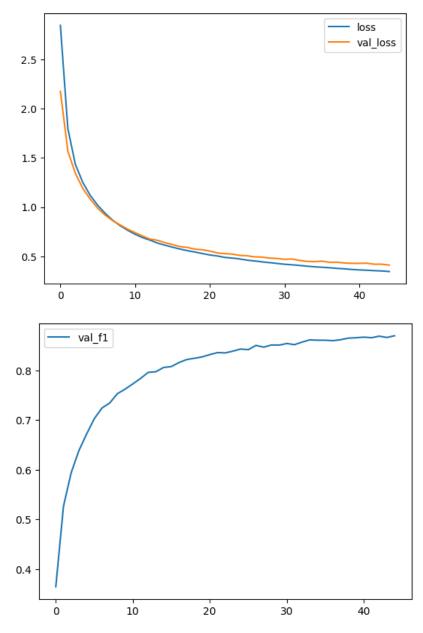
Offline 3 report Hasan Masum 1805052

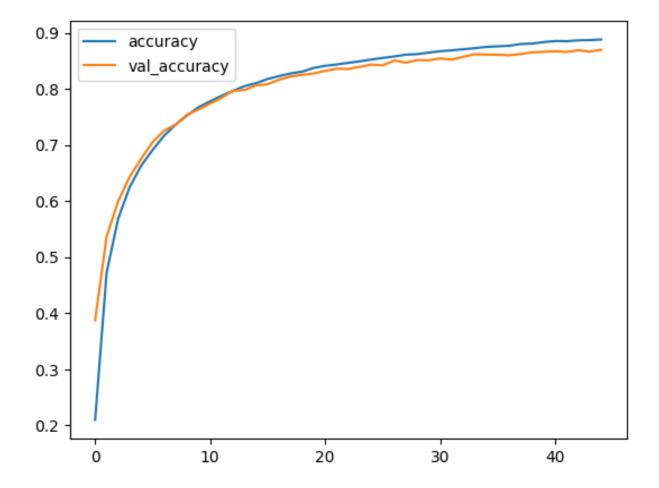
Model-1

```
# 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

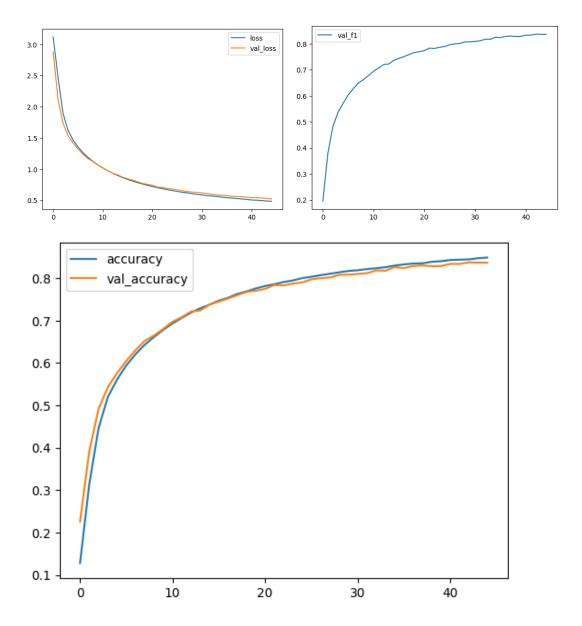
Test accuracy: 0.8701 Test loss: 0.4098 Test f1: 0.8700





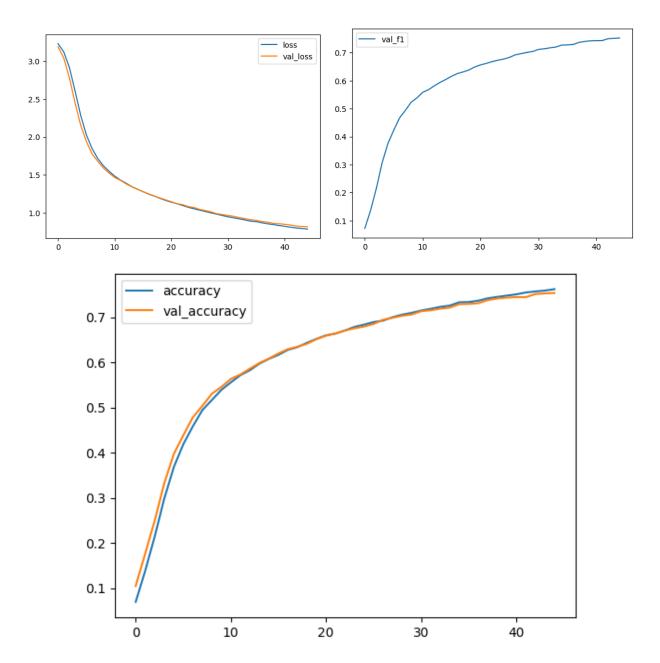
	0 -	678	6	4	8	4	2	9	10	0	1	1	0	2	7	11	4	25	10	0	3	3	0	2	3	1	6
	٦ -	9	715	1	7	4	1	13	19	0	3	1	2	1	6	3	0	3	2	1	1	0	0	0	1	0	7
	- 2	4	2	733	1	29	2	4	0	1	0	2	4	0	0	6	1	2	3	0	0	2	0	1	1	1	1
	m -	15	13	1	686	0	0	3	1	1	7	1	1	2	8	39	4	3	2	0	0	6	0	2	1	3	1
	4 -	8	2	31	1	720	4	4	0	0	1	1	1	0	0	3	3	3	6	1	4	1	0	1	1	0	4
	ი -	2	0	0	1	2	707	3	0	2	3	0	3	0	0	0	38	2	7	3	23	0	0	0	1	1	2
	9 -	24	15	5	3	5	6	577	0	1	9	0	0	0	1	2	2	125	1	16	1	2	0	1	0	4	0
	۲ -	10	18	0	7	0	1	0	682	1	0	19	11	10	22	0	1	0	2	0	1	4	0	6	3	2	0
	∞ -	0	0	3	1	1	1	1	0	576	15	0	175	0	0	0	0	1	3	3	2	1	1	1	3	0	12
	ი -	0	2	0	16	1	2	5	0	29	697	0	4	0	0	1	1	1	0	9	21	1	2	0	0	4	4
	임 -	3	5	1	0	2	3	0	22	0	1	704	7	2	4	0	0	1	10	0	6	3	1	4	16	2	3
	Π-	0	0	6	0	0	3	0	8	186	0	5	574	0	0	1	1	2	3	0	0	2	0	0	0	5	4
Actual	12 -	5	0	0	1	0	0	0	5	0	0	2	0	756	15	1	2	0	0	0	2	2	0	7	1	0	1
Act	13 -	20	0	0	9	0	0	0	14	0	0	11	1	21	682	1	4	0	5	0	1	7	3	17	3	1	0
	4 -	9	0	5	15	2	0	1	0	0	0	0	0	0	3	752	2	5	0	1	0	4	0	1	0	0	0
	15	1	0	0	6	1	15	2	0	0	0	0	0	0	3	0	749	7	8	0	5	0	1	0	0	1	1
	16	34	3	2	3	9	8	106	0	4	0	0	0	0	2	4	8	599	1	3	2	3	0	0	0	9	0
	17	12	2	4	0	8	9	0	1	2	0	19	1	2	5	1	10	1	688	1	12	0	10	1	5	4	2
	- 18	6	0	0	1	1	1	17	1	2	13	0	0	0	1	0	0	2	0	753	1	0	0	0	0	1	0
	19	0	4	3	1	5	10	0	1	2	7	3	3	0	0	1	0	2	13	1	725	0	0	0	2	14	3
	20	2	0	1	3	0	0	4	4	0	1	0	2	2	1	4	0	2	0	1	0	724	36	11	0	2	0
	21	0	0	0	3	0	0	0	0	0	1	2	1	1	1	0	1	0	8	1	0	25	728	6	4	18	0
	22	4	1	0	1	0	0	0	3	0	1	1	0	3	12	0	0	1	0	0	1	10	5	756	1	0	0
	23	5	0	0	1	0	1	0	2	3	1	21	2	0	1	0	0	2	5	0	2	3	7	1	725	14	4
	24	0	1	0	1	0	0	12	2	0	10	2	3	1	0	0	2	3	4	2	9	2	19	2	13	712	0
	25	5	6	1	4	7	0	4	1	9	0	0	3	0	0	0	0	4	2	0	2	0	0	0	3	0	749
		ò	i	2	3	4	5	6	7	8	9	10	ii,	12 Predi	13 icted	14	15	16	17	18	19	20	21	22	23	24	25

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



	0 -	615	6	4	15	6	6	13	11	0	1	6	0	8	8	16	6	40	7	1	2	17	0	2	3	0	7
	٦.	- 10	685	1	16	4	0	18	25	3	1	0	4	1	5	5	2	4	1	1	3	0	0	0	0	0	11
	7	- 4	2	724	3	31	1	2	0	2	1	1	5	0	0	7	0	3	5	2	2	2	0	1	0	0	2
	ω -	- 14	22	1	652	0	1	3	6	1	11	6	0	2	3	52	6	4	0	2	0	7	0	3	0	3	1
	4 -	- 12	4	40	0	695	8	2	0	1	0	1	1	1	0	5	2	2	9	3	6	1	0	0	2	0	5
	5 -	- 1	3	0	2	4	692	3	0	2	3	0	0	1	0	0	38	5	8	4	29	0	0	0	0	3	2
	9 -	- 28	19	10	3	5	12	515	1	2	10	0	0	1	1	5	5	140	2	26	1	2	0	1	1	9	1
	7	- 10	15	0	8	0	1	0	666	1	0	24	13	10	25	0	1	0	3	0	2	8	0	7	2	2	2
	ω -	- 0	1	1	1	1	2	0	0	544	17	2	194	0	0	1	0	1	4	6	1	0	2	1	4	6	11
	6 -	- 4	3	0	20	0	4	12	1	29	682	0	5	0	0	1	0	1	0	10	18	2	2	0	0	4	2
	10	- 5	6	1	0	1	5	0	33	1	0	678	9	3	8	0	0	1	15	0	4	2	5	4	15	3	1
	11	- 1	2	8	3	1	2	0	5	193	3	3	563	0	0	0	0	0	3	0	4	2	1	0	0	5	1
Actual	12	- 7	0	0	1	0	0	2	10	0	0	1	0	737	22	0	0	1	4	0	5	3	0	6	0	1	0
Act	13	- 23	0	0	10	0	0	0	19	0	0	10	0	35	648	2	1	0	9	0	1	12	4	22	2	2	0
	14	- 2	3	3	10	1	0	1	0	0	1	0	0	1	4	763	4	3	0	0	0	2	2	0	0	0	0
	15	- 2	0	0	3	1	27	4	0	0	0	0	1	1	5	0	730	5	10	0	8	0	1	0	1	0	1
	16		2	5	5	6	7	119	1	5	7	1	0	1	2	9	10	559	4	1	7	5	0	2	0	6	1
	17	- 22	2	6	0	7	13	0	3	3	0	14	1	5	4	1	6	6	659	0	24	0	7	0	6	4	7
	18	- 4	3	3	1	3	2	28	1	3	22	0	0	0	2	2	0	4	1	718	0	0	0	0	0	0	3
	19	- 2	4	1	2	6	15	0	5	6	0	4	7	0	0	2	4	3	14	1	701	0	0	0	2	19	2
	20	- 6	2	1	6	0	0	1	7	0	5	4	1	1	9	5	0	5	0	1	0	696	34	14	1	0	1
	21	- 0	0	0	3	0	0	0	0	0	1	2	3	2	2	0	1	2	7	1	1	39	704	2	3	27	0
	22	- 1	1	0	5	0	0	0	4	0	0	2	0	8	10	0	0	1	0	0	1	15	6	745	1	0	0
	23	- 8	1	0	2	0	1	1	5	5	0	31	3	2	1	0	0	2	6	1	2	0	7	2	692	24	4
	24	- 0	3	0	6	0	0	12	1	2	15	1	2	1	2	0	1	8	5	4	10	0	33	1	13	680	0
	25	- 5	5	3	8	17	0	5	0	6	4	2	7	2	0	0	3	3	3	3	3	0	0	0	4	0	717
		ò	i	2	3	4	5	6	7	8	9	10	11	12 Pred	13 icted	14	15	16	17	18	19	20	21	22	23	24	25

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



	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
	٦ -	- 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
	7	- 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
	m -	- 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
	2 -	- 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
	9 -	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
	ω -	- 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
	6 -	- 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
la	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
Actual	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
		Ó	í	2	3	4	5	6	7	8	9	10	'n	12 rodi	13	14	15	16	17	18	19	20	21	22	23	24	25

Model 2

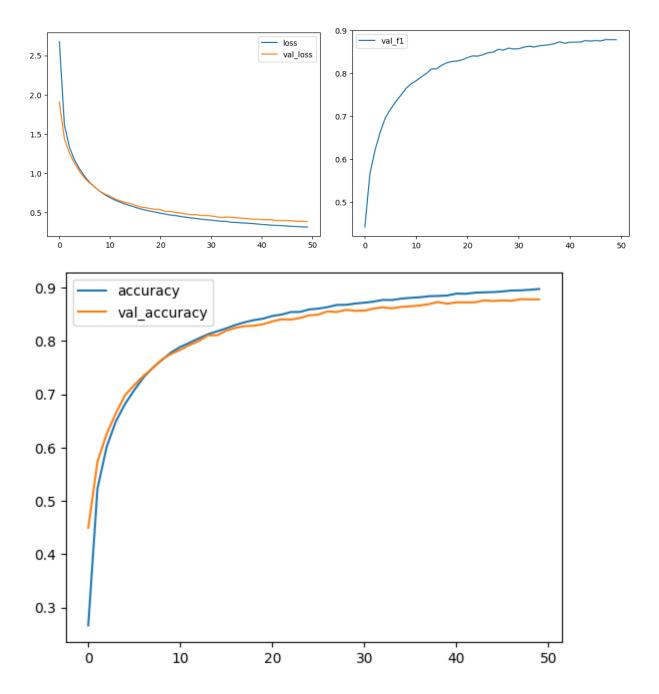
```
# learning rate
lr = [0.005, 0.0025, 0.001, 0.00075]
for lrate in lr:
    model = FNN(
        loss=CategoricalCrossEntropyLoss(),
        optimizer=SGD(learning_rate=lrate),
        learning_rate=lrate,
        layers=[
            Flatten(),
            DenseLayer(input_size, 1024, ReLU()),
            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:

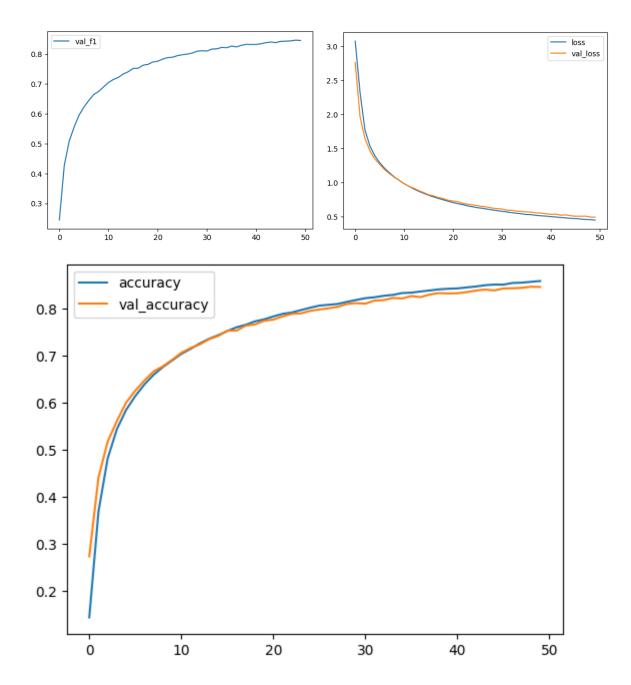
0.8769679654957349



	0 -	668	4	6	13	5	2	11	8	0	0	6	1	1	7	7	4	29	7	0	1	8	0	0	3	0	9
	٦ -	- 8	721	1	7	4	0	12	19	0	0	0	4	1	4	1	1	2	2	5	1	0	0	0	0	0	7
	7	- 0	0	733	2	30	0	3	0	0	0	1	7	0	0	5	1	2	7	4	2	1	0	1	0	0	1
	m -	- 9	21	1	693	0	1	2	3	1	5	0	3	1	2	37	10	2	2	1	1	4	0	0	0	0	1
	4 -	4	5	25	1	733	5	1	0	0	0	0	3	0	0	1	3	1	6	1	5	1	0	1	2	0	2
	2 -	- 1	0	0	1	3	717	6	0	1	0	0	1	0	0	0	25	3	8	3	29	0	0	0	0	1	1
	9 -	- 20	20	9	2	4	6	582	0	0	7	0	0	0	1	2	2	124	2	13	0	1	0	0	0	5	0
	7	- 6	9	0	5	0	1	0	708	1	0	15	10	9	17	0	1	0	2	0	4	5	0	4	1	1	1
	ω -	1	0	2	1	1	1	1	2	541	15	0	214	0	0	0	0	0	5	4	1	1	0	1	3	0	6
	6 -	0	2	0	9	1	1	6	0	21	712	0	4	0	0	0	0	1	0	11	15	0	1	0	1	11	4
	10	- 2	5	1	0	3	2	0	19	1	1	722	4	0	2	0	0	0	13	0	4	2	2	1	13	2	1
	Ξ-	0	2	7	2	2	2	0	5	158	3	6	601	0	0	0	0	1	1	0	1	1	0	0	1	5	2
nal	12	- 5	1	0	0	0	0	0	9	0	0	0	0	744	20	0	0	0	2	0	3	2	0	10	2	1	1
Act	13 12	- 15	1	0	7	0	0	1	18	0	1	6	0	17	698	1	0	1	3	0	1	6	3	14	4	3	0
	14	- 2	1	5	19	1	0	2	0	0	0	0	0	0	3	758	2	3	0	1	0	3	0	0	0	0	0
	15	0	0	0	3	2	15	0	0	0	0	0	0	0	1	0	753	7	12	0	2	0	0	0	0	3	2
	16	34	2	2	5	6	8	89	1	1	1	0	0	1	2	8	6	609	3	1	5	3	0	2	1	6	4
	17	- 8	1	4	0	5	6	0	1	1	0	13	1	3	1	0	10	3	696	0	19	0	12	0	8	6	2
	18	- 3	6	2	0	0	3	11	1	2	11	0	1	0	1	0	0	2	0	756	1	0	0	0	0	0	0
	19	0	8	1	1	5	10	0	3	5	3	3	1	0	0	2	0	2	4	1	731	0	0	0	3	16	1
	20	- 5	0	2	4	0	0	2	4	0	3	3	1	0	4	4	0	0	1	1	0	725	31	8	0	2	0
	21	0	0	0	4	0	0	0	0	0	1	0	2	0	1	0	0	1	10	0	1	35	718	3	4	20	0
	22	1	1	0	2	0	0	0	2	0	0	2	0	3	13	0	0	1	0	0	1	8	1	763	0	2	0
	23	- 3	0	0	1	2	1	0	1	0	0	27	2	1	4	0	0	2	6	0	3	1	5	1	719	17	4
	24	0	4	0	1	0	0	9	2	1	8	1	0	0	0	0	1	8	6	1	9	5	22	0	8	714	0
	25		0	4	4	6	0	5	1	5	1	0	6	0	0	0	0	1	2	1	4	0	0	0	3	0	752
		Ó	i	2	3	4	5	6	7	8	9	10	11 F	12 red	13 icted	14	15	16	17	18	19	20	21	22	23	24	25

 $test\ loss:\ 0.49303265428495935,\ test\ accuracy:\ 0.8479326923076923,\ test\ f1:$

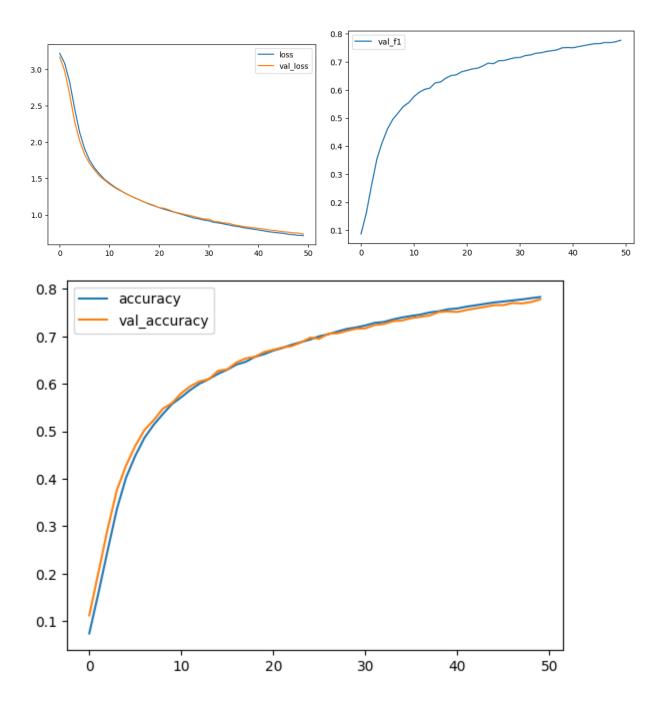
0.8477188075617893



-632	3	6	9	13	3	12	12	0	1	5	0	7	9	19	8	36	3	4	2	5	0	2	2	0	7
- 11	697	0	18	5	0	16	22	1	0	0	5	1	3	4	0	1	2	2	0	1	0	1	1	0	9
y - 3	0	717	3	32	1	3	0	1	0	1	6	0	0	10	2	2	8	2	3	1	0	2	1	0	2
n - 16	23	1	641	1	3	3	3	0	10	5	2	1	9	50	6	7	0	0	1	9	1	0	0	3	5
- 10	8	30	0	704	7	1	0	1	0	0	1	0	1	4	2	4	12	5	4	0	0	1	1	0	4
n - 2	2	0	3	2	695	2	0	2	3	2	1	0	0	0	45	3	8	2	25	0	0	0	0	3	0
o - 21	22	11	5	7	10	530	0	0	9	1	1	0	2	5	3	137	2	23	0	0	0	0	1	8	2
- 16	17	0	11	0	0	1	655	0	0	28	14	13	23	0	1	0	2	0	4	3	0	3	5	4	0
0 - 0	1	1	2	2	3	0	0	556	20	1	185	0	0	0	0	2	5	5	2	0	2	0	3	0	10
n - 1	1	0	23	1	2	4	1	32	675	0	5	0	1	0	0	1	0	18	15	2	2	0	0	8	8
գ - 3	3	3	2	0	4	0	34	1	0	685	8	2	4	0	0	0	9	0	8	5	3	2	18	3	3
- 0	3	9	1	1	4	0	0	199	3	6	552	0	1	1	1	0	2	0	3	1	2	0	3	7	1
<u> </u>	0	0	1	1	0	0	7	0	0	1	0	737	23	0	4	1	2	0	3	3	0	7	2	3	1
ៗ - 22	1	0	8	1	1	1	23	0	1	11	0	32	657	1	1	1	5	0	0	5	1	23	4	0	1
<u> </u>	4	3	16	1	1	2	0	0	0	0	0	0	2	756	0	4	1	2	0	2	0	1	0	0	0
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g - 5	5	1	3	1	4	19	1	1	22	0	1	0	1	1	0	2	1	731	1	0	0	0	0	0	0
ភ្ន - 2	4	1	3	7	9	1	0	8	2	8	4	1	1	1	2	2	14	1	711	0	0	1	3	14	0
2 - 6	1	3	7	0	0	2	3	0	2	3	0	1	2	8	0	1	0	1	0	707	34	17	1	1	0
7 - 0	0	0	4	0	0	0	1	0	1	2	1	0	3	0	1	1	12	1	1	41	697	3	3	28	0
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4 - 0	2	0	5	0	0	11	1	0	11	0	4	1	1	0	2	4	6	2	13	4	36	1	8	688	0
Q - 4	5	3	3	9	0	5	3	7	2	1	6	2	1	0	1	1	3	1	3	0	0	0	6	1	733
Ö	i	2	3	4	5	6	7	8	9	10	11	12 Pred	13 icted	14	15	16	17	18	19	20	21	22	23	24	25
	1 - 11 N - 3 N - 16 N - 2 N - 3 N - 6 N -	1 - 11 697	697 0 N - 3 0 717 N - 16 23 1 N - 10 8 30 N - 2 2 0 N - 21 22 11 N - 16 17 0 N - 0 1 1 N - 1 1 0 N - 3 3 3 N - 4 0 0 N - 22 1 0 N - 3 3 3 N - 4 0 0 N - 3 5 1 N - 5 4 3 N - 3 0 0 N - 35 3 1 N - 17 0 4 N - 5 5 1 N - 17 0 4 N - 5 5 1 N - 1 1 3 N - 0 0 0 N - 0 1 0 N - 0 1 0 N - 0 1 0 N - 0 2 0 N - 0 2 0 N - 0 2 0 N - 0 2 0 N - 0 2 0 N - 0 2 0	11 697 0 18 18 0 717 3 10 16 23 1 641 11 10 8 30 0 10 2 2 0 3 10 2 11 5 10 1 1 2 10 1 1 2 10 1 1 2 10 3 3 2 11 0 23 3 2 11 0 23 3 2 12 0 3 9 1 12 2 1 0 8 14 0 0 1 15 4 3 16 16 3 0 4 17 0 4 0 16 3 1 2 17 0 4 0 18 3 1 2 19 3 <t< td=""><td>4 - 11 697 0 18 5 5 - 3 0 717 3 32 6 - 16 23 1 641 1 6 - 20 2 0 3 2 6 - 21 22 11 5 7 6 - 16 17 0 11 0 6 - 1 1 0 23 1 6 - 3 3 3 2 0 7 - 4 0 0 1 1 7 - 22 1 0 8 1 1 - 3 3 3 2 0 1 - 4 0 0 1 1 1 - 5 4 3 16 1 1 - 3 0 4 1 1 2 - 35 3 1 2 8 3 - 17 0 4 0 11 4 - 3 3 7 0 4 - 17 0 4 0 11 4 - 17 0 4 0</td><td>4 - 11 697 0 18 5 0 N - 3 0 717 3 32 1 N - 16 23 1 641 1 3 N - 2 2 0 3 2 695 N - 21 22 11 5 7 10 N - 16 17 0 11 0 0 N - 1 1 0 23 1 2 N - 1 1 0 23 1 2 N - 2 1 0 0 1 1 0 N - 3 3 3 2 0 4 N - 4 0 0 1 1 0 N - 5 4 3 16 1 1 N - 6 3 1 2 8 13 N - 7 0 4 0 11 12 N - 3 3 1 2 8 13 N - 1 0 4 0 11 12<td>1 - 11 697 0 18 5 0 16 1 - 16 23 1 641 1 3 3 1 - 10 8 30 0 704 7 1 1 - 2 2 0 3 2 695 2 2 - 21 22 11 5 7 10 530 3 - 16 17 0 11 0 0 1 4 - 3 3 3 2 0 4 0 4 - 3 3 3 2 0 4 0 4 - 3 3 3 2 0 4 0 4 - 4 0 0 1 1 0 0 4 - 5 4 3 16 1 1 2 4 - 35 3 16 1 1 2 4 4 - 5 4 3 16 1 1 2 4 1 29 4 4 1 29 4 1 2<td>1 - 11 697 0 18 5 0 16 22 1 - 16 23 1 641 1 3 3 3 1 - 10 8 30 0 704 7 1 0 1 - 2 2 0 3 2 695 2 0 2 - 21 22 11 5 7 10 530 0 2 - 16 17 0 11 0 0 1 655 3 - 1 1 2 2 3 0 0 4 - 3 3 3 2 0 4 0 34 4 - 3 3 3 2 0 4 0 34 4 - 4 0 0 1 1 0 0 7 4 - 22 1 0 8 1 1 1 23 4 - 3 3 16 1 1 2 0 4 - 3 3 16 1 1 2 0<</td><td>1 - 11 697 0 18 5 0 16 22 1 1 - 16 23 1 641 1 3 3 3 0 1 - 10 8 30 0 704 7 1 0 1 1 - 2 2 0 3 2 695 2 0 2 2 - 16 17 0 11 0 0 1 655 0 3 - 16 17 0 11 0 0 1 655 0 4 - 3 3 2 0 4 0 34 1 4 - 3 3 3 2 0 4 0 34 1 4 - 4 0 0 1 1 0 0 7 0 4 - 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4 0 0 1 1 0 N - 5 4 3 16 1 1 N - 6 3 1 2 8 13 N - 7 0 4 0 11 12 N - 3 3 1 2 8 13 N - 1 0 4 0 11 12 <td>1 - 11 697 0 18 5 0 16 1 - 16 23 1 641 1 3 3 1 - 10 8 30 0 704 7 1 1 - 2 2 0 3 2 695 2 2 - 21 22 11 5 7 10 530 3 - 16 17 0 11 0 0 1 4 - 3 3 3 2 0 4 0 4 - 3 3 3 2 0 4 0 4 - 3 3 3 2 0 4 0 4 - 4 0 0 1 1 0 0 4 - 5 4 3 16 1 1 2 4 - 35 3 16 1 1 2 4 4 - 5 4 3 16 1 1 2 4 1 29 4 4 1 29 4 1 2<td>1 - 11 697 0 18 5 0 16 22 1 - 16 23 1 641 1 3 3 3 1 - 10 8 30 0 704 7 1 0 1 - 2 2 0 3 2 695 2 0 2 - 21 22 11 5 7 10 530 0 2 - 16 17 0 11 0 0 1 655 3 - 1 1 2 2 3 0 0 4 - 3 3 3 2 0 4 0 34 4 - 3 3 3 2 0 4 0 34 4 - 4 0 0 1 1 0 0 7 4 - 22 1 0 8 1 1 1 23 4 - 3 3 16 1 1 2 0 4 - 3 3 16 1 1 2 0<</td><td>1 - 11 697 0 18 5 0 16 22 1 1 - 16 23 1 641 1 3 3 3 0 1 - 10 8 30 0 704 7 1 0 1 1 - 2 2 0 3 2 695 2 0 2 2 - 16 17 0 11 0 0 1 655 0 3 - 16 17 0 11 0 0 1 655 0 4 - 3 3 2 0 4 0 34 1 4 - 3 3 3 2 0 4 0 34 1 4 - 4 0 0 1 1 0 0 7 0 4 - 5 4 3 16 1 1 2 0 0 4 - 5 4 3 16 1 1 2 0 0 4 - 5 4 3 16</td><td>1 - 11 697 0 18 5 0 16 22 1 0 1 - 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3 3 16 1 1 2 0 4 - 3 3 16 1 1 2 0<	1 - 11 697 0 18 5 0 16 22 1 1 - 16 23 1 641 1 3 3 3 0 1 - 10 8 30 0 704 7 1 0 1 1 - 2 2 0 3 2 695 2 0 2 2 - 16 17 0 11 0 0 1 655 0 3 - 16 17 0 11 0 0 1 655 0 4 - 3 3 2 0 4 0 34 1 4 - 3 3 3 2 0 4 0 34 1 4 - 4 0 0 1 1 0 0 7 0 4 - 5 4 3 16 1 1 2 0 0 4 - 5 4 3 16 1 1 2 0 0 4 - 5 4 3 16	1 - 11 697 0 18 5 0 16 22 1 0 1 - 3 0 717 3 32 1 3 0 10 1 - 16 23 1 641 1 3 3 0 10 1 - 10 8 30 0 704 7 1 0 1 0 2 - 2 2 0 3 2 695 2 0 2 3 3 - 16 17 0 11 0 0 1 655 0 0 4 - 1 1 2 2 3 0 0 556 20 4 - 3 3 3 2 0 4 0 34 1 0 4 - 4 0 0 1 1 0 0 7 0 0 4 - 5 4 3 16 1 1 2	1		1	1	1		1							1 1 1 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	

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

0.7773129243972582



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Actual	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
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	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
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	25		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
	•	ó	í	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
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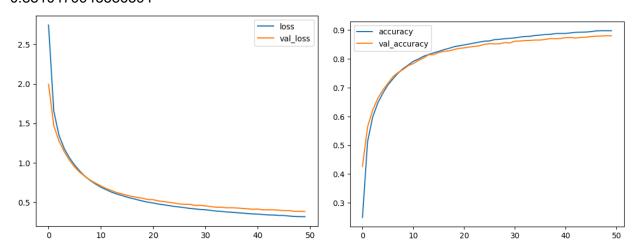
Model 3

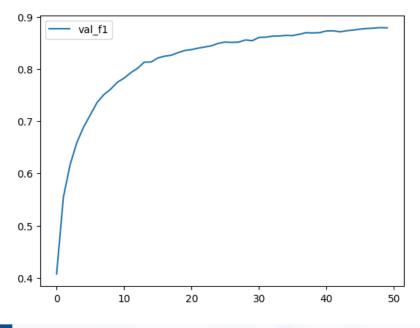
```
# learning rate
lr = [0.005, 0.0025, 0.001, 0.00075]
for lrate in lr:
    model = FNN(
        loss=CategoricalCrossEntropyLoss(),
        optimizer=SGD(learning_rate=lrate),
        learning_rate=lrate,
        layers=[
            Flatten(),
            DenseLayer(input_size, 1024, ReLU()),
            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

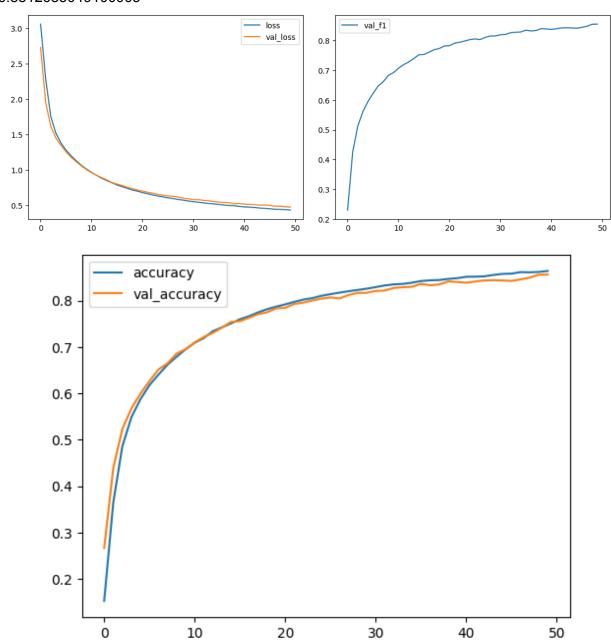
test loss: 0.3740598363955921, test accuracy: 0.881201923076923, test f1: 0.8810479945586394





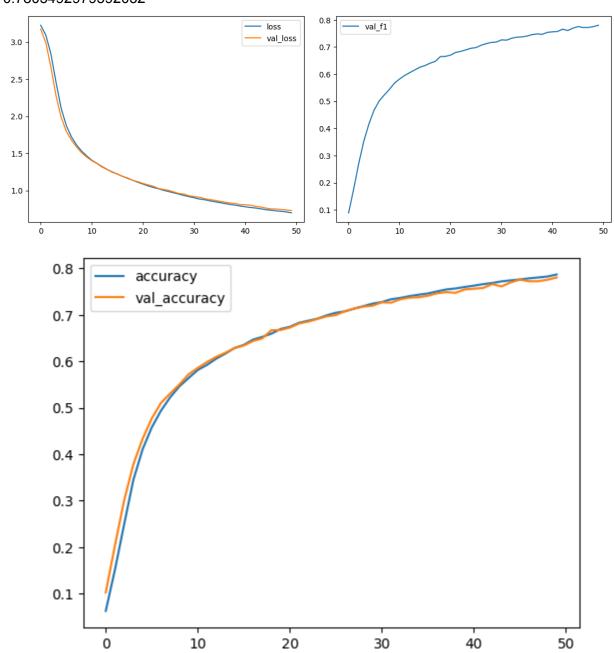
o -684 4 3 10 5 5 13 9 0 0 0 16 17 0 4 18 0 738 5 1 0 0 4 726 2 0 φ - 22 21 6 2 6 1 0 1 699 2 0 12 11 9 20 1 577 22 0 176 0 2 25 714 0 4 10 13 0 25 0 1 708 4 3 3 195 3 3 569 0 0 0 0 0 759 17 0 0 24 707 2 0 3 765 1 5 2 2 746 9 0 10 1 10 0 1 6 2 0 5 0 0 0 4 0 748 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

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



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	7 -	- 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
	m -	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
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	2 -	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
	9 -	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
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Actu	13 12	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
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	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
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	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
		0	í	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	2 ['] 5
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test loss: 0.723144904547535, test accuracy: 0.7813942307692308, test f1: 0.7805492979592032



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η-	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
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