Offline 3 report

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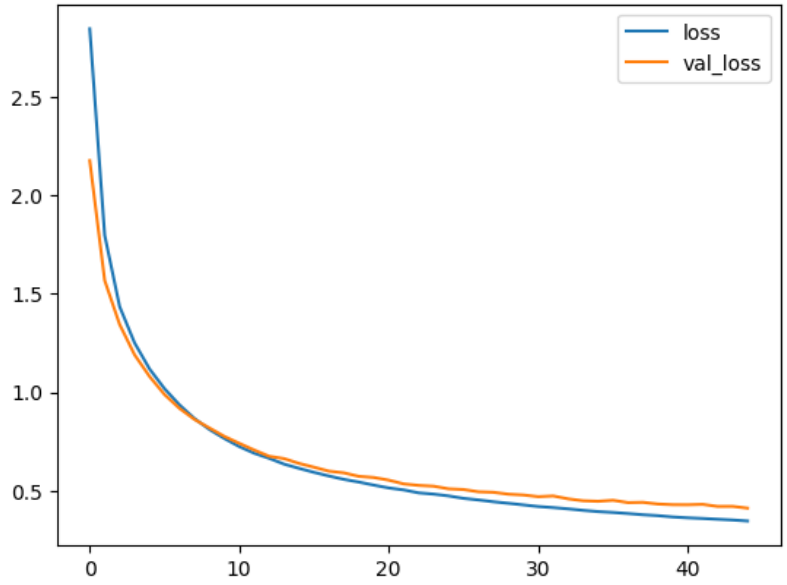
Model-1

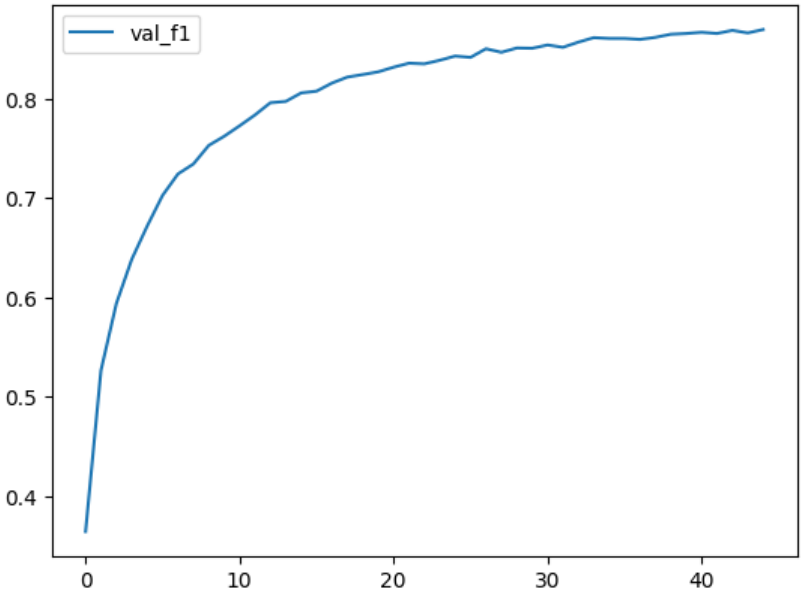
```
# learning rate
lr = [0.005, 0.0025, 0.001, 0.00075]
for lrate in lr:
    model = FNN(
        loss=CategoricalCrossEntropyLoss(),
        optimizer=SGD(learning_rate=lrate),
        learning_rate=lrate,
        layers=[
            Flatten(),
            DenseLayer(input_size, 1024, ReLU()),
            DropoutLayer(dropout_rate=0.3),
            DenseLayer(1024, 256, ReLU()),
            DropoutLayer(dropout_rate=0.2),
            DenseLayer(256, 64, ReLU()),
            DropoutLayer(dropout_rate=0.1),
            DenseLayer(64, output_size, Softmax()),
        ]
    )
```

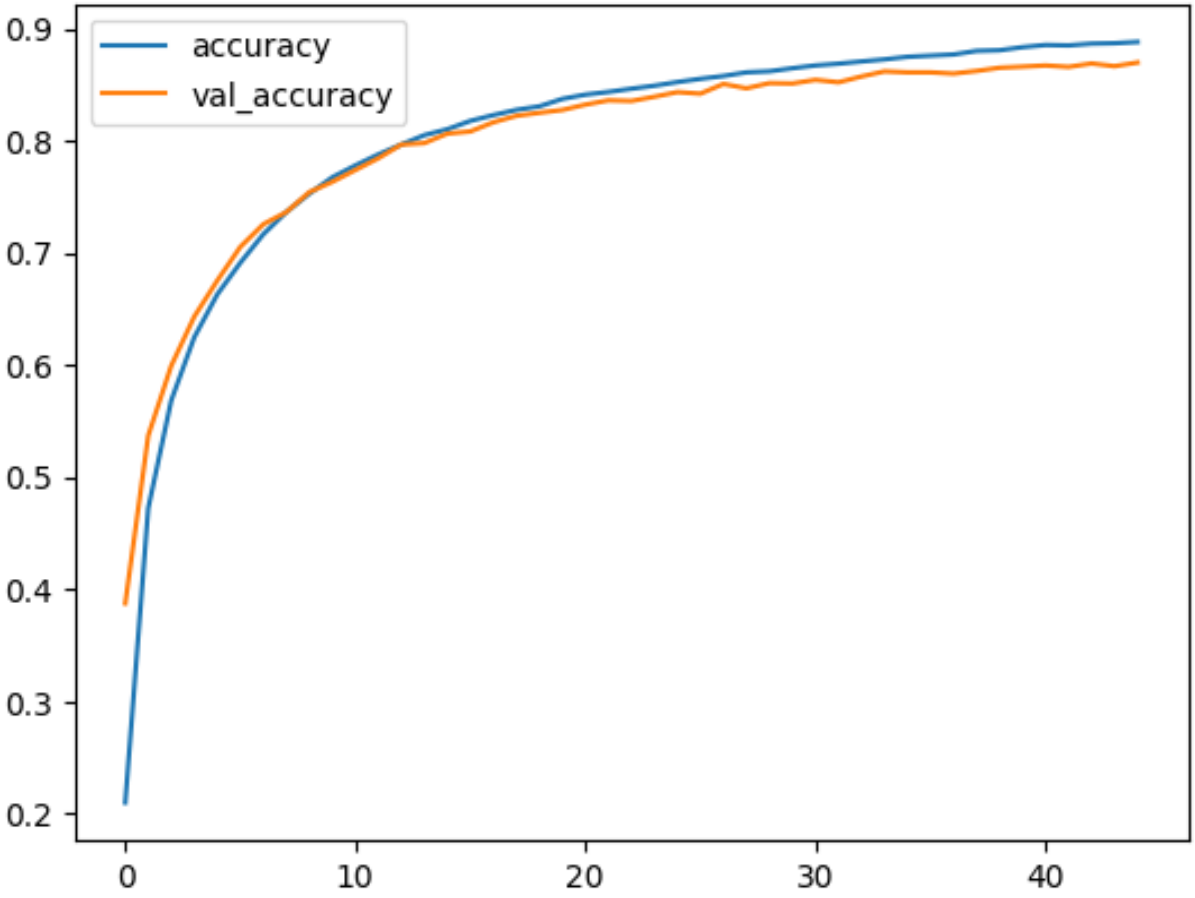
Epoch: 45
Batch-size: 64
Input size: 768
Output size: 26

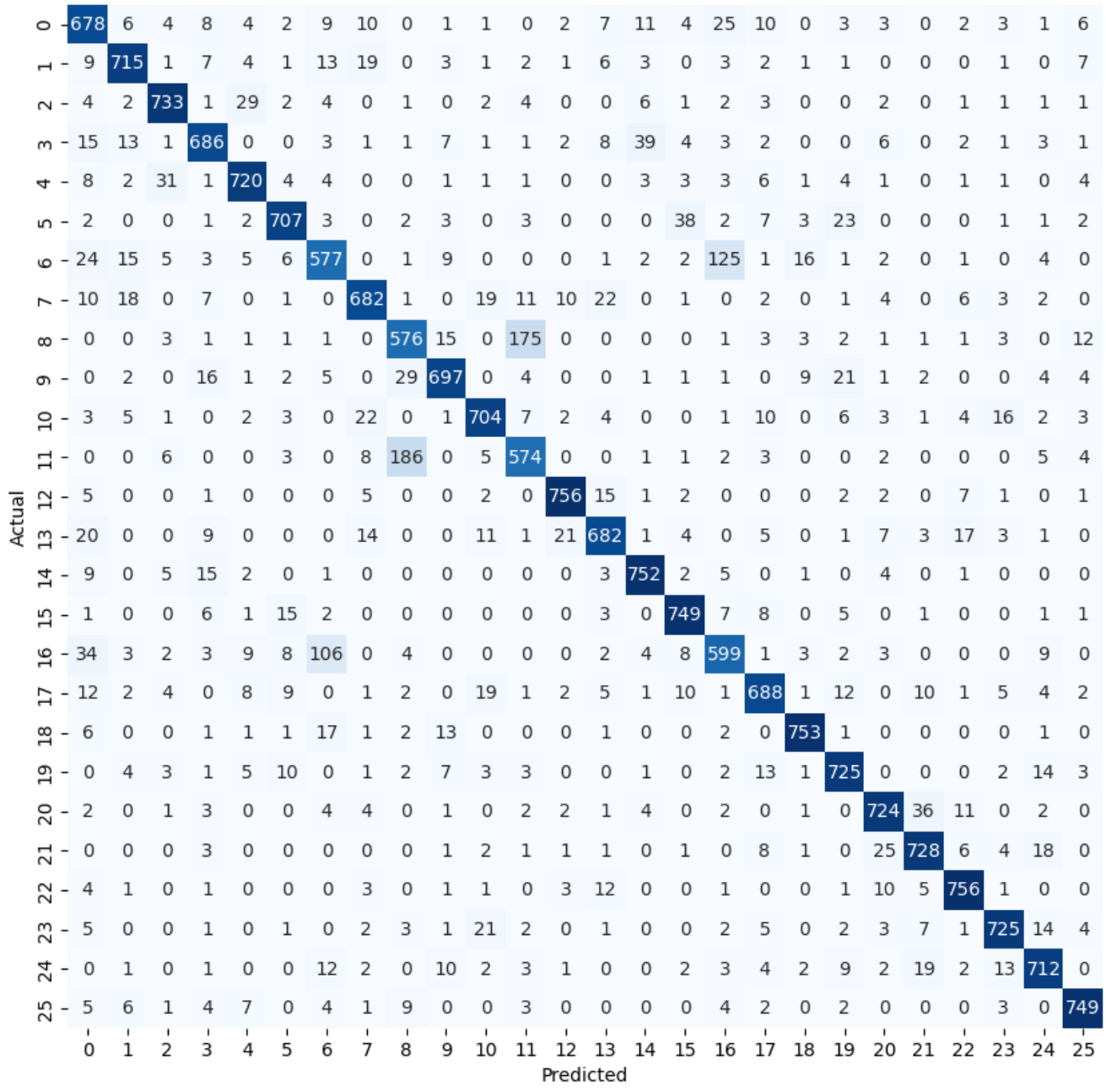
Learning rate 0.005

Test accuracy: 0.8701 Test loss: 0.4098 Test f1: 0.8700



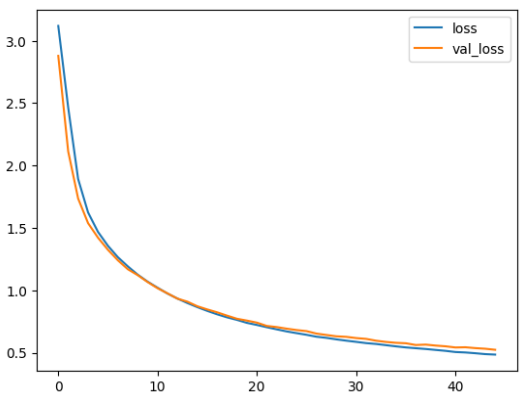


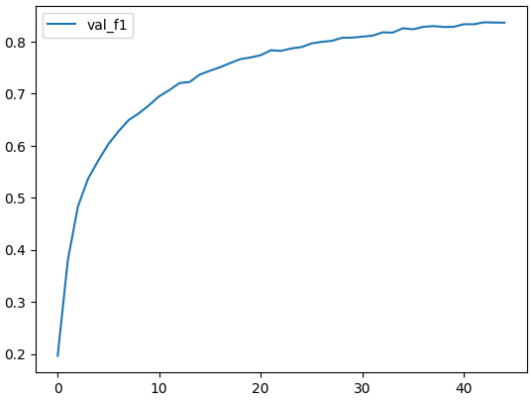

accuracy
val_accuracy
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40

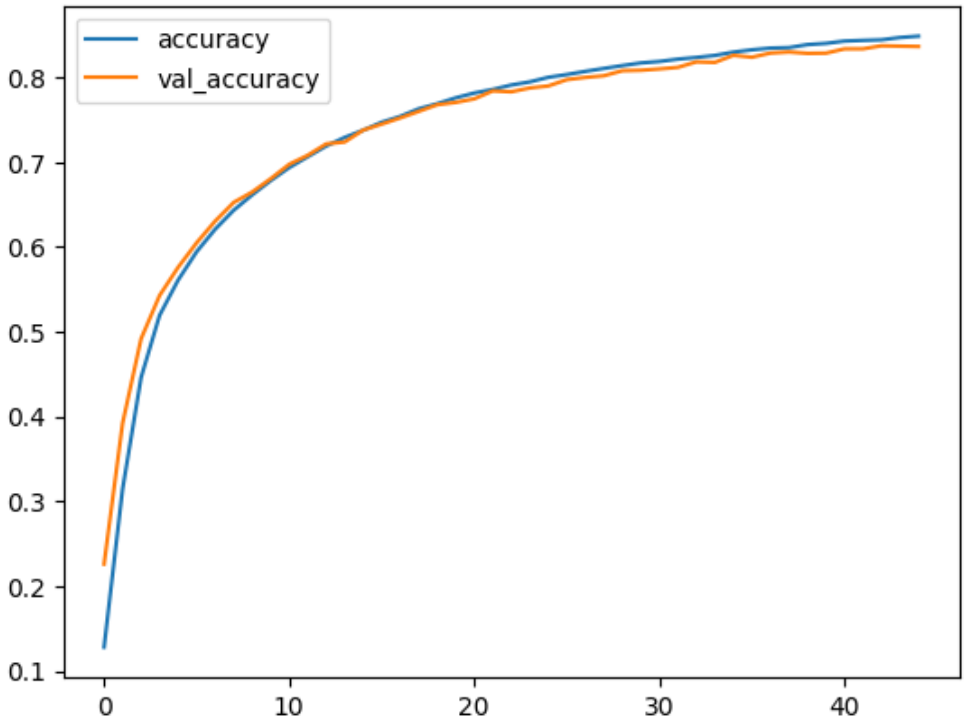


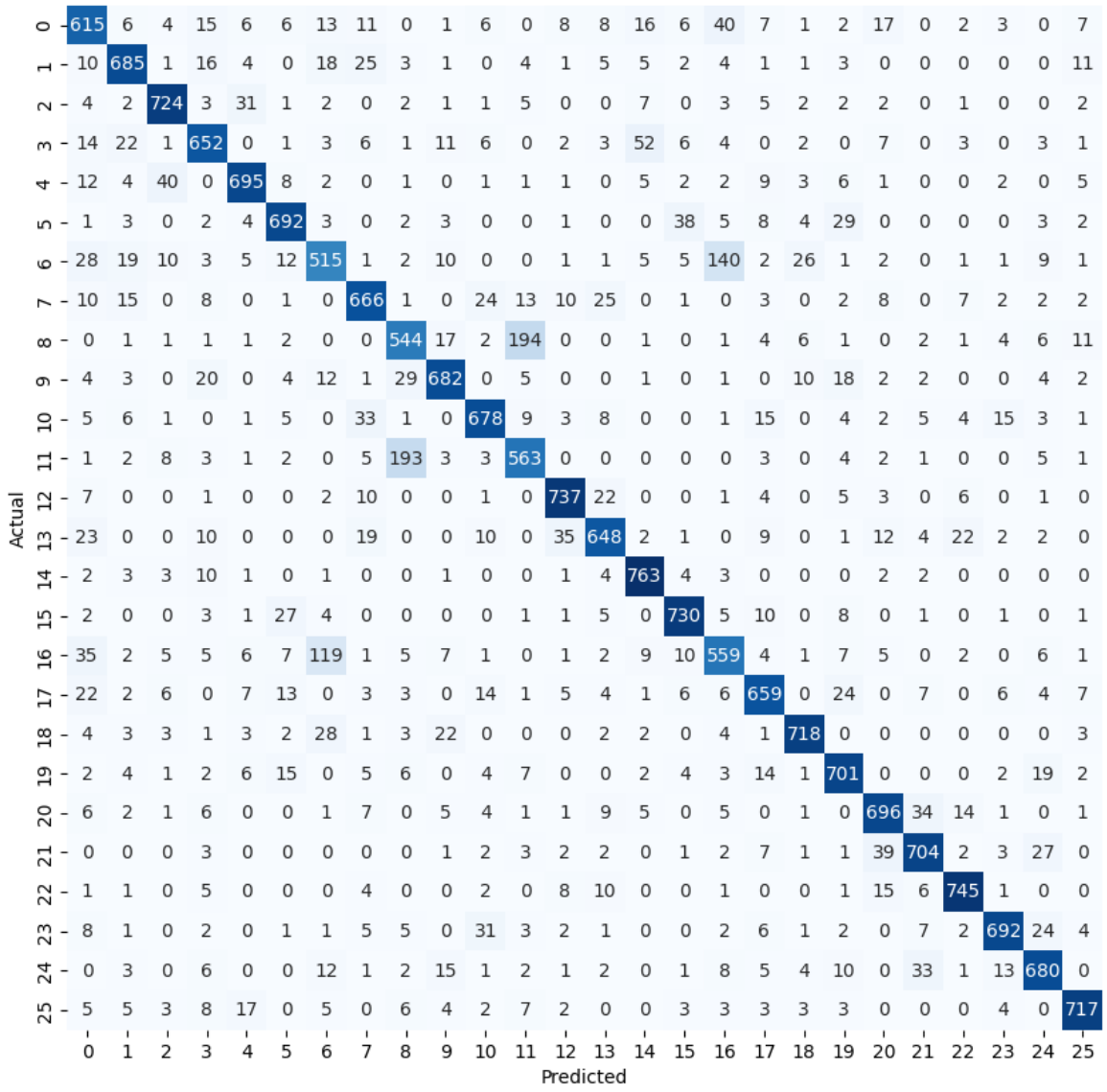
Learning rate 0.0025

Test accuracy:0.8367
Test loss: 0.5253
Test f1: 0.8364


loss
val_loss
3.0
2.5
2.0
1.5
1.0
0.5
0
10
20
30
40

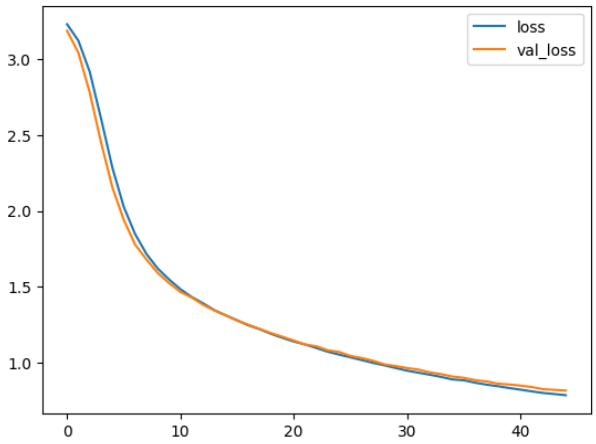

val_f1
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40

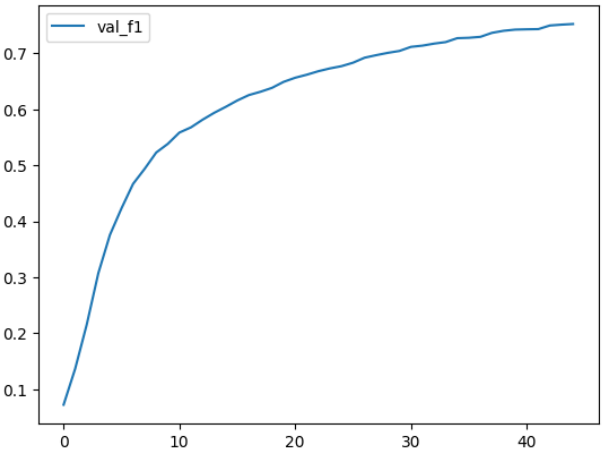

accuracy
val_accuracy
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40

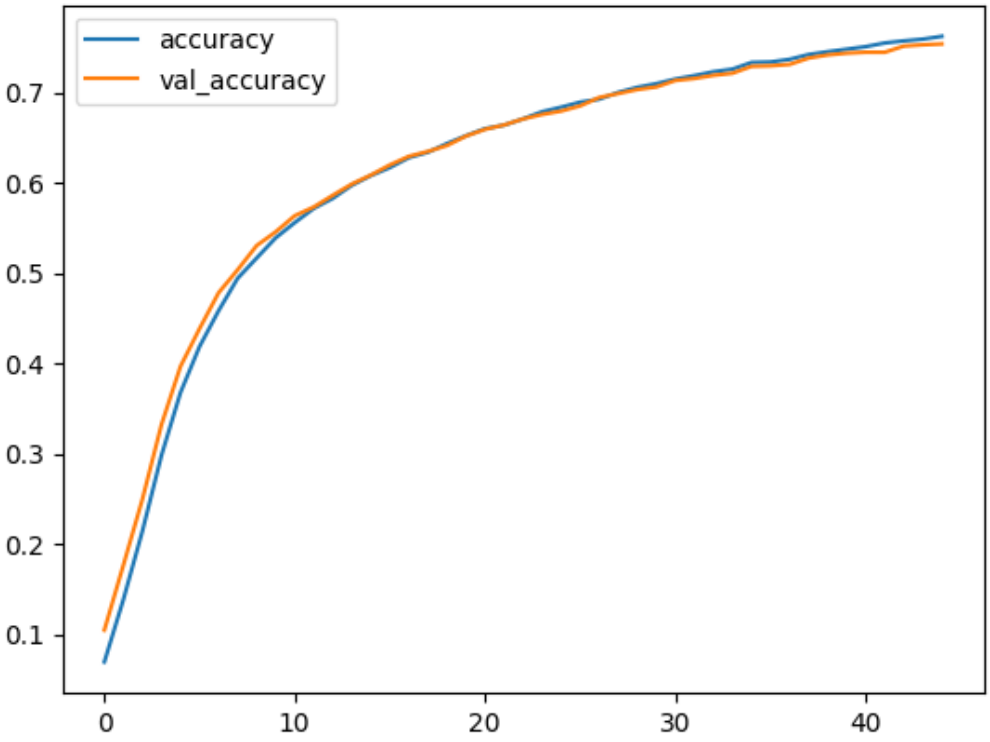


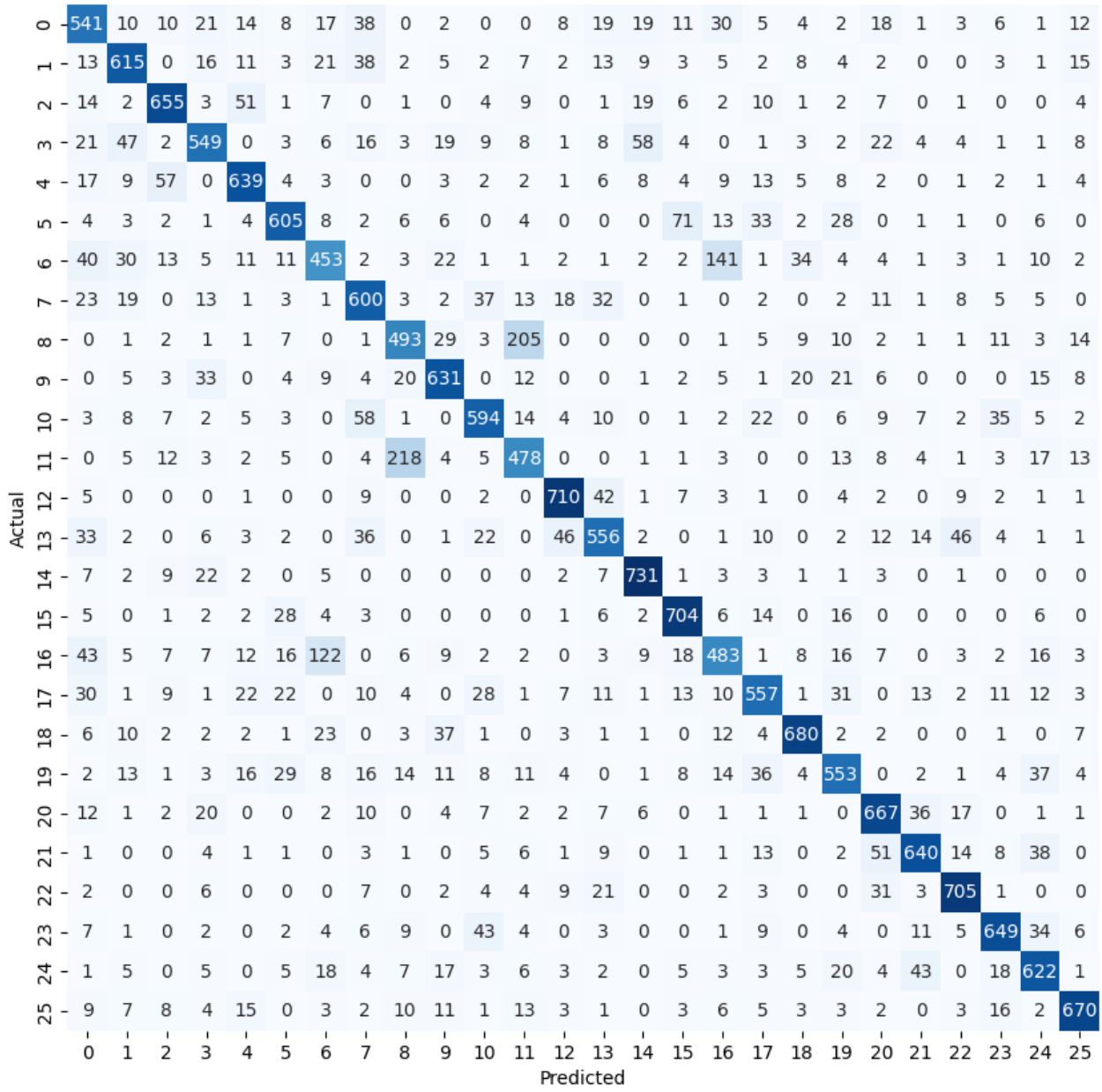
Learning rate 0.001

Test accuracy: 0.7588
Test loss: 0.7973
Test f1: 0.7580


loss
val_loss
3.0
2.5
2.0
1.5
1.0
0
10
20
30
40


val_f1
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40


accuracy
val_accuracy
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40


Actual
Predicted
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
0 541 10 10 21 14 8 17 38 0 2 0 0 8 19 19 11 30 5 4 2 18 1 3 6 1 12
1 13 615 0 16 11 3 21 38 2 5 2 7 2 13 9 3 5 2 8 4 2 0 0 3 1 15
2 14 2 655 3 51 1 7 0 1 0 4 9 0 1 19 6 2 10 1 2 7 0 1 0 0 4
3 21 47 2 549 0 3 6 16 3 19 9 8 1 8 58 4 0 1 3 2 22 4 4 1 1 8
4 17 9 57 0 639 4 3 0 0 3 2 2 1 6 8 4 9 13 5 8 2 0 1 2 1 4
5 4 3 2 1 4 605 8 2 6 6 0 4 0 0 0 71 13 33 2 28 0 1 1 0 6 0
6 40 30 13 5 11 11 453 2 3 22 1 1 2 1 2 2 141 1 34 4 4 1 3 1 10 2
7 23 19 0 13 1 3 1 600 3 2 37 13 18 32 0 1 0 2 0 2 11 1 8 5 5 0
8 0 1 2 1 1 7 0 1 493 29 3 205 0 0 0 0 1 5 9 10 2 1 1 11 3 14
9 0 5 3 33 0 4 9 4 20 631 0 12 0 0 1 2 5 1 20 21 6 0 0 0 15 8
10 3 8 7 2 5 3 0 58 1 0 594 14 4 10 0 1 2 22 0 6 9 7 2 35 5 2
11 0 5 12 3 2 5 0 4 218 4 5 478 0 0 1 1 3 0 0 13 8 4 1 3 17 13
12 5 0 0 0 1 0 0 9 0 0 2 0 710 42 1 7 3 1 0 4 2 0 9 2 1 1
13 33 2 0 6 3 2 0 36 0 1 22 0 46 556 2 0 1 10 0 2 12 14 46 4 1 1
14 7 2 9 22 2 0 5 0 0 0 0 0 2 7 731 1 3 3 1 1 3 0 1 0 0 0
15 5 0 1 2 2 28 4 3 0 0 0 0 1 6 2 704 6 14 0 16 0 0 0 0 6 0
16 43 5 7 7 12 16 122 0 6 9 2 2 0 3 9 18 483 1 8 16 7 0 3 2 16 3
17 30 1 9 1 22 22 0 10 4 0 28 1 7 11 1 13 10 557 1 31 0 13 2 11 12 3
18 6 10 2 2 2 1 23 0 3 37 1 0 3 1 1 0 12 4 680 2 2 0 0 1 0 7
19 2 13 1 3 16 29 8 16 14 11 8 11 4 0 1 8 14 36 4 553 0 2 1 4 37 4
20 12 1 2 20 0 0 2 10 0 4 7 2 2 7 6 0 1 1 1 0 667 36 17 0 1 1
21 1 0 0 4 1 1 0 3 1 0 5 6 1 9 0 1 1 13 0 2 51 640 14 8 38 0
22 2 0 0 6 0 0 0 7 0 2 4 4 9 21 0 0 2 3 0 0 31 3 705 1 0 0
23 7 1 0 2 0 2 4 6 9 0 43 4 0 3 0 0 1 9 0 4 0 11 5 649 34 6
24 1 5 0 5 0 5 18 4 7 17 3 6 3 2 0 5 3 3 5 20 4 43 0 18 622 1
25 9 7 8 4 15 0 3 2 10 11 1 13 3 1 0 3 6 5 3 3 2 0 3 16 2 670

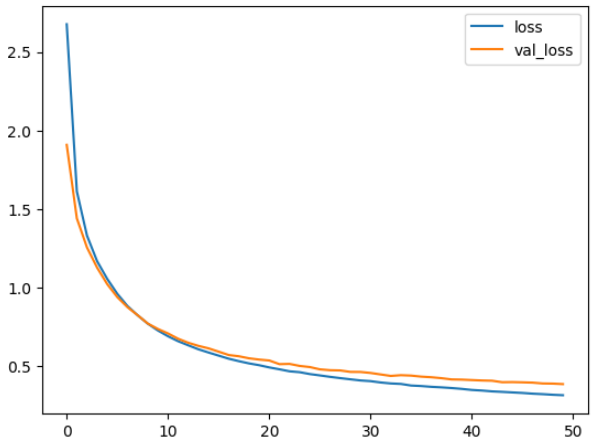
Model 2

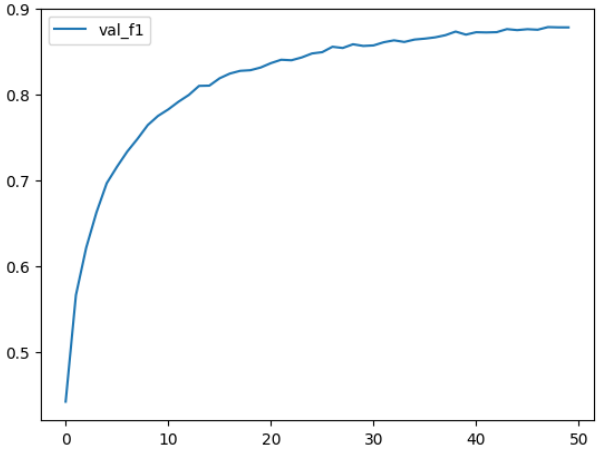
```
# learning rate
lr = [0.005, 0.0025, 0.001, 0.00075]
for lrate in lr:
    model = FNN(
        loss=CategoricalCrossEntropyLoss(),
        optimizer=SGD(learning_rate=lrate),
        learning_rate=lrate,
        layers=[
            Flatten(),
            DenseLayer(input_size, 1024, ReLU()),
            DropoutLayer(dropout_rate=0.3),
            DenseLayer(1024, 512, ReLU()),
            DropoutLayer(dropout_rate=0.2),
            DenseLayer(512, 64, ReLU()),
            DropoutLayer(dropout_rate=0.1),
            DenseLayer(64, output_size, Softmax()),
        ]
    )
```

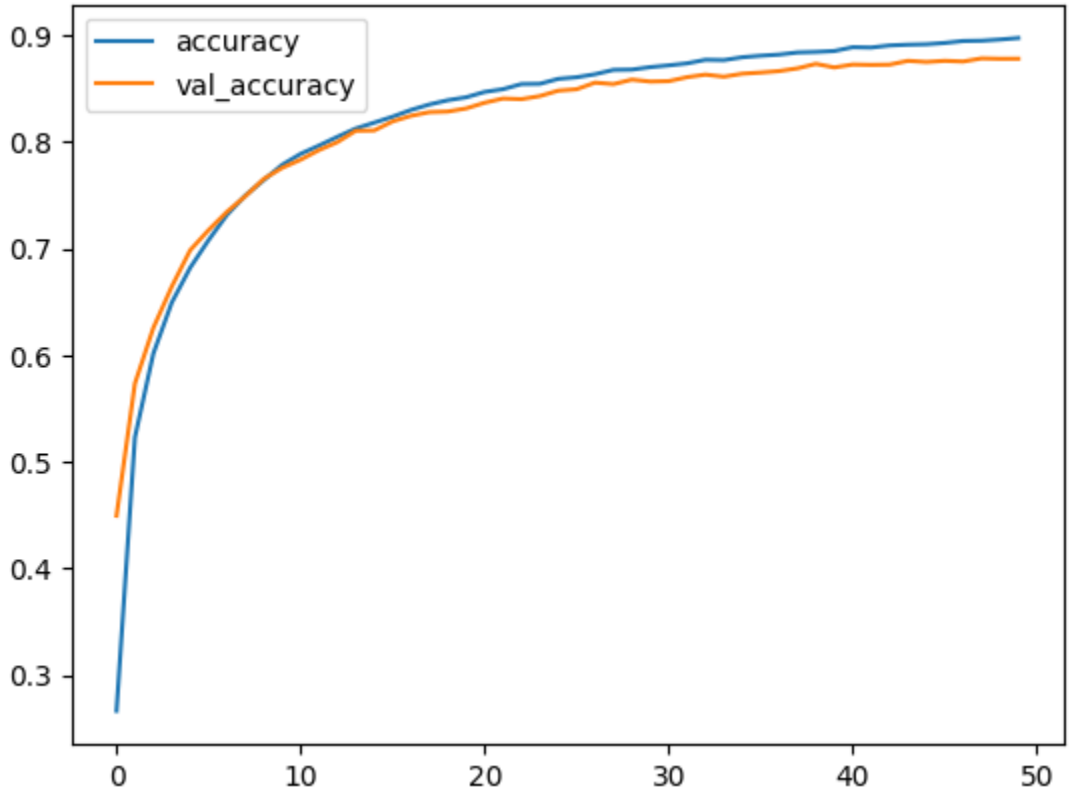
epoch : 50
Batch size: 64

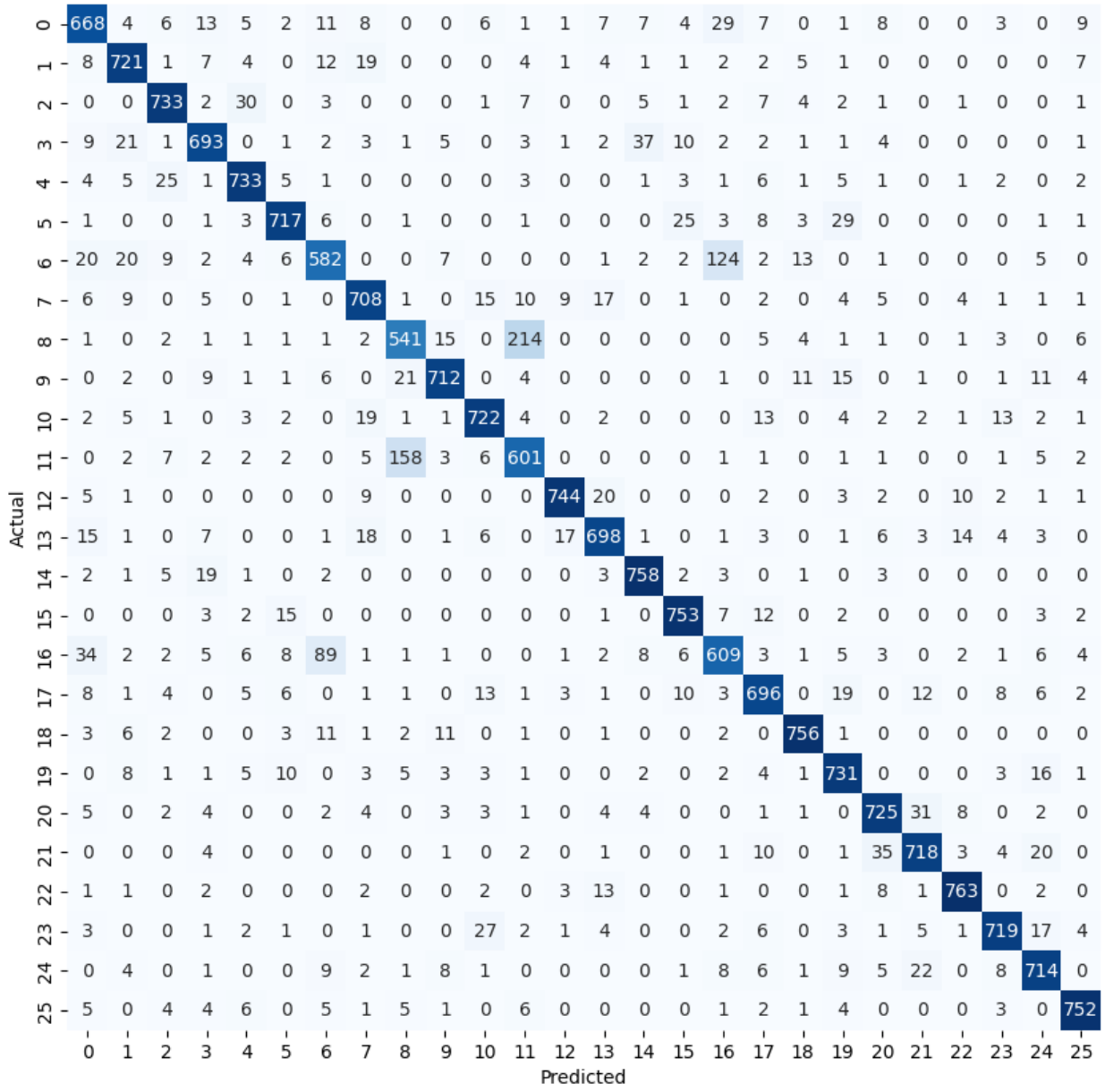
Learning rate: 0.005

test loss: 0.38948337996316845, test accuracy: 0.8771634615384616, test f1: 0.8769679654957349


loss
val_loss
2.5
2.0
1.5
1.0
0.5
0
10
20
30
40
50

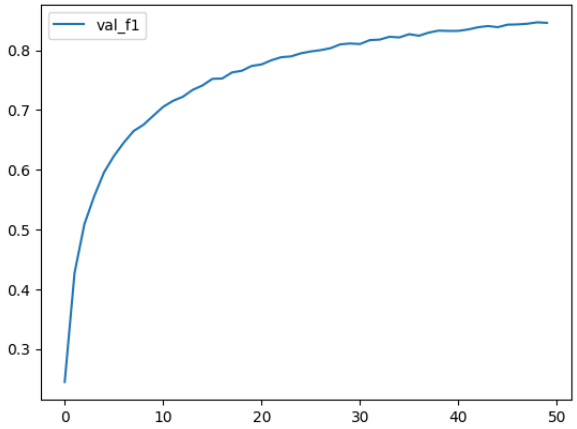

val_f1
0.9
0.8
0.7
0.6
0.5
0
10
20
30
40
50

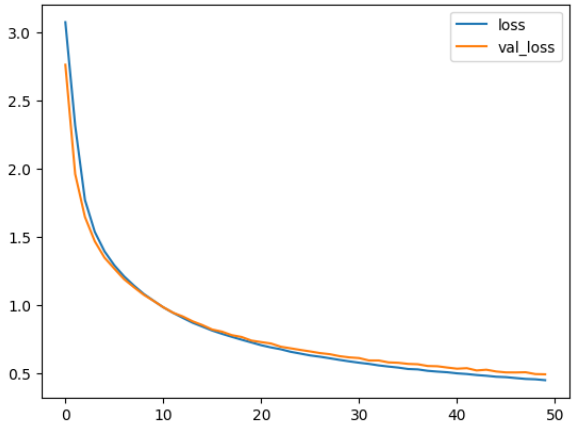

accuracy
val_accuracy
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50

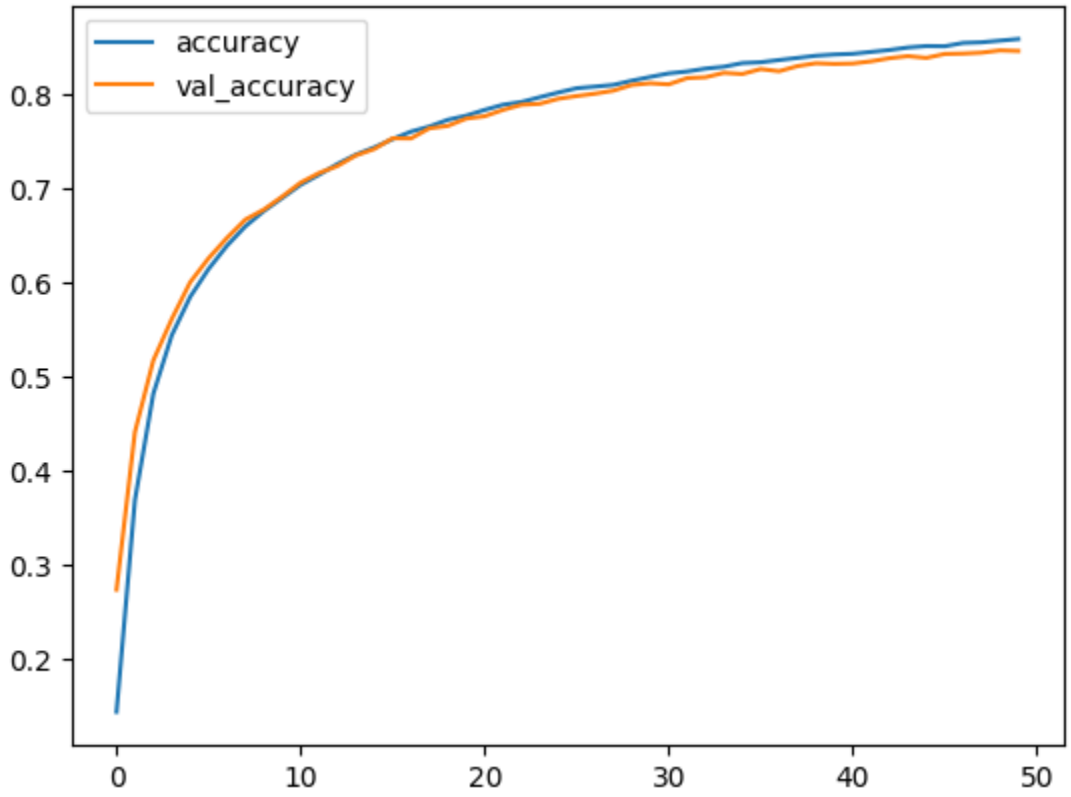


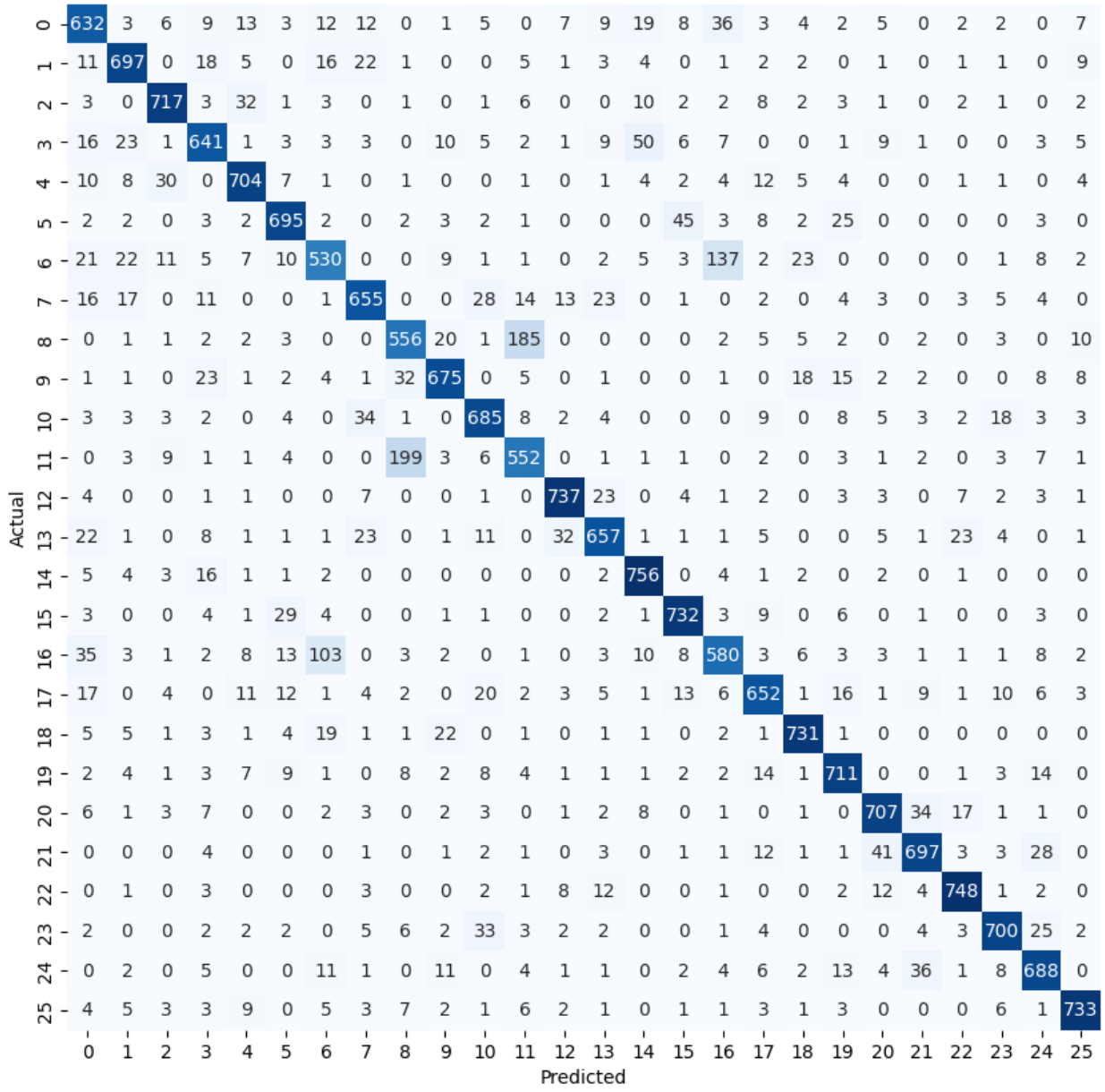
Learning rate: 0.0025

test loss: 0.49303265428495935, test accuracy: 0.8479326923076923, test f1: 0.8477188075617893


val_f1
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50

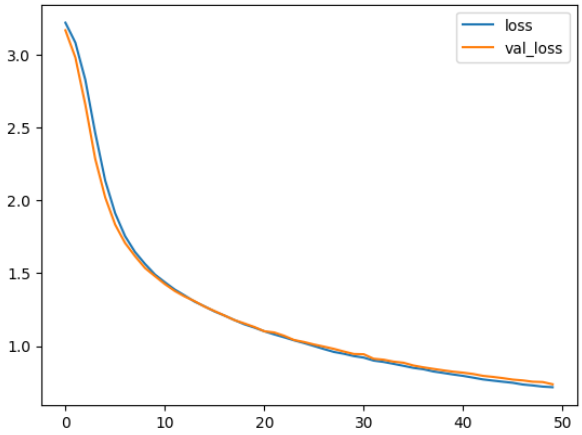

loss
val_loss
3.0
2.5
2.0
1.5
1.0
0.5
0
10
20
30
40
50

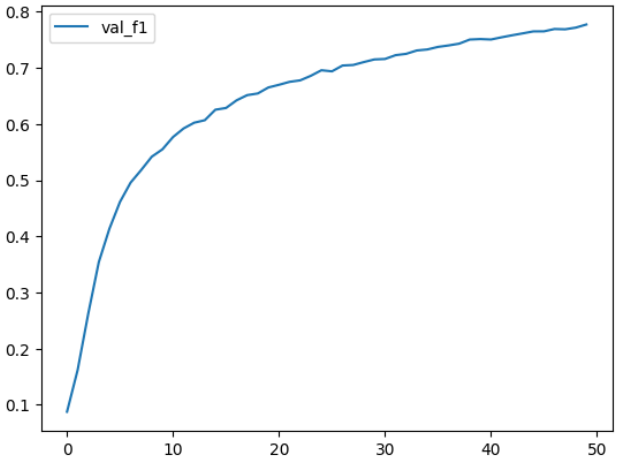

accuracy
val_accuracy
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40
50



Learning rate: 0.001

test loss: 0.7346842407856224, test accuracy: 0.7780769230769231, test f1: 0.7773129243972582


loss
val_loss
3.0
2.5
2.0
1.5
1.0
0
10
20
30
40
50


val_f1
0.8
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0.6
0.5
0.4
0.3
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0.1
0
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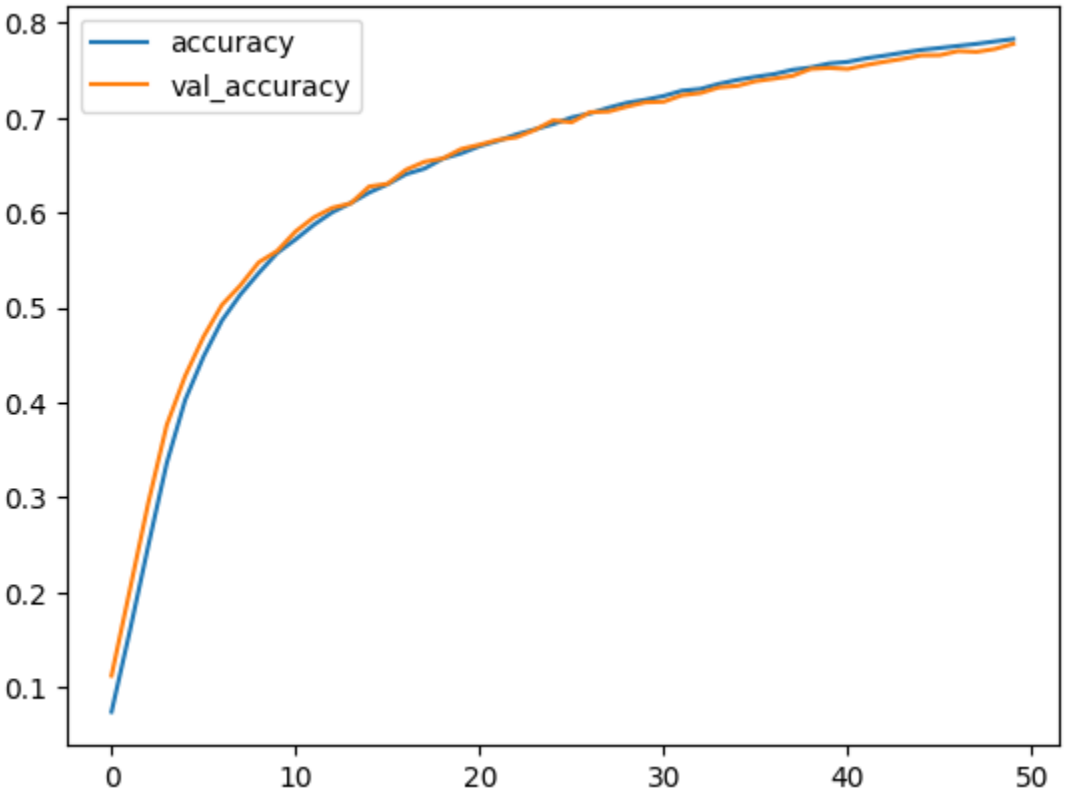
20
30
40
50


accuracy
val_accuracy
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0.6
0.5
0.4
0.3
0.2
0.1
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10
20
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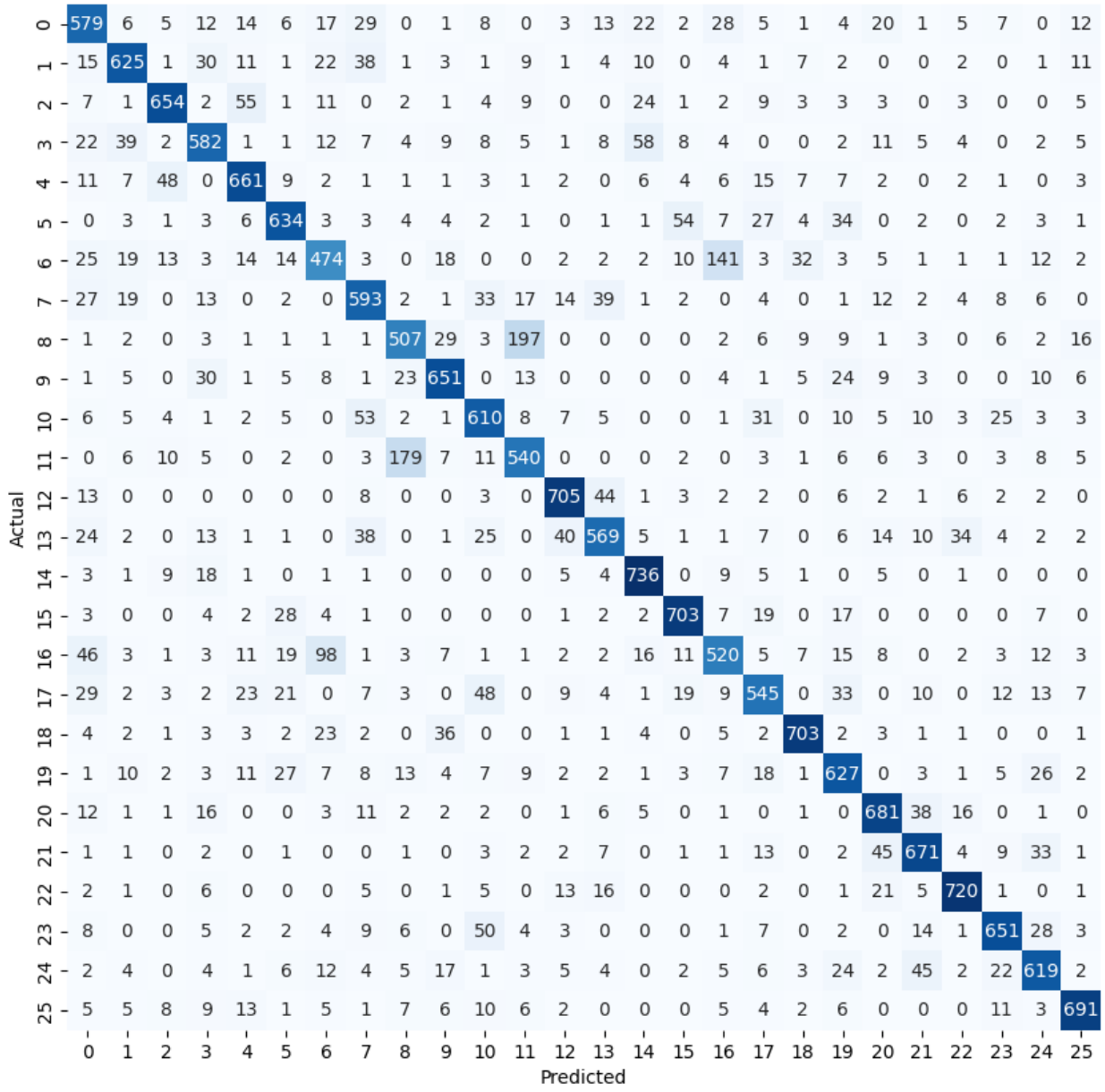
40
50


Actual
Predicted
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
0 579 6 5 12 14 6 17 29 0 1 8 0 3 13 22 2 28 5 1 4 20 1 5 7 0 12
1 15 625 1 30 11 1 22 38 1 3 1 9 1 4 10 0 4 1 7 2 0 0 2 0 1 11
2 7 1 654 2 55 1 11 0 2 1 4 9 0 0 24 1 2 9 3 3 3 0 3 0 0 5
3 22 39 2 582 1 1 12 7 4 9 8 5 1 8 58 8 4 0 0 2 11 5 4 0 2 5
4 11 7 48 0 661 9 2 1 1 1 3 1 2 0 6 4 6 15 7 7 2 0 2 1 0 3
5 0 3 1 3 6 634 3 3 4 4 2 1 0 1 1 54 7 27 4 34 0 2 0 2 3 1
6 25 19 13 3 14 14 474 3 0 18 0 0 2 2 2 10 141 3 32 3 5 1 1 1 12 2
7 27 19 0 13 0 2 0 593 2 1 33 17 14 39 1 2 0 4 0 1 12 2 4 8 6 0
8 1 2 0 3 1 1 1 1 507 29 3 197 0 0 0 0 2 6 9 9 1 3 0 6 2 16
9 1 5 0 30 1 5 8 1 23 651 0 13 0 0 0 0 4 1 5 24 9 3 0 0 10 6
10 6 5 4 1 2 5 0 53 2 1 610 8 7 5 0 0 1 31 0 10 5 10 3 25 3 3
11 0 6 10 5 0 2 0 3 179 7 11 540 0 0 0 2 0 3 1 6 6 3 0 3 8 5
12 13 0 0 0 0 0 0 8 0 0 3 0 705 44 1 3 2 2 0 6 2 1 6 2 2 0
13 24 2 0 13 1 1 0 38 0 1 25 0 40 569 5 1 1 7 0 6 14 10 34 4 2 2
14 3 1 9 18 1 0 1 1 0 0 0 0 5 4 736 0 9 5 1 0 5 0 1 0 0 0
15 3 0 0 4 2 28 4 1 0 0 0 0 1 2 2 703 7 19 0 17 0 0 0 0 7 0
16 46 3 1 3 11 19 98 1 3 7 1 1 2 2 16 11 520 5 7 15 8 0 2 3 12 3
17 29 2 3 2 23 21 0 7 3 0 48 0 9 4 1 19 9 545 0 33 0 10 0 12 13 7
18 4 2 1 3 3 2 23 2 0 36 0 0 1 1 4 0 5 2 703 2 3 1 1 0 0 1
19 1 10 2 3 11 27 7 8 13 4 7 9 2 2 1 3 7 18 1 627 0 3 1 5 26 2
20 12 1 1 16 0 0 3 11 2 2 2 0 1 6 5 0 1 0 1 0 681 38 16 0 1 0
21 1 1 0 2 0 1 0 0 1 0 3 2 2 7 0 1 1 13 0 2 45 671 4 9 33 1
22 2 1 0 6 0 0 0 5 0 1 5 0 13 16 0 0 0 2 0 1 21 5 720 1 0 1
23 8 0 0 5 2 2 4 9 6 0 50 4 3 0 0 0 1 7 0 2 0 14 1 651 28 3
24 2 4 0 4 1 6 12 4 5 17 1 3 5 4 0 2 5 6 3 24 2 45 2 22 619 2
25 5 5 8 9 13 1 5 1 7 6 10 6 2 0 0 0 5 4 2 6 0 0 0 11 3 691

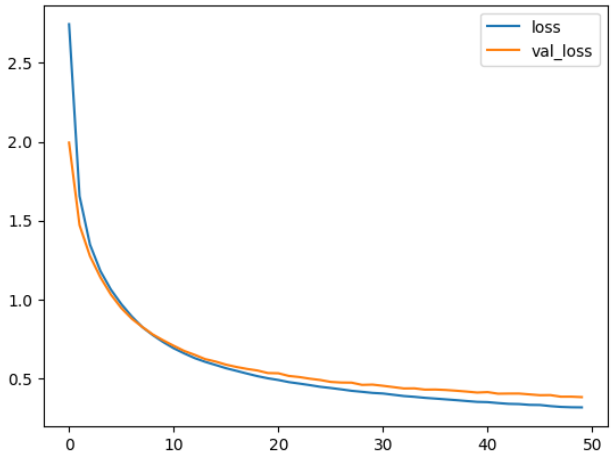
Model 3

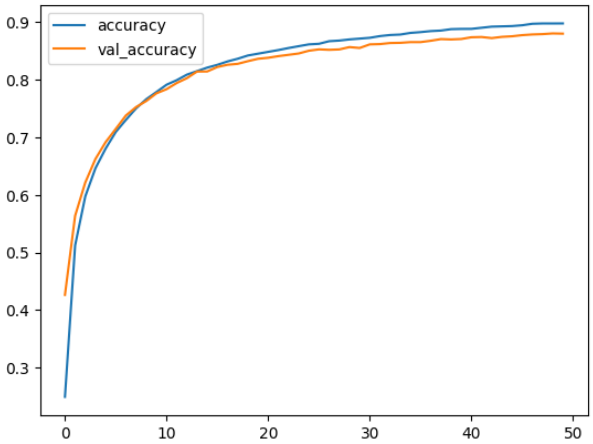
```
# learning rate
lr = [0.005, 0.0025, 0.001, 0.00075]
for lrate in lr:
    model = FNN(
        loss=CategoricalCrossEntropyLoss(),
        optimizer=SGD(learning_rate=lrate),
        learning_rate=lrate,
        layers=[
            Flatten(),
            DenseLayer(input_size, 1024, ReLU()),
            DropoutLayer(dropout_rate=0.3),
            DenseLayer(1024, 256, ReLU()),
            DropoutLayer(dropout_rate=0.2),
            DenseLayer(256, 128, ReLU()),
            DropoutLayer(dropout_rate=0.1),
            DenseLayer(128, output_size, Softmax()),
        ]
    )
```

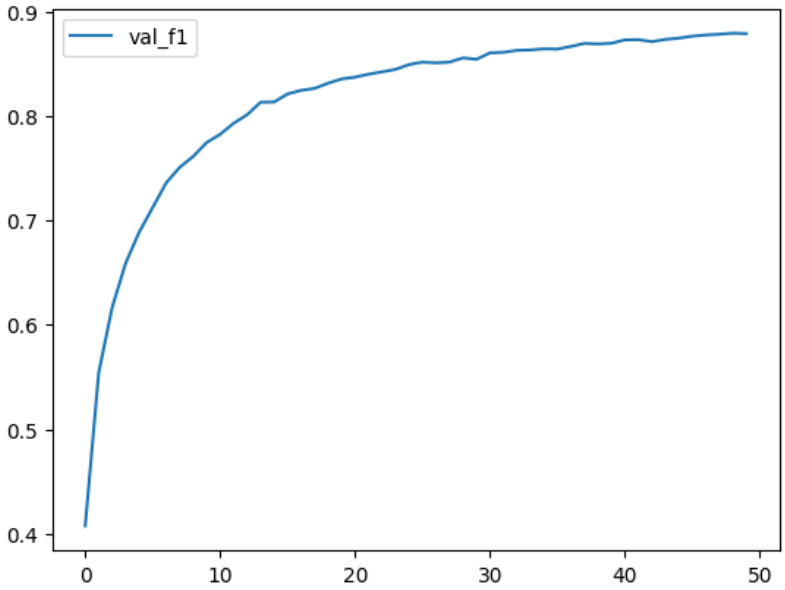
epoch : 50
Batch size: 64

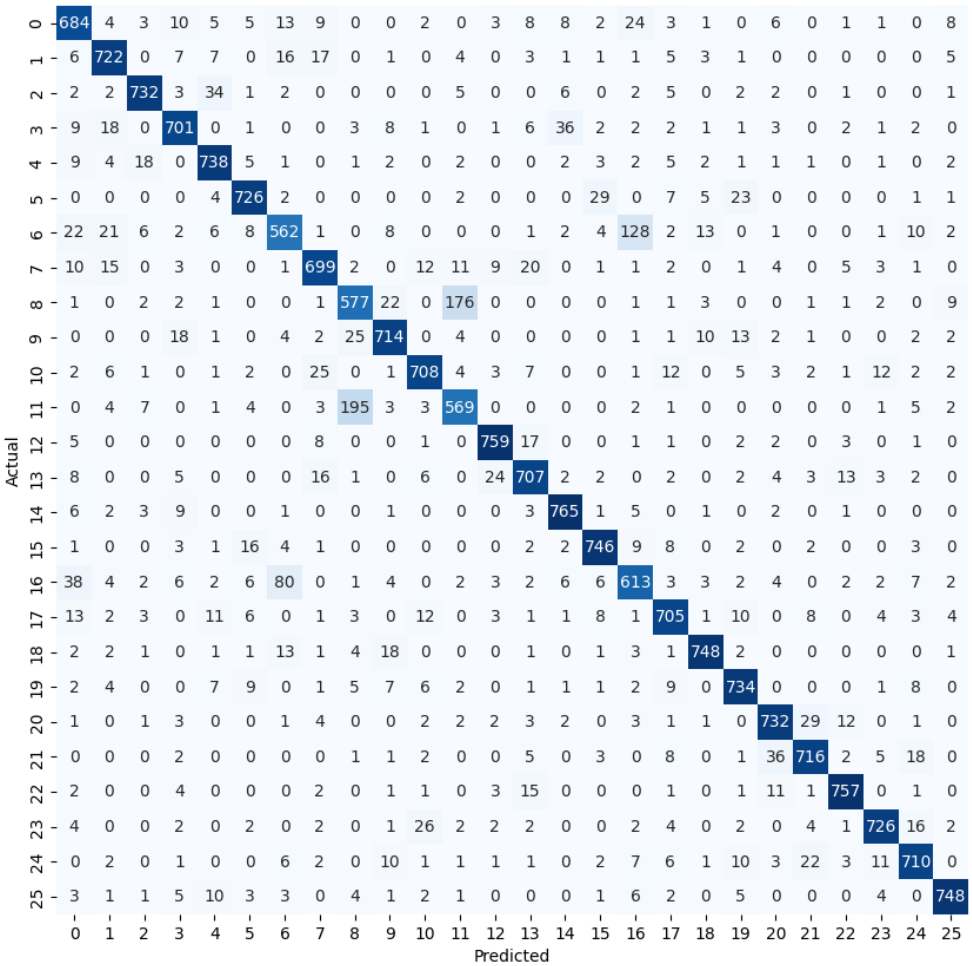
Learning rate: 0.005

test loss: 0.3740598363955921, test accuracy: 0.881201923076923, test f1: 0.8810479945586394



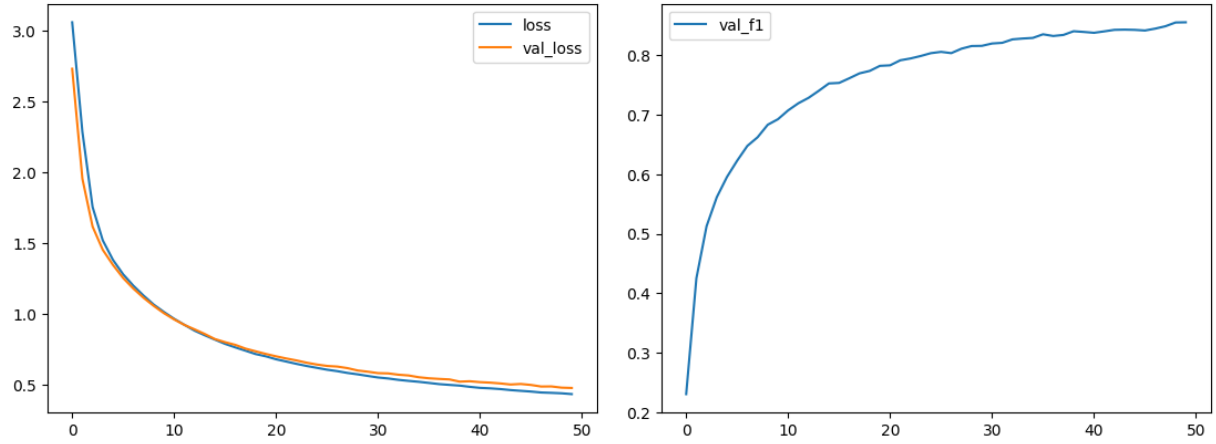


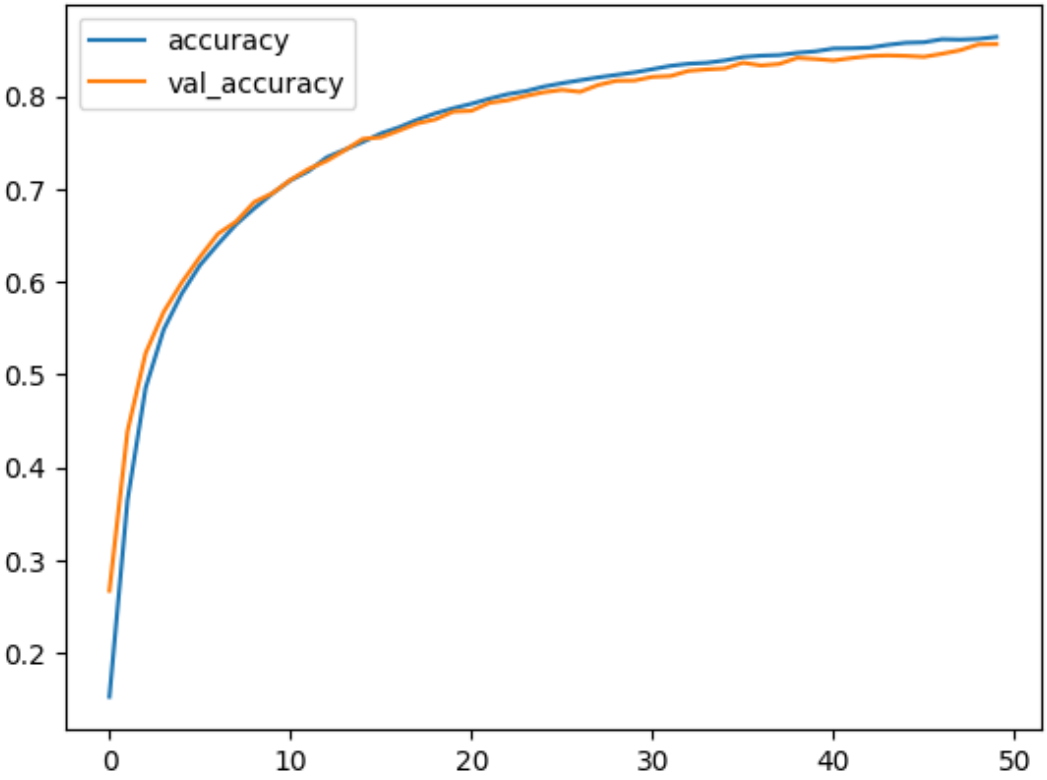

val_f1
0.9
0.8
0.7
0.6
0.5
0.4
0
10
20
30
40
50

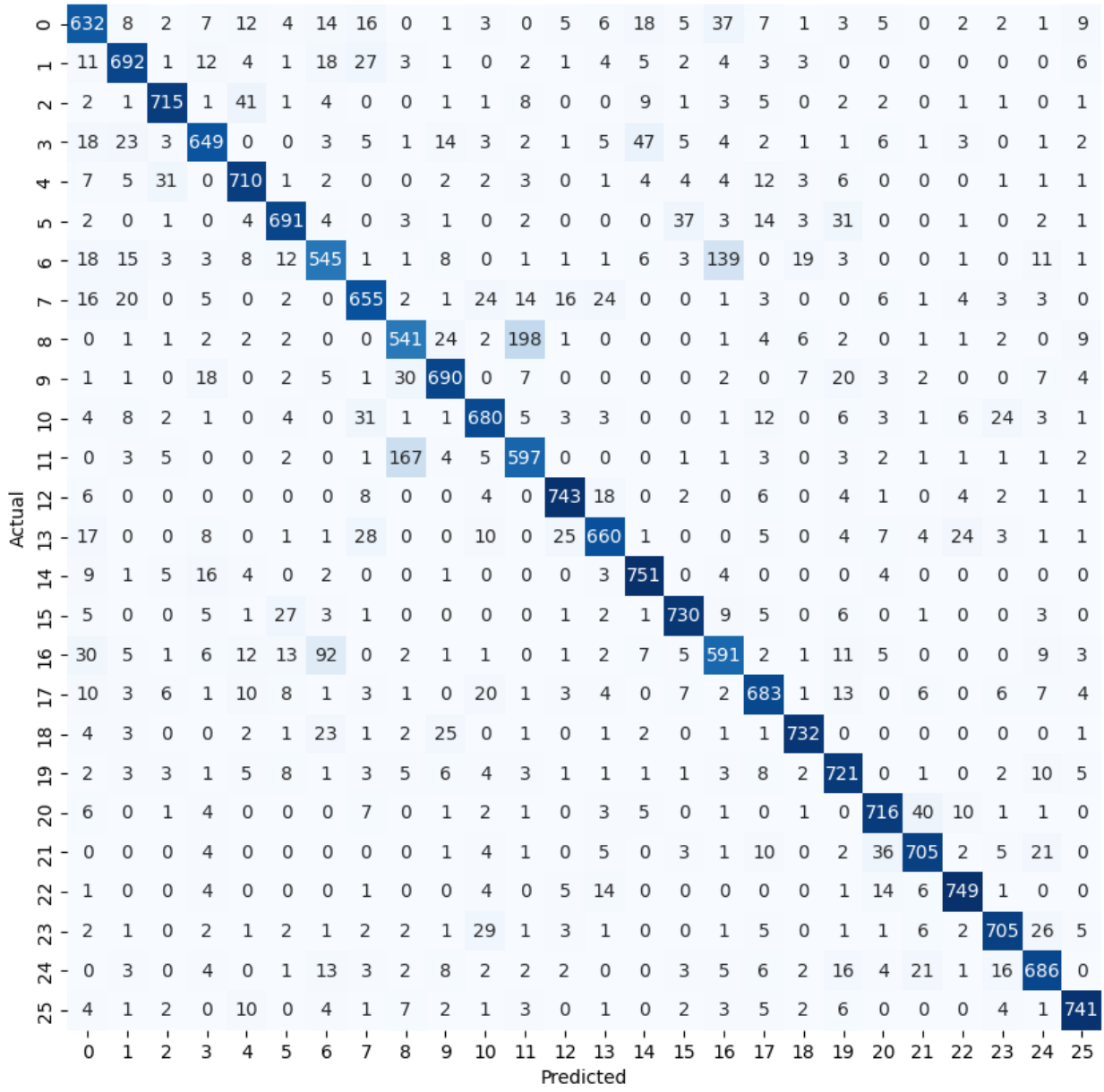

Actual
Predicted
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
0 684 4 3 10 5 5 13 9 0 0 2 0 3 8 8 2 24 3 1 0 6 0 1 1 0 8
1 6 722 0 7 7 0 16 17 0 1 0 4 0 3 1 1 1 5 3 1 0 0 0 0 0 5
2 2 2 732 3 34 1 2 0 0 0 0 5 0 0 6 0 2 5 0 2 2 0 1 0 0 1
3 9 18 0 701 0 1 0 0 3 8 1 0 1 6 36 2 2 2 1 1 3 0 2 1 2 0
4 9 4 18 0 738 5 1 0 1 2 0 2 0 0 2 3 2 5 2 1 1 1 0 1 0 2
5 0 0 0 0 4 726 2 0 0 0 0 2 0 0 0 29 0 7 5 23 0 0 0 0 1 1
6 22 21 6 2 6 8 562 1 0 8 0 0 0 1 2 4 128 2 13 0 1 0 0 1 10 2
7 10 15 0 3 0 0 1 699 2 0 12 11 9 20 0 1 1 2 0 1 4 0 5 3 1 0
8 1 0 2 2 1 0 0 1 577 22 0 176 0 0 0 0 1 1 3 0 0 1 1 2 0 9
9 0 0 0 18 1 0 4 2 25 714 0 4 0 0 0 0 1 1 10 13 2 1 0 0 2 2
10 2 6 1 0 1 2 0 25 0 1 708 4 3 7 0 0 1 12 0 5 3 2 1 12 2 2
11 0 4 7 0 1 4 0 3 195 3 3 569 0 0 0 0 2 1 0 0 0 0 0 1 5 2
12 5 0 0 0 0 0 0 8 0 0 1 0 759 17 0 0 1 1 0 2 2 0 3 0 1 0
13 8 0 0 5 0 0 0 16 1 0 6 0 24 707 2 2 0 2 0 2 4 3 13 3 2 0
14 6 2 3 9 0 0 1 0 0 1 0 0 0 3 765 1 5 0 1 0 2 0 1 0 0 0
15 1 0 0 3 1 16 4 1 0 0 0 0 0 2 2 746 9 8 0 2 0 2 0 0 3 0
16 38 4 2 6 2 6 80 0 1 4 0 2 3 2 6 6 613 3 3 2 4 0 2 2 7 2
17 13 2 3 0 11 6 0 1 3 0 12 0 3 1 1 8 1 705 1 10 0 8 0 4 3 4
18 2 2 1 0 1 1 13 1 4 18 0 0 0 1 0 1 3 1 748 2 0 0 0 0 0 1
19 2 4 0 0 7 9 0 1 5 7 6 2 0 1 1 1 2 9 0 734 0 0 0 1 8 0
20 1 0 1 3 0 0 1 4 0 0 2 2 2 3 2 0 3 1 1 0 732 29 12 0 1 0
21 0 0 0 2 0 0 0 0 1 1 2 0 0 5 0 3 0 8 0 1 36 716 2 5 18 0
22 2 0 0 4 0 0 0 2 0 1 1 0 3 15 0 0 0 1 0 1 11 1 757 0 1 0
23 4 0 0 2 0 2 0 2 0 1 26 2 2 2 0 0 2 4 0 2 0 4 1 726 16 2
24 0 2 0 1 0 0 6 2 0 10 1 1 1 1 0 2 7 6 1 10 3 22 3 11 710 0
25 3 1 1 5 10 3 3 0 4 1 2 1 0 0 0 1 6 2 0 5 0 0 0 4 0 748

Learning rate: 0.0025

test loss: 0.4787475552579321, test accuracy: 0.8514903846153846, test f1: 0.8512685049100903

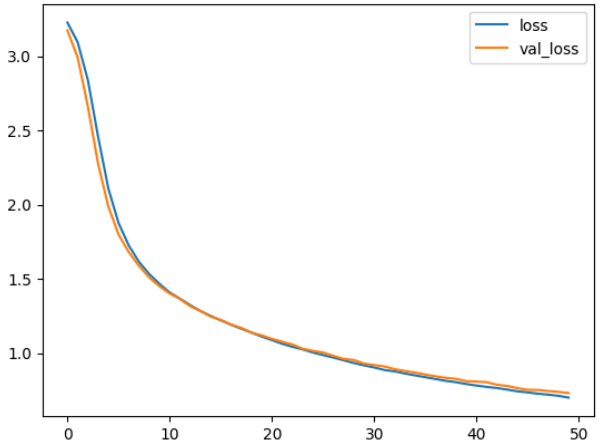


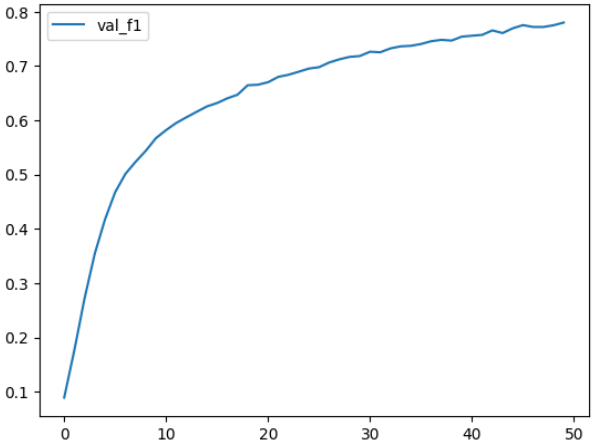


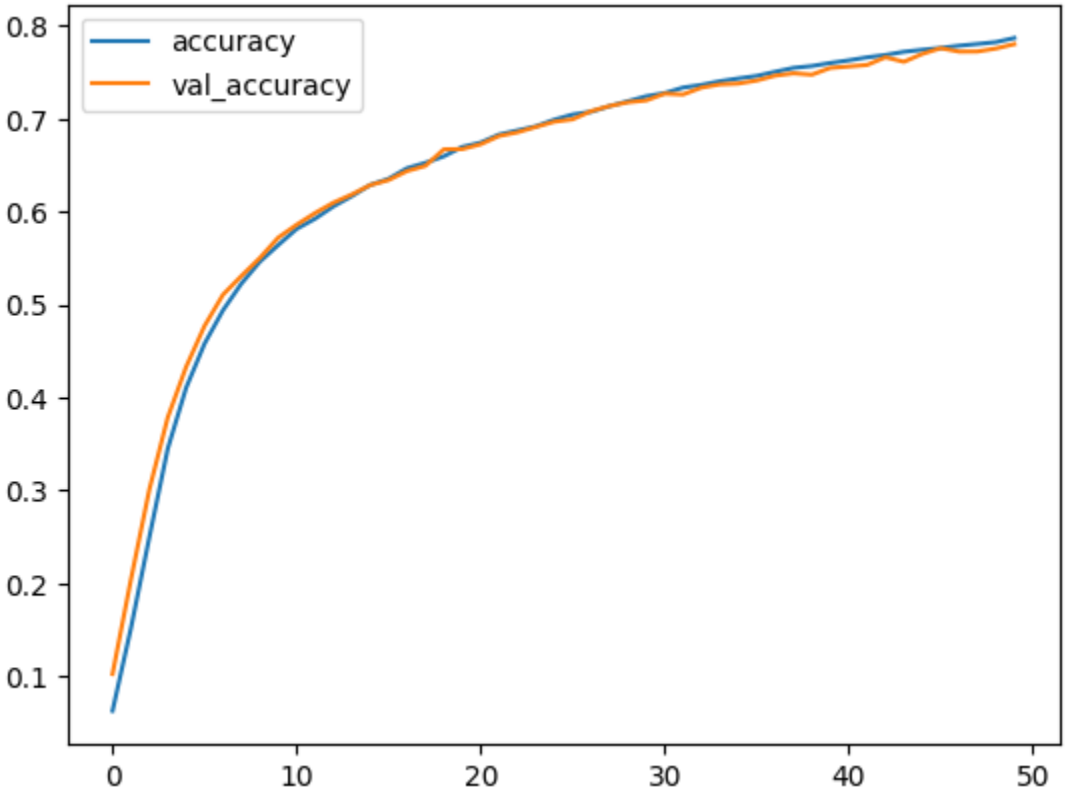

Actual
Predicted
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
0 632 8 2 7 12 4 14 16 0 1 3 0 5 6 18 5 37 7 1 3 5 0 2 2 1 9
1 11 692 1 12 4 1 18 27 3 1 0 2 1 4 5 2 4 3 3 0 0 0 0 0 0 6
2 2 1 715 1 41 1 4 0 0 1 1 8 0 0 9 1 3 5 0 2 2 0 1 1 0 1
3 18 23 3 649 0 0 3 5 1 14 3 2 1 5 47 5 4 2 1 1 6 1 3 0 1 2
4 7 5 31 0 710 1 2 0 0 2 2 3 0 1 4 4 4 12 3 6 0 0 0 1 1 1
5 2 0 1 0 4 691 4 0 3 1 0 2 0 0 0 37 3 14 3 31 0 0 1 0 2 1
6 18 15 3 3 8 12 545 1 1 8 0 1 1 1 6 3 139 0 19 3 0 0 1 0 11 1
7 16 20 0 5 0 2 0 655 2 1 24 14 16 24 0 0 1 3 0 0 6 1 4 3 3 0
8 0 1 1 2 2 2 0 0 541 24 2 198 1 0 0 0 1 4 6 2 0 1 1 2 0 9
9 1 1 0 18 0 2 5 1 30 690 0 7 0 0 0 0 2 0 7 20 3 2 0 0 7 4
10 4 8 2 1 0 4 0 31 1 1 680 5 3 3 0 0 1 12 0 6 3 1 6 24 3 1
11 0 3 5 0 0 2 0 1 167 4 5 597 0 0 0 1 1 3 0 3 2 1 1 1 1 2
12 6 0 0 0 0 0 0 8 0 0 4 0 743 18 0 2 0 6 0 4 1 0 4 2 1 1
13 17 0 0 8 0 1 1 28 0 0 10 0 25 660 1 0 0 5 0 4 7 4 24 3 1 1
14 9 1 5 16 4 0 2 0 0 1 0 0 0 3 751 0 4 0 0 0 4 0 0 0 0 0
15 5 0 0 5 1 27 3 1 0 0 0 0 1 2 1 730 9 5 0 6 0 1 0 0 3 0
16 30 5 1 6 12 13 92 0 2 1 1 0 1 2 7 5 591 2 1 11 5 0 0 0 9 3
17 10 3 6 1 10 8 1 3 1 0 20 1 3 4 0 7 2 683 1 13 0 6 0 6 7 4
18 4 3 0 0 2 1 23 1 2 25 0 1 0 1 2 0 1 1 732 0 0 0 0 0 0 1
19 2 3 3 1 5 8 1 3 5 6 4 3 1 1 1 1 3 8 2 721 0 1 0 2 10 5
20 6 0 1 4 0 0 0 7 0 1 2 1 0 3 5 0 1 0 1 0 716 40 10 1 1 0
21 0 0 0 4 0 0 0 0 0 1 4 1 0 5 0 3 1 10 0 2 36 705 2 5 21 0
22 1 0 0 4 0 0 0 1 0 0 4 0 5 14 0 0 0 0 0 1 14 6 749 1 0 0
23 2 1 0 2 1 2 1 2 2 1 29 1 3 1 0 0 1 5 0 1 1 6 2 705 26 5
24 0 3 0 4 0 1 13 3 2 8 2 2 2 0 0 3 5 6 2 16 4 21 1 16 686 0
25 4 1 2 0 10 0 4 1 7 2 1 3 0 1 0 2 3 5 2 6 0 0 0 4 1 741

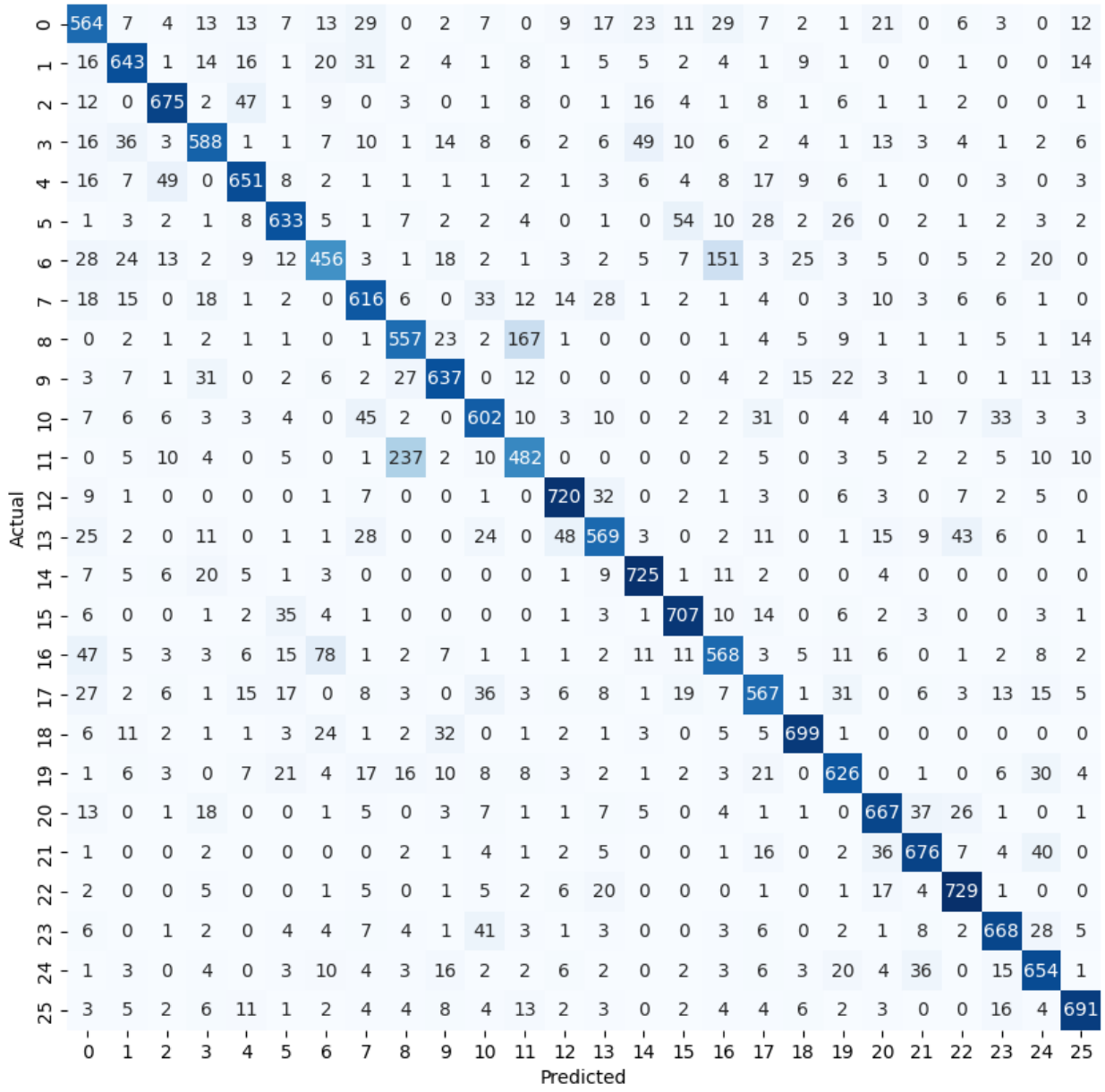
Learning rate: 0.001

test loss: 0.723144904547535, test accuracy: 0.7813942307692308, test f1: 0.7805492979592032








Actual
Predicted
0 564 7 4 13 13 7 13 29 0 2 7 0 9 17 23 11 29 7 2 1 21 0 6 3 0 12
1 16 643 1 14 16 1 20 31 2 4 1 8 1 5 5 2 4 1 9 1 0 0 1 0 0 14
2 12 0 675 2 47 1 9 0 3 0 1 8 0 1 16 4 1 8 1 6 1 1 2 0 0 1
3 16 36 3 588 1 1 7 10 1 14 8 6 2 6 49 10 6 2 4 1 13 3 4 1 2 6
4 16 7 49 0 651 8 2 1 1 1 1 2 1 3 6 4 8 17 9 6 1 0 0 3 0 3
5 1 3 2 1 8 633 5 1 7 2 2 4 0 1 0 54 10 28 2 26 0 2 1 2 3 2
6 28 24 13 2 9 12 456 3 1 18 2 1 3 2 5 7 151 3 25 3 5 0 5 2 20 0
7 18 15 0 18 1 2 0 616 6 0 33 12 14 28 1 2 1 4 0 3 10 3 6 6 1 0
8 0 2 1 2 1 1 0 1 557 23 2 167 1 0 0 0 1 4 5 9 1 1 1 5 1 14
9 3 7 1 31 0 2 6 2 27 637 0 12 0 0 0 0 4 2 15 22 3 1 0 1 11 13
10 7 6 6 3 3 4 0 45 2 0 602 10 3 10 0 2 2 31 0 4 4 10 7 33 3 3
11 0 5 10 4 0 5 0 1 237 2 10 482 0 0 0 0 2 5 0 3 5 2 2 5 10 10
12 9 1 0 0 0 0 1 7 0 0 1 0 720 32 0 2 1 3 0 6 3 0 7 2 5 0
13 25 2 0 11 0 1 1 28 0 0 24 0 48 569 3 0 2 11 0 1 15 9 43 6 0 1
14 7 5 6 20 5 1 3 0 0 0 0 0 1 9 725 1 11 2 0 0 4 0 0 0 0 0
15 6 0 0 1 2 35 4 1 0 0 0 0 1 3 1 707 10 14 0 6 2 3 0 0 3 1
16 47 5 3 3 6 15 78 1 2 7 1 1 1 2 11 11 568 3 5 11 6 0 1 2 8 2
17 27 2 6 1 15 17 0 8 3 0 36 3 6 8 1 19 7 567 1 31 0 6 3 13 15 5
18 6 11 2 1 1 3 24 1 2 32 0 1 2 1 3 0 5 5 699 1 0 0 0 0 0 0
19 1 6 3 0 7 21 4 17 16 10 8 8 3 2 1 2 3 21 0 626 0 1 0 6 30 4
20 13 0 1 18 0 0 1 5 0 3 7 1 1 7 5 0 4 1 1 0 667 37 26 1 0 1
21 1 0 0 2 0 0 0 0 2 1 4 1 2 5 0 0 1 16 0 2 36 676 7 4 40 0
22 2 0 0 5 0 0 1 5 0 1 5 2 6 20 0 0 0 1 0 1 17 4 729 1 0 0
23 6 0 1 2 0 4 4 7 4 1 41 3 1 3 0 0 3 6 0 2 1 8 2 668 28 5
24 1 3 0 4 0 3 10 4 3 16 2 2 6 2 0 2 3 6 3 20 4 36 0 15 654 1
25 3 5 2 6 11 1 2 4 4 8 4 13 2 3 0 2 4 4 6 2 3 0 0 16 4 691
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25