.1957 - val_loss: 0.2891 - val_accuracy: 0.9286 -
val_f1_score: 0.1957
Epoch 2/30
1579/1579 [==============================] - 12s 7ms/step - loss: 0.2222 -
accuracy: 0.9433 - f1_score: 0.1957 - val_loss: 0.2856 - val_accuracy: 0.9334 -
val_f1_score: 0.1957
Epoch 3/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1743 -
accuracy: 0.9564 - f1_score: 0.1957 - val_loss: 0.2328 - val_accuracy: 0.9488 -
val_f1_score: 0.1957
Epoch 4/30
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1502 -
accuracy: 0.9629 - f1_score: 0.1957 - val_loss: 0.1928 - val_accuracy: 0.9534 -
val_f1_score: 0.1957
Epoch 5/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1377 -
accuracy: 0.9656 - f1_score: 0.1957 - val_loss: 0.2851 - val_accuracy: 0.9502 -
val_f1_score: 0.1957
Epoch 6/30
1579/1579 [==============================] - 12s 7ms/step - loss: 0.1217 -
accuracy: 0.9698 - f1_score: 0.1957 - val_loss: 0.2291 - val_accuracy: 0.9541 -
val_f1_score: 0.1957
Epoch 7/30
1579/1579 [==============================] - 13s 8ms/step - loss: 0.1110 -
accuracy: 0.9729 - f1_score: 0.1957 - val_loss: 0.2076 - val_accuracy: 0.9549 -
val_f1_score: 0.1957
Epoch 8/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.1013 -
accuracy: 0.9753 - f1_score: 0.1957 - val_loss: 0.1868 - val_accuracy: 0.9606 -
val_f1_score: 0.1957
Epoch 9/30
1579/1579 [==============================] - 13s 8ms/step - loss: 0.0932 -
accuracy: 0.9778 - f1_score: 0.1957 - val_loss: 0.1998 - val_accuracy: 0.9602 -
val_f1_score: 0.1957
Epoch 10/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0946 -
accuracy: 0.9769 - f1_score: 0.1957 - val_loss: 0.2210 - val_accuracy: 0.9650 -
```

```
val_f1_score: 0.1957
Epoch 11/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0834 -
accuracy: 0.9801 - f1_score: 0.1957 - val_loss: 0.1795 - val_accuracy: 0.9659 -
val_f1_score: 0.1957
Epoch 12/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0815 -
accuracy: 0.9802 - f1_score: 0.1957 - val_loss: 0.1755 - val_accuracy: 0.9637 -
val_f1_score: 0.1957
Epoch 13/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0777 -
accuracy: 0.9812 - f1_score: 0.1957 - val_loss: 0.2126 - val_accuracy: 0.9643 -
val_f1_score: 0.1957
Epoch 14/30
1579/1579 [==============================] - 12s 7ms/step - loss: 0.0763 -
accuracy: 0.9820 - f1_score: 0.1957 - val_loss: 0.1864 - val_accuracy: 0.9604 -
val_f1_score: 0.1957
Epoch 15/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0703 -
accuracy: 0.9837 - f1_score: 0.1957 - val_loss: 0.1869 - val_accuracy: 0.9644 -
val_f1_score: 0.1957
Epoch 16/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0753 -
accuracy: 0.9817 - f1_score: 0.1957 - val_loss: 0.1904 - val_accuracy: 0.9627 -
val_f1_score: 0.1957
Epoch 17/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0780 -
accuracy: 0.9812 - f1_score: 0.1957 - val_loss: 0.2000 - val_accuracy: 0.9583 -
val_f1_score: 0.1957
Epoch 18/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0738 -
accuracy: 0.9822 - f1_score: 0.1957 - val_loss: 0.1999 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
Epoch 19/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0666 -
accuracy: 0.9840 - f1_score: 0.1957 - val_loss: 0.2348 - val_accuracy: 0.9568 -
val_f1_score: 0.1957
Epoch 20/30
1579/1579 [==============================] - 13s 8ms/step - loss: 0.0752 -
accuracy: 0.9812 - f1_score: 0.1957 - val_loss: 0.2343 - val_accuracy: 0.9607 -
val_f1_score: 0.1957
Epoch 21/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0625 -
accuracy: 0.9849 - f1_score: 0.1957 - val_loss: 0.1750 - val_accuracy: 0.9663 -
val_f1_score: 0.1957
Epoch 22/30
1579/1579 [==============================] - 11s 7ms/step - loss: 0.0771 -
accuracy: 0.9807 - f1_score: 0.1957 - val_loss: 0.2322 - val_accuracy: 0.9629 -
```

```
val_f1_score: 0.1957
Epoch 23/30
1579/1579 [==============================] - 11s 7ms/step - loss: 0.0804 -
accuracy: 0.9797 - f1_score: 0.1957 - val_loss: 0.2043 - val_accuracy: 0.9576 -
val_f1_score: 0.1957
Epoch 24/30
1579/1579 [==============================] - 11s 7ms/step - loss: 0.0655 -
accuracy: 0.9837 - f1_score: 0.1957 - val_loss: 0.1568 - val_accuracy: 0.9672 -
val_f1_score: 0.1957
Epoch 25/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0561 -
accuracy: 0.9864 - f1_score: 0.1957 - val_loss: 0.2169 - val_accuracy: 0.9614 -
val_f1_score: 0.1957
Epoch 26/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0528 -
accuracy: 0.9870 - f1_score: 0.1957 - val_loss: 0.1755 - val_accuracy: 0.9681 -
val_f1_score: 0.1957
Epoch 27/30
1579/1579 [==============================] - 12s 8ms/step - loss: 0.0570 -
accuracy: 0.9871 - f1_score: 0.1957 - val_loss: 0.1959 - val_accuracy: 0.9604 -
val_f1_score: 0.1957
Epoch 28/30
1579/1579 [==============================] - 13s 8ms/step - loss: 0.0582 -
accuracy: 0.9861 - f1_score: 0.1957 - val_loss: 0.1995 - val_accuracy: 0.9608 -
val_f1_score: 0.1957
Epoch 29/30
1579/1579 [==============================] - 13s 8ms/step - loss: 0.0568 -
accuracy: 0.9864 - f1_score: 0.1957 - val_loss: 0.1919 - val_accuracy: 0.9668 -
val_f1_score: 0.1957
Epoch 30/30
1579/1579 [==============================] - 12s 7ms/step - loss: 0.0543 -
accuracy: 0.9874 - f1_score: 0.1957 - val_loss: 0.1864 - val_accuracy: 0.9652 -
val_f1_score: 0.1957
```


Training and Validation Loss
Training Loss
Validation Loss
Loss
Epoch
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
30


Training and Validation Accuracy
Training Accuracy
Validation Accuracy
Accuracy
Epoch
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0
5
10
15
20
25
30


Training and Validation F1 Score
1e−5+1.956e−1
Training F1 Score
Validation F1 Score
F1 Score
Epoch
6.0
5.8
5.6
5.4
5.2
5.0
0
5
10
15
20
25
30

```
395/395 [==============================] - 2s 4ms/step - loss: 0.1864 -
accuracy: 0.9652 - f1_score: 0.1957

2024-02-12 20:54:23,167 - INFO - Nodes: 64, Layers: 16, Epochs: 30, Test
Accuracy: 0.9651512503623962, F1 Score: 0.19566017389297485, Training Time:
369.9495384693146s

2024-02-12 20:54:23,302 - INFO - Model saved to D:\Desktop\Deep Learning\Lab
3\Main MNSIT-
MLPClassifer\ModelExperiments\model_nodes_64_layers_16_epochs_30.keras

2024-02-12 20:54:23,360 - INFO - Program completed successfully.
```

[ ]: