

Offline Assignment 3 Report

CSE 472 Sessional

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How to run code:

- **Running all code:**
 1. Open 1905016.ipynb file.
 2. Run all the code blocks sequentially.
- **Loading saved model and evaluating test set:**
 1. Open 1905016.ipynb file.
 2. Run “Downloading the dataset”, “Preprocessing” code blocks.
 3. Run “FNN and other necessary classes” code block.
 4. Run “Evaluating the test set on best performing model” code block.

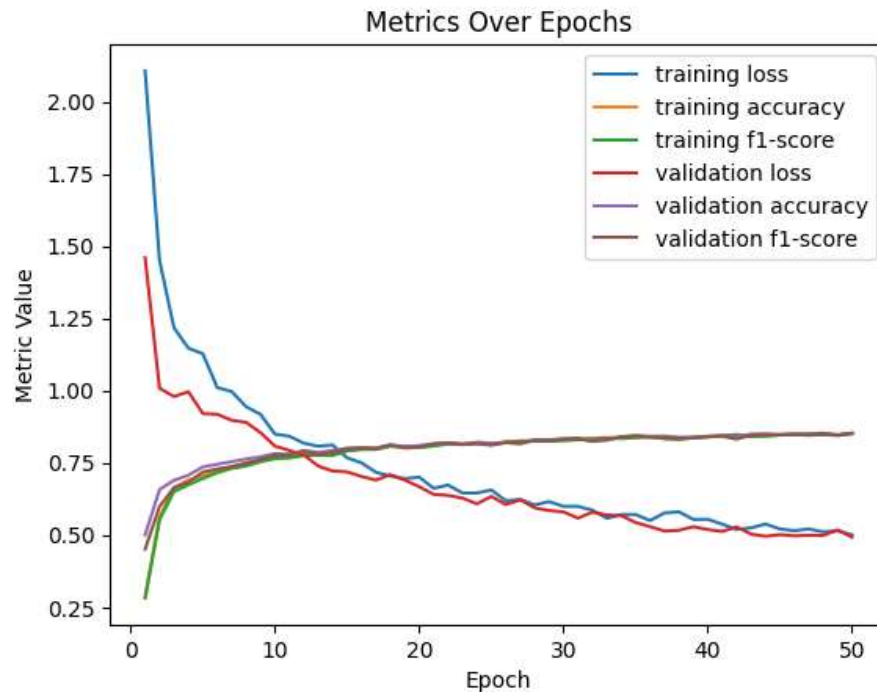
Model-1 Architecture:

```
# model 1
fnn = FNN()
fnn.add_layer(Dense(784,256))
fnn.add_layer(BatchNormalization(256))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.5))
fnn.add_layer(Dense(256,64))
fnn.add_layer(BatchNormalization(64))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.5))
fnn.add_layer(Dense(64,10))
fnn.add_layer(BatchNormalization(10))
fnn.add_layer(SoftMax())
```

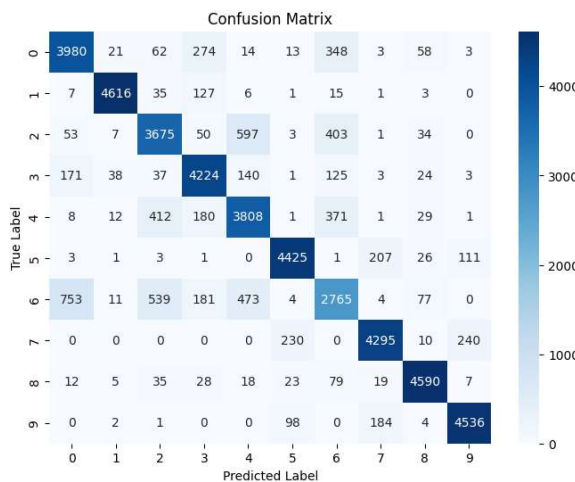
Learning rate: 0.005, Epoch: 50

training loss: 0.5007355727770096, training accuracy: 0.852375, training f1-score: 0.8510114910849614

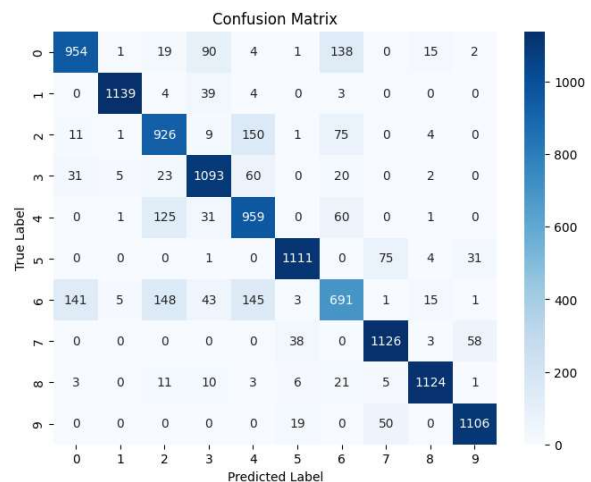
validation loss: 0.4925672223011959, validation accuracy: 0.8524166666666667, validation f1-score: 0.8513456810974638



Training confusion matrix



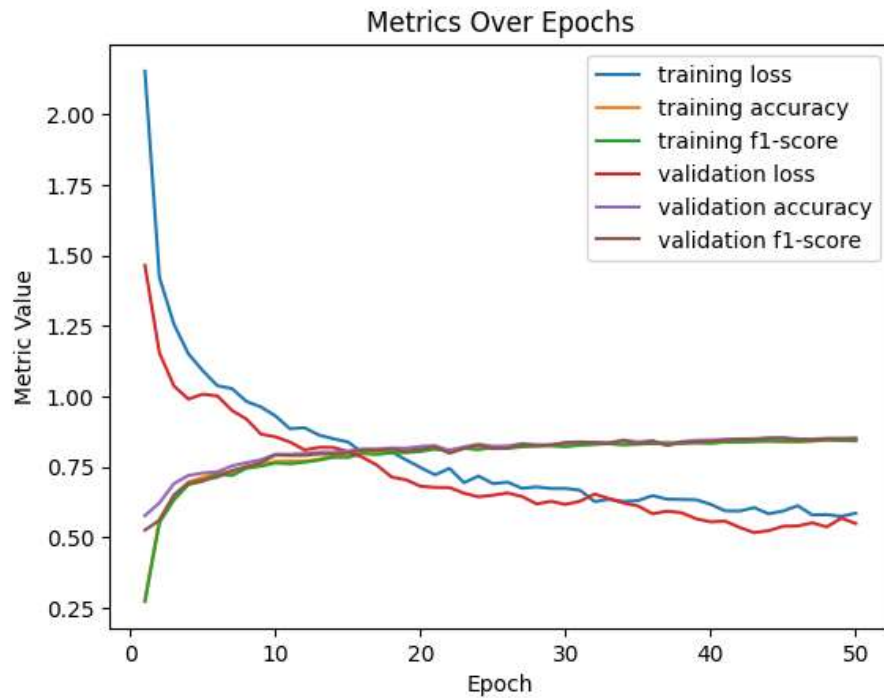
Validation confusion matrix



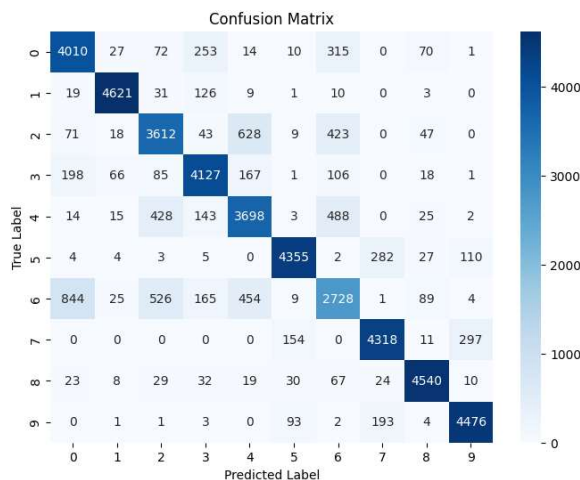
Learning rate: 0.003, Epoch: 50

training loss: 0.5860802004315963, training accuracy: 0.8434375, training f1-score: 0.8423170493023768

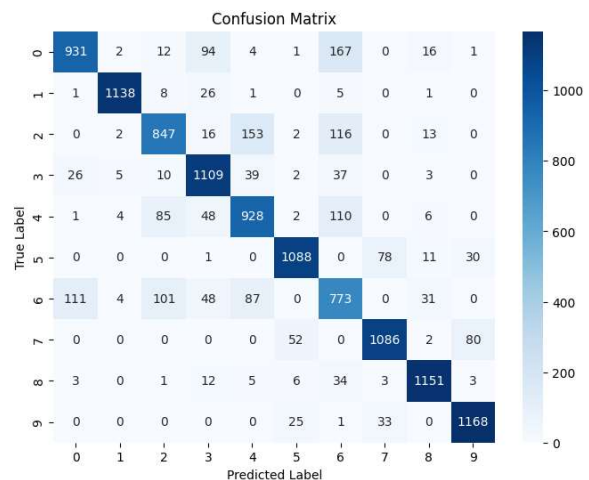
validation loss: 0.549521049949944, validation accuracy: 0.8515833333333334, validation f1-score: 0.8504545617093979



Training confusion matrix



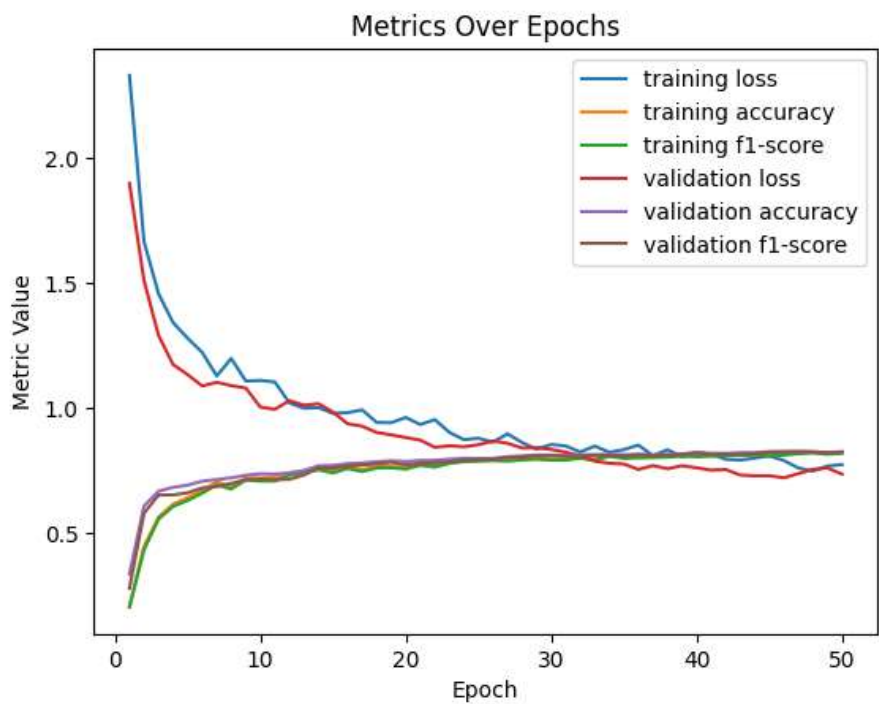
Validation confusion matrix



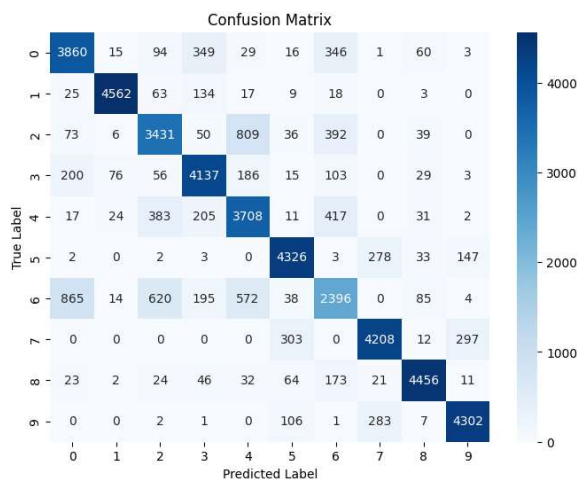
Learning rate: 0.001, Epoch: 50

training loss: 0.7726770635656777, training accuracy: 0.8205416666666666,
training f1-score: 0.8184653541246861

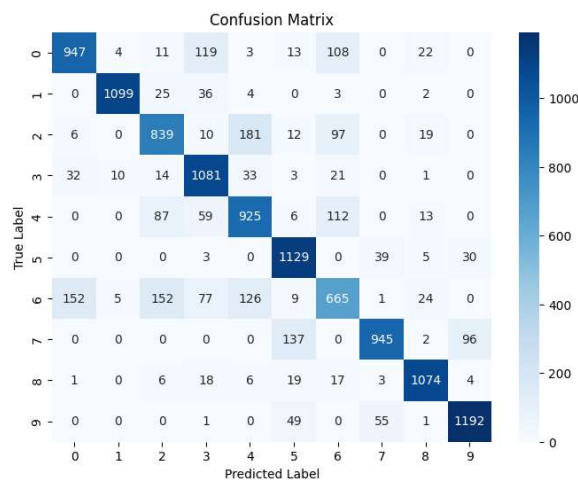
validation loss: 0.7348460592224668, validation accuracy: 0.8246666666666667,
validation f1-score: 0.822907222165081



Training confusion matrix



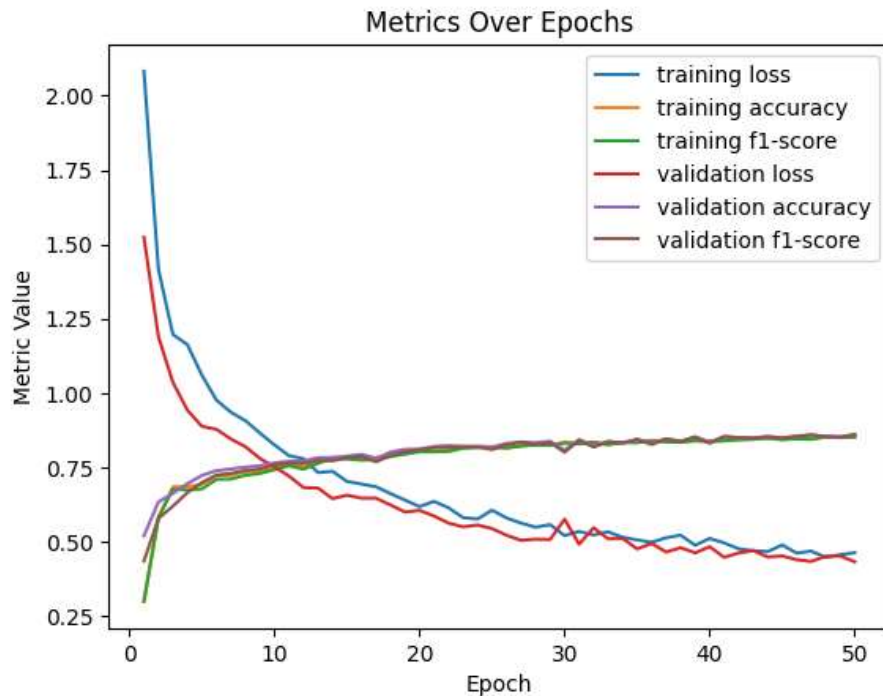
Validation confusion matrix



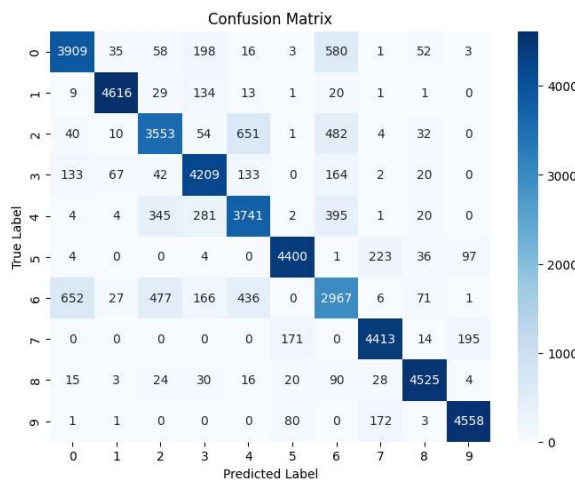
Learning rate: 0.01, Epoch: 50

training loss: 0.46284257441220544, training accuracy: 0.8518958333333333,
training f1-score: 0.8517328459371422

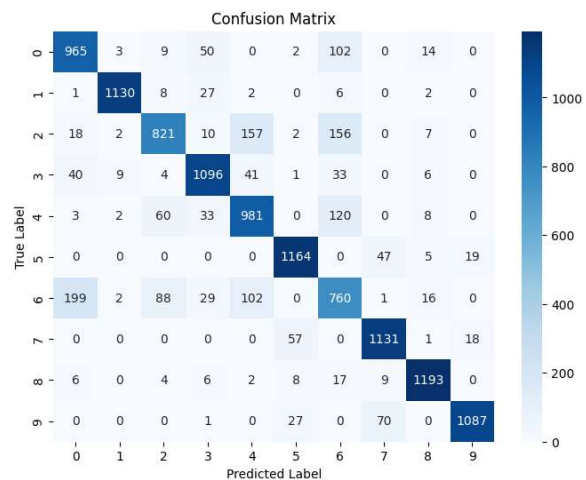
validation loss: 0.43251175027082733, validation accuracy: 0.8606666666666667,
validation f1-score: 0.8595753279070412



Training confusion matrix



Validation confusion matrix



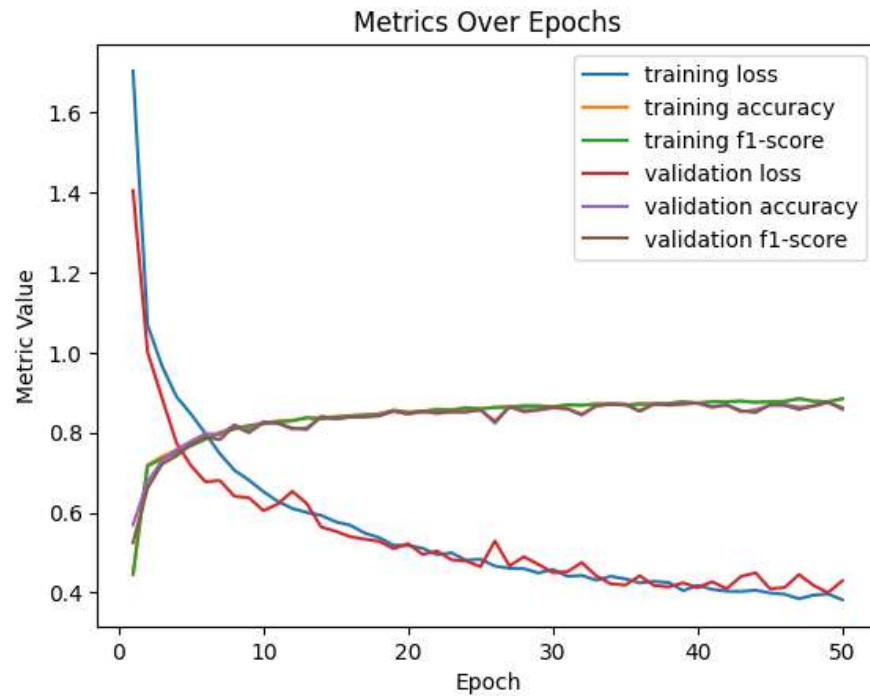
Model-2 Architecture:

```
# model 2
fnn = FNN()
fnn.add_layer(Dense(784,512))
fnn.add_layer(BatchNormalization(512))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.4))
fnn.add_layer(Dense(512,256))
fnn.add_layer(BatchNormalization(256))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.3))
fnn.add_layer(Dense(256,64))
fnn.add_layer(BatchNormalization(64))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.2))
fnn.add_layer(Dense(64,10))
fnn.add_layer(BatchNormalization(10))
fnn.add_layer(SoftMax())
```

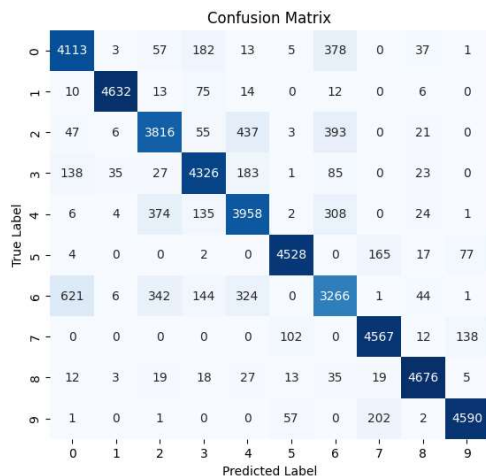

Learning rate: 0.005, Epoch: 50

training loss: 0.382063951232085, training accuracy: 0.8848333333333334,
training f1-score: 0.8842021944257399

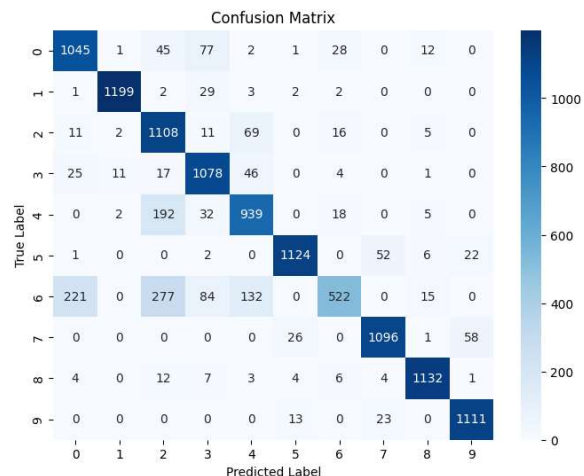
validation loss: 0.4294578591890024, validation accuracy: 0.8628333333333333,
validation f1-score: 0.8582923350823242



Training confusion matrix



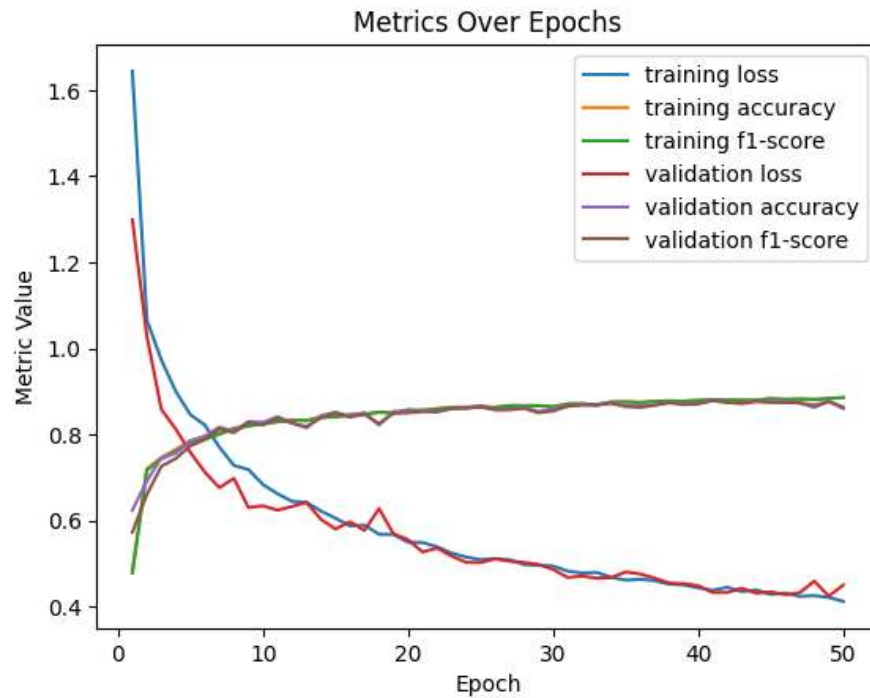
Validation confusion matrix



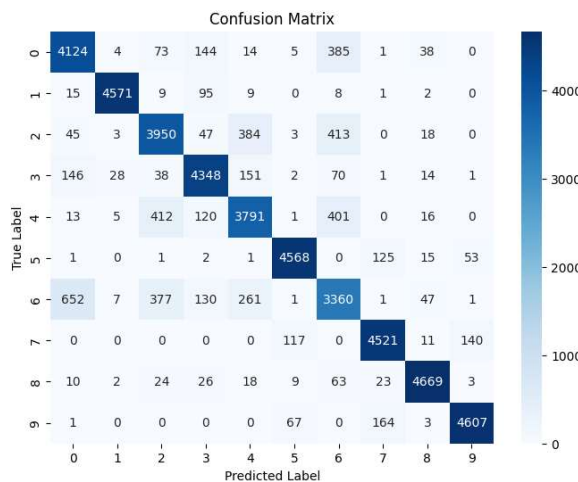
Learning rate: 0.003, Epoch: 50

training loss: 0.41193706404503594, training accuracy: 0.8856041666666666,
training f1-score: 0.8857016591243954

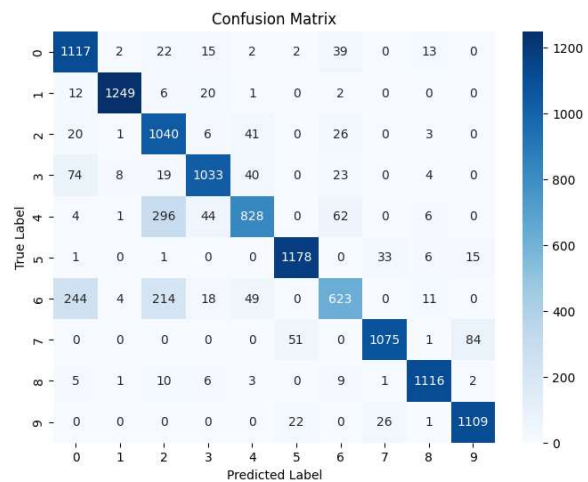
validation loss: 0.45016360160055313, validation accuracy: 0.864, validation f1-score: 0.8603595144346903



Training confusion matrix



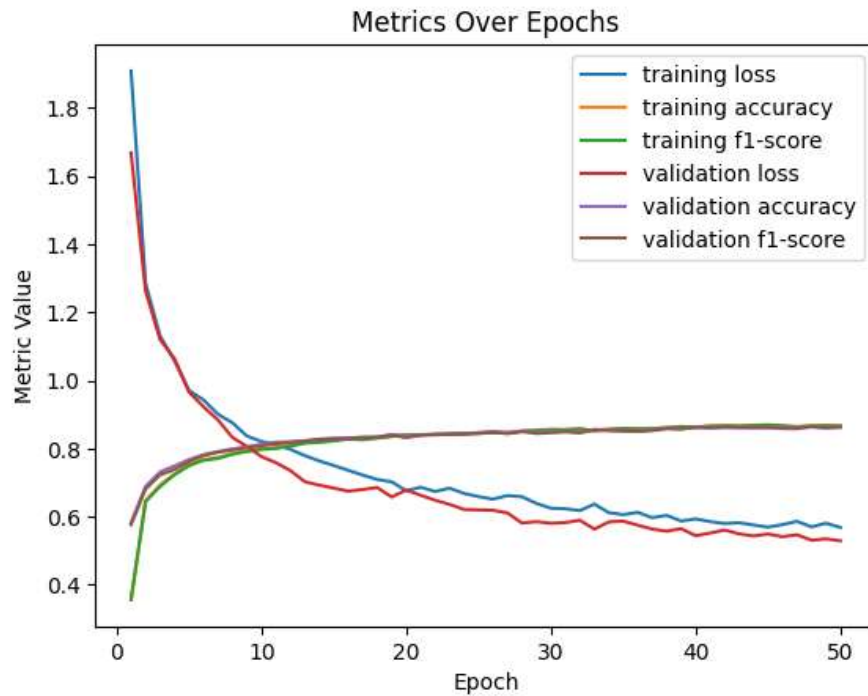
Validation confusion matrix



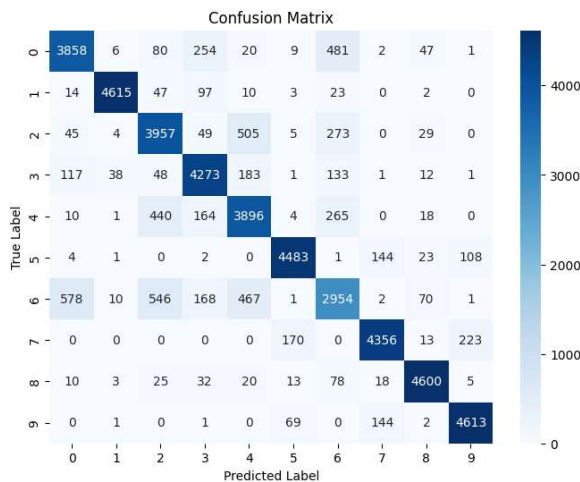
Learning rate: 0.001, Epoch: 50

training loss: 0.568040209441761, training accuracy: 0.8667708333333334,
training f1-score: 0.8660567228578984

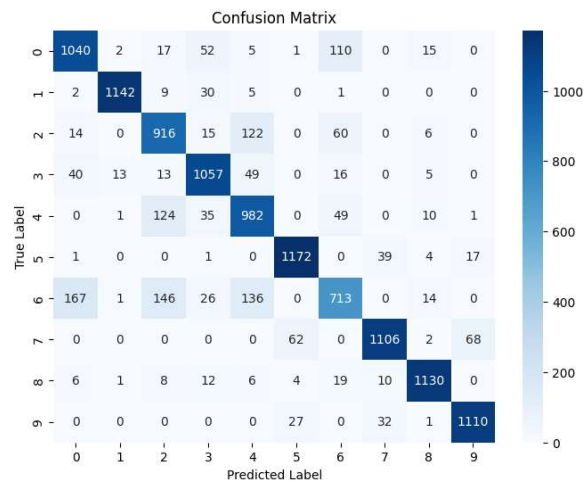
validation loss: 0.5289906421250361, validation accuracy: 0.864, validation f1-
score: 0.8624538086512352



Training confusion matrix



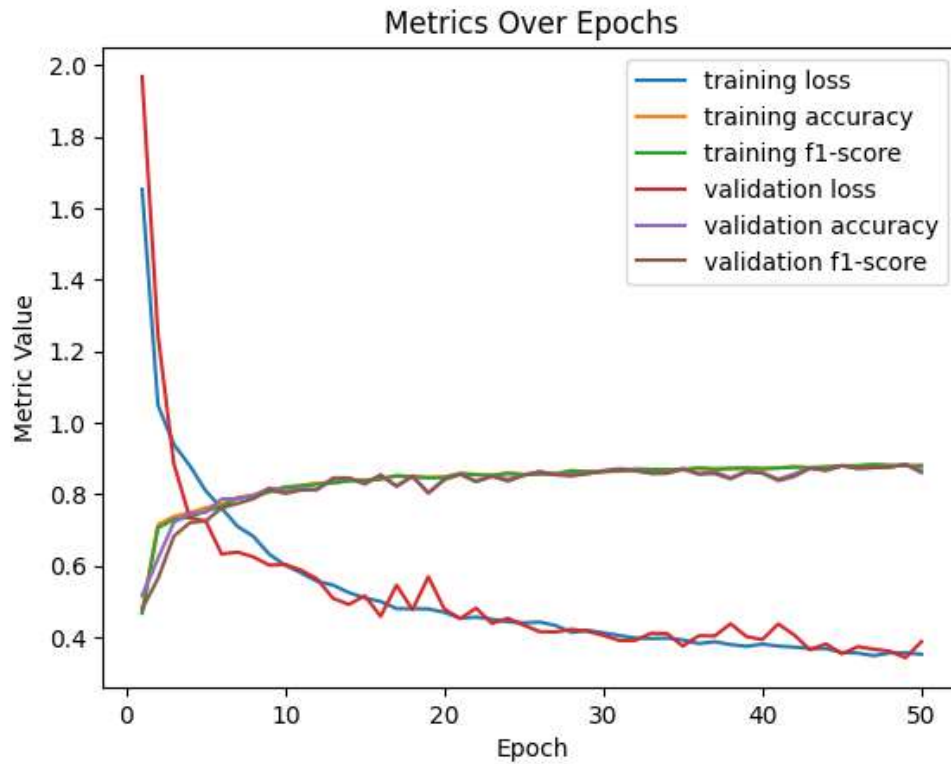
Validation confusion matrix



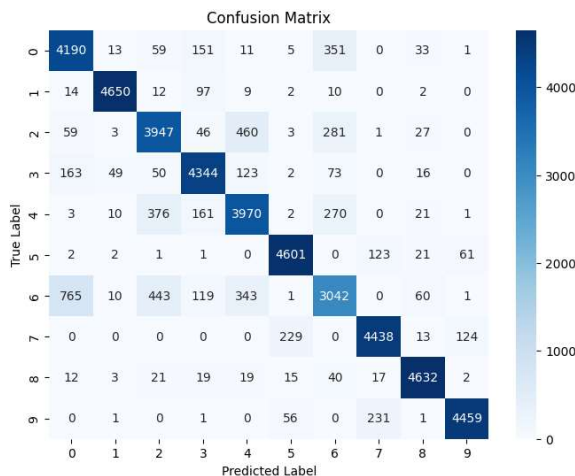
Learning rate: 0.01, Epoch: 50

training loss: 0.35242657018719603, training accuracy: 0.8806875, training f1-score: 0.87966815143994

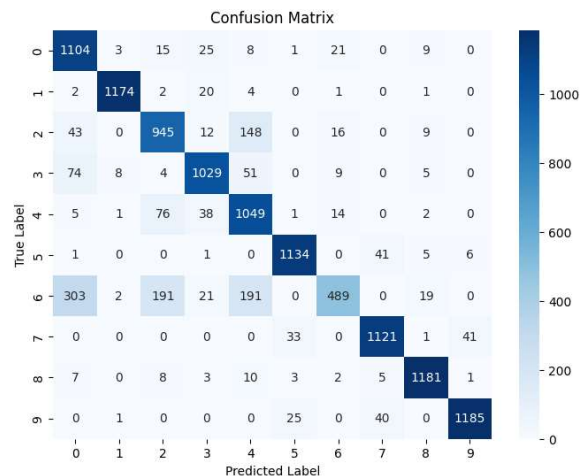
validation loss: 0.38756872693414623, validation accuracy: 0.8675833333333334, validation f1-score: 0.8605152494569721



Training confusion matrix



Validation confusion matrix



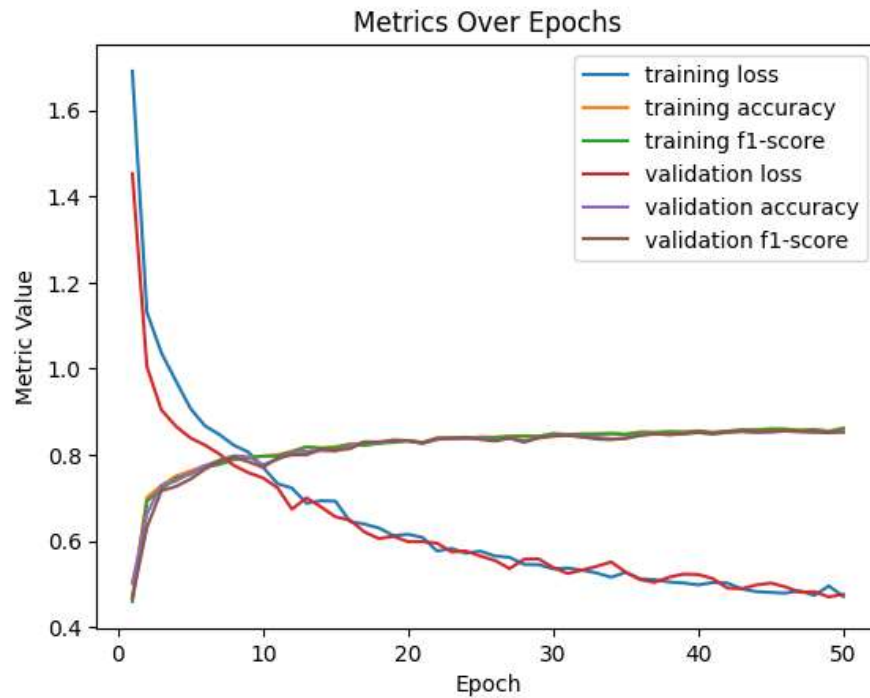
Model-3 Architecture:

```
# model 3
fnn = FNN()
fnn.add_layer(Dense(784,128))
fnn.add_layer(BatchNormalization(128))
fnn.add_layer(ReLU())
fnn.add_layer(Dropout(0.5))
fnn.add_layer(Dense(128,10))
fnn.add_layer(BatchNormalization(10))
fnn.add_layer(SoftMax())
```

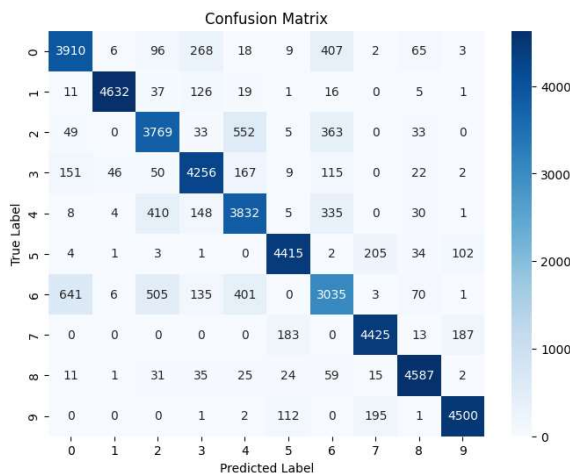
Learning rate: 0.005, Epoch: 50

training loss: 0.4709408817206369, training accuracy: 0.8616875, training f1-score: 0.8609704507435776

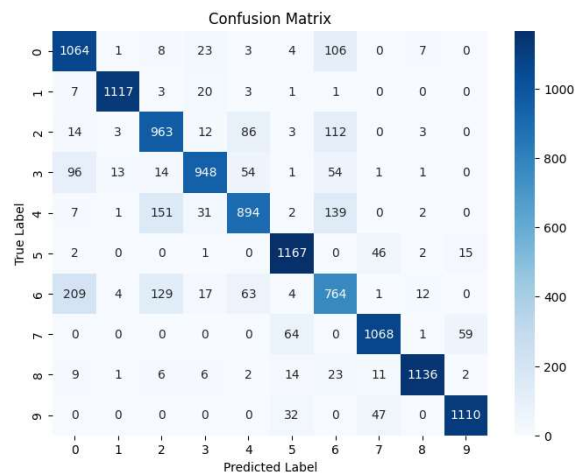
validation loss: 0.4757430698180543, validation accuracy: 0.8525833333333334, validation f1-score: 0.8533633587933165



Training confusion matrix



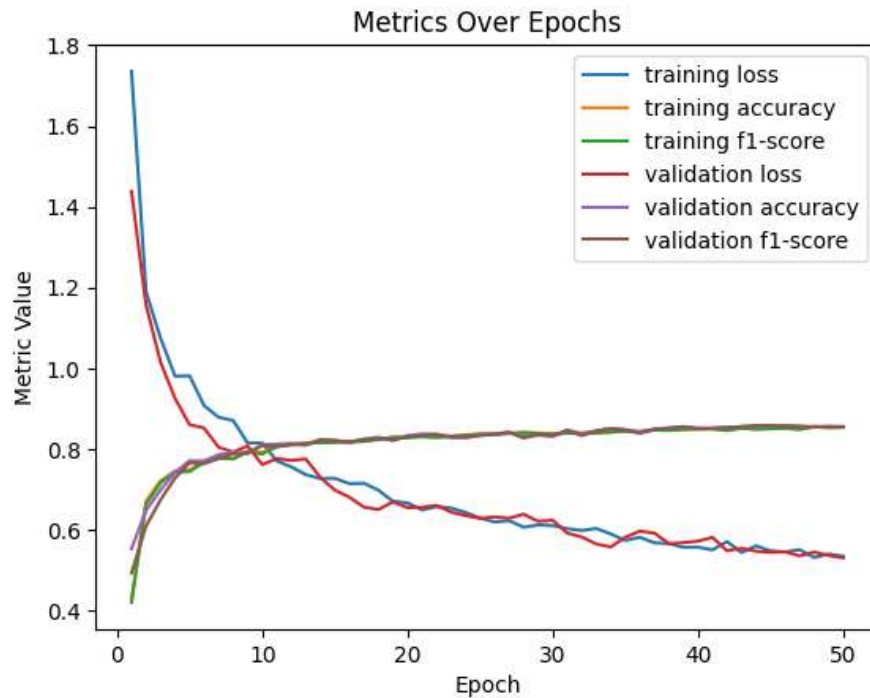
Validation confusion matrix



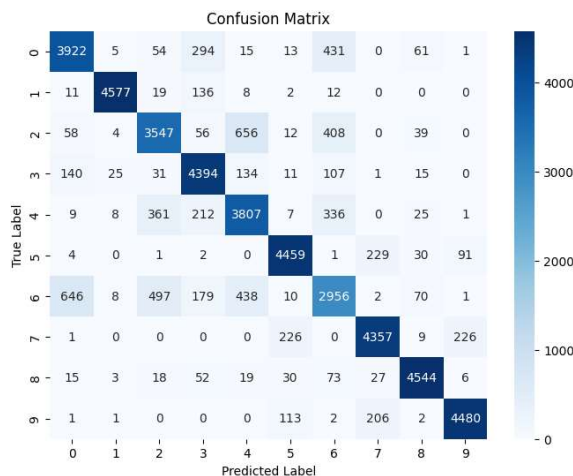
Learning rate: 0.003, Epoch: 50

training loss: 0.5346029983253986, training accuracy: 0.8550625, training f1-score: 0.854102675259276

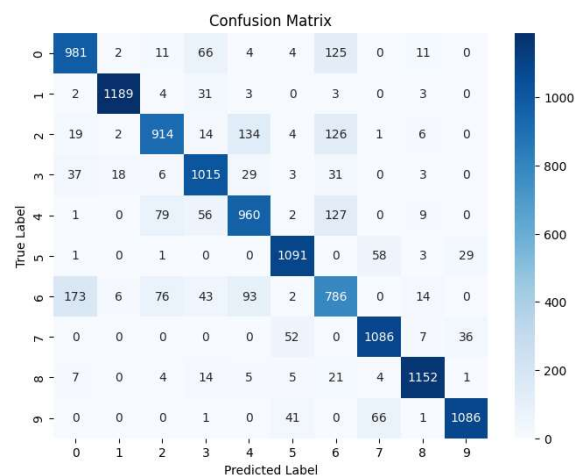
validation loss: 0.5305204877520904, validation accuracy: 0.855, validation f1-score: 0.8549691293931261



Training confusion matrix



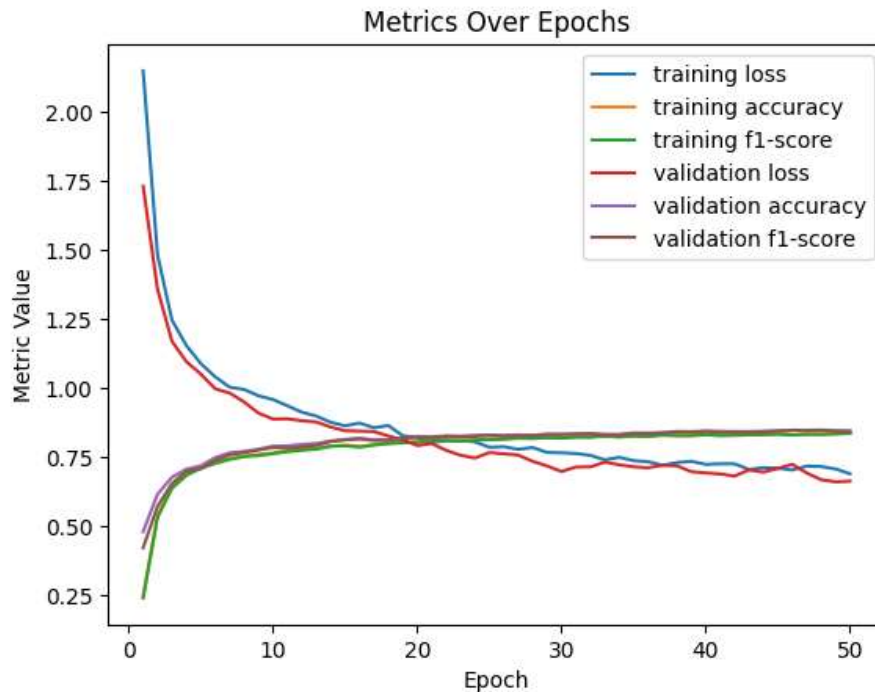
Validation confusion matrix



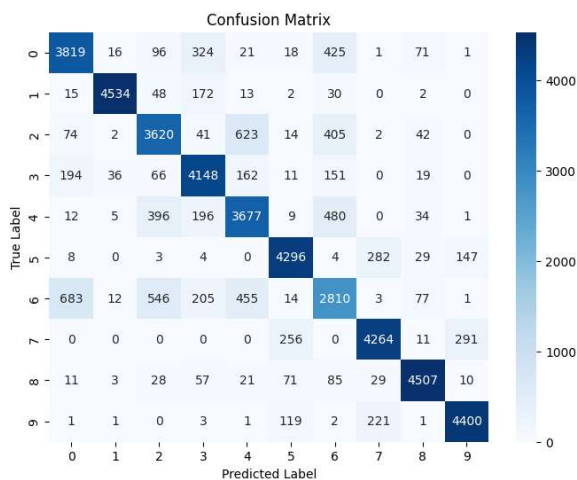
Learning rate: 0.001, Epoch: 50

training loss: 0.6879503040054713, training accuracy: 0.8348958333333333,
training f1-score: 0.8343571538151531

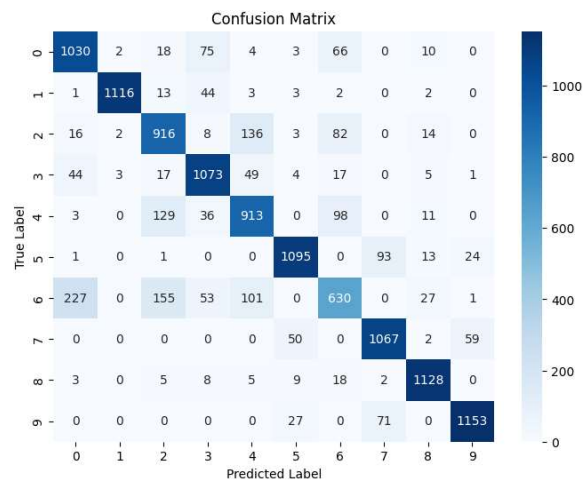
validation loss: 0.6612935514296884, validation accuracy: 0.8434166666666667,
validation f1-score: 0.8407962014021143



Training confusion matrix



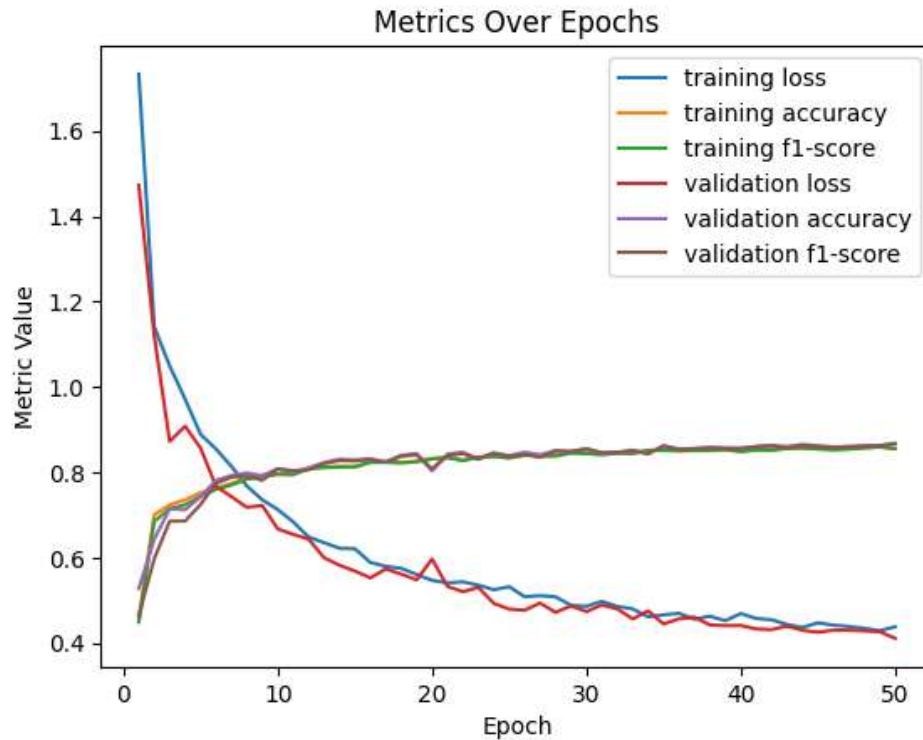
Validation confusion matrix



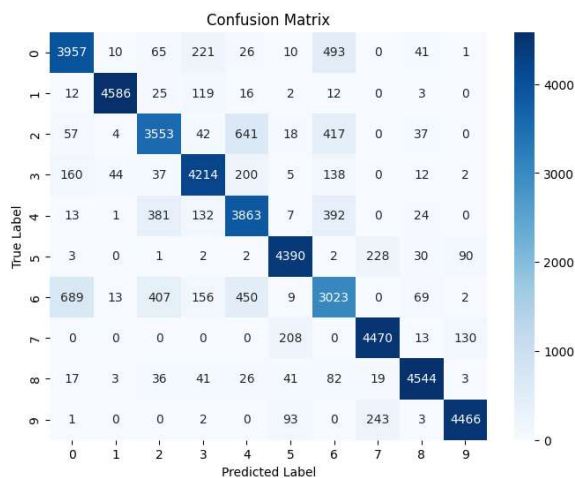
Learning rate: 0.01, Epoch: 50

training loss=0.438, training accuracy=0.856, training f1-score=0.855

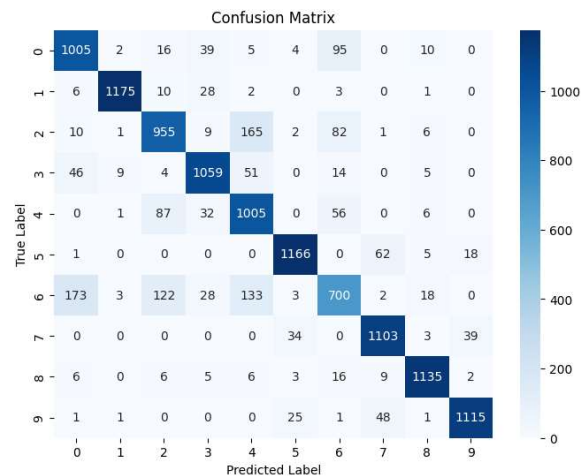
validation loss: 0.41096565764722814, validation accuracy: 0.8681666666666666,
validation f1-score: 0.866423619742586



Training confusion matrix



Validation confusion matrix



Best performing model:

Model 3 with learning rate 0.01

Independent test set performance on best model:

test loss: 0.4481490284391808, test accuracy: 0.8508, test f1-score:
0.8496342033555038