

(Machine Learning Sessional)

**CSE 472**

*“Convolutional Neural Network”*

Report

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**Department:** CSE

**Section:** B

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# ***Section 0: Configuration of Models***

## **Model-1:**

***(Convolution=3, ReLU=3, MaxPool=1, Flatten=1, FC=1, Softmax=1)***

Convolution -> ReLU -> MaxPool -> Convolution -> ReLU ->  
Convolution -> ReLU -> Flatten -> FC -> Softmax

## **Model-2:**

***(Convolution=3, ReLU=5, MaxPool=2, Flatten=1, FC=3, Softmax=1)***

Convolution -> ReLU -> MaxPool -> Convolution -> ReLU ->  
MaxPool -> Convolution -> ReLU -> Flatten -> FC -> ReLU ->  
FC -> ReLU -> FC -> Softmax

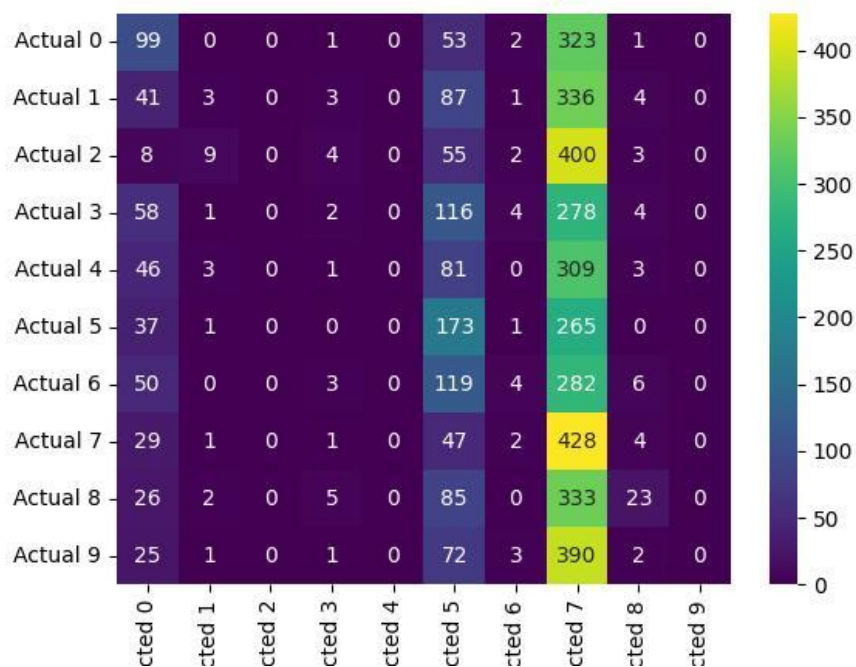
## **Model-3:**

***(Convolution=3, ReLU=4, MaxPool=1, Flatten=1, FC=3, Softmax=1)***

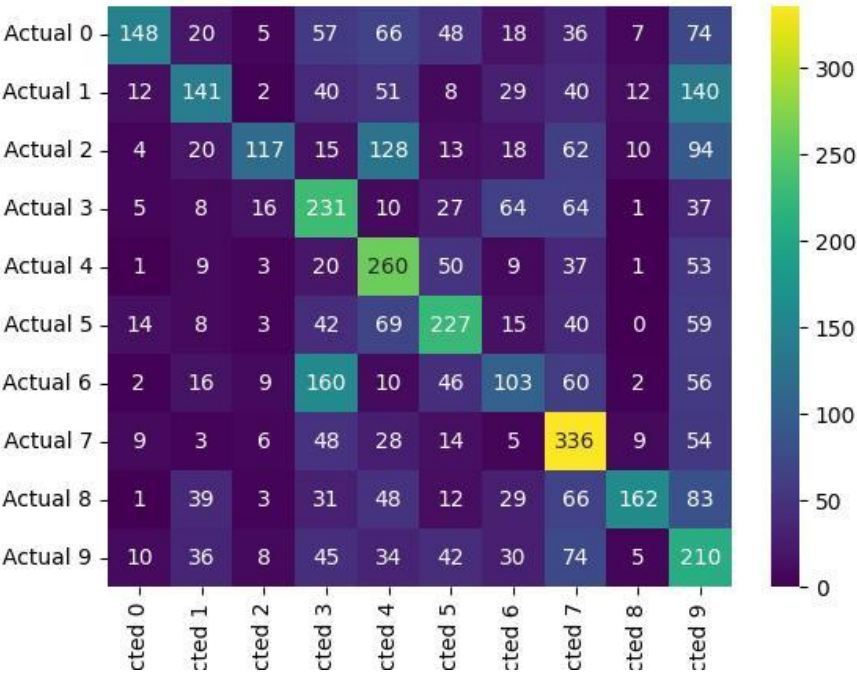
Convolution -> ReLU -> MaxPool -> Convolution -> ReLU ->  
Convolution -> ReLU -> Flatten -> FC -> FC -> ReLU ->  
FC -> Softmax

## Section A: Model-1 Results

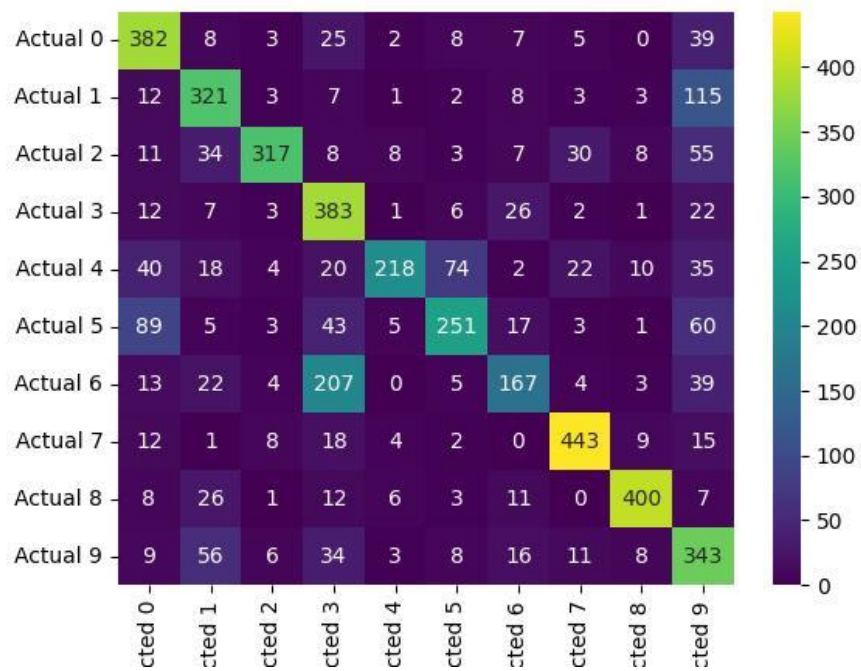
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.290	9.030	2.302	10.584	0.074
	2	2.290	10.710	2.302	12.159	0.079
	3	2.289	12.327	2.301	13.104	0.079
0.001	4	2.289	13.503	2.301	13.965	0.080
	5	2.288	14.112	2.301	14.637	0.081
	6	2.288	14.763	2.300	14.931	0.080
	7	2.287	15.099	2.299	15.372	0.082



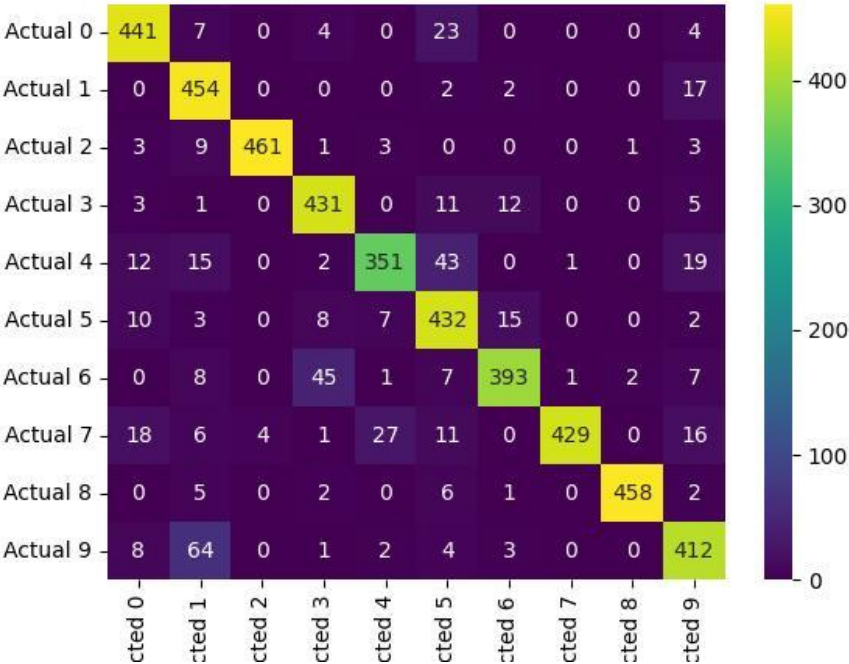
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.289	11.256	2.301	14.616	0.080
	2	2.287	15.477	2.297	16.338	0.081
	3	2.282	16.758	2.289	14.931	0.062
0.005	4	2.265	10.731	2.259	10.437	0.028
	5	2.216	12.915	2.182	17.409	0.117
	6	2.092	26.732	2.016	30.596	0.285
	7	1.904	36.959	1.827	40.634	0.403



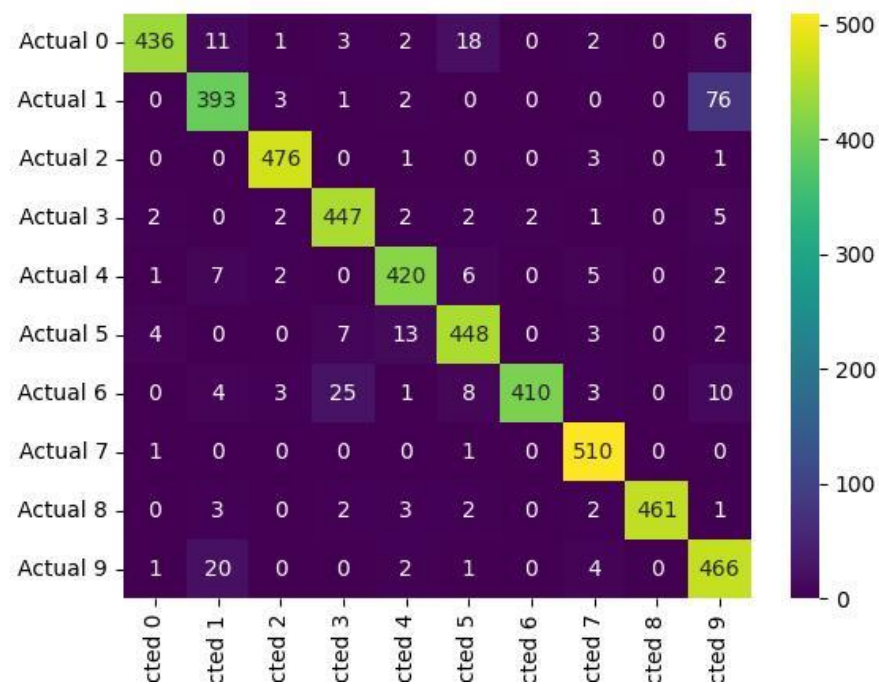
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.288	13.629	2.297	16.170	0.079
	2	2.274	12.831	2.260	10.878	0.034
	3	2.159	19.509	2.031	27.740	0.245
0.01	4	1.857	37.610	1.719	43.700	0.430
	5	1.549	48.740	1.404	55.145	0.550
	6	1.294	57.707	1.173	62.558	0.621
	7	1.105	64.490	1.015	67.724	0.674



Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.132	21.714	1.744	42.230	0.408
	2	1.443	52.898	1.024	66.422	0.661
	3	0.921	69.089	0.768	75.052	0.751
0.05	4	0.666	76.921	0.735	75.115	0.753
	5	0.504	82.003	0.500	82.612	0.827
	6	0.394	86.455	0.359	87.379	0.874
	7	0.316	88.660	0.297	89.500	0.895

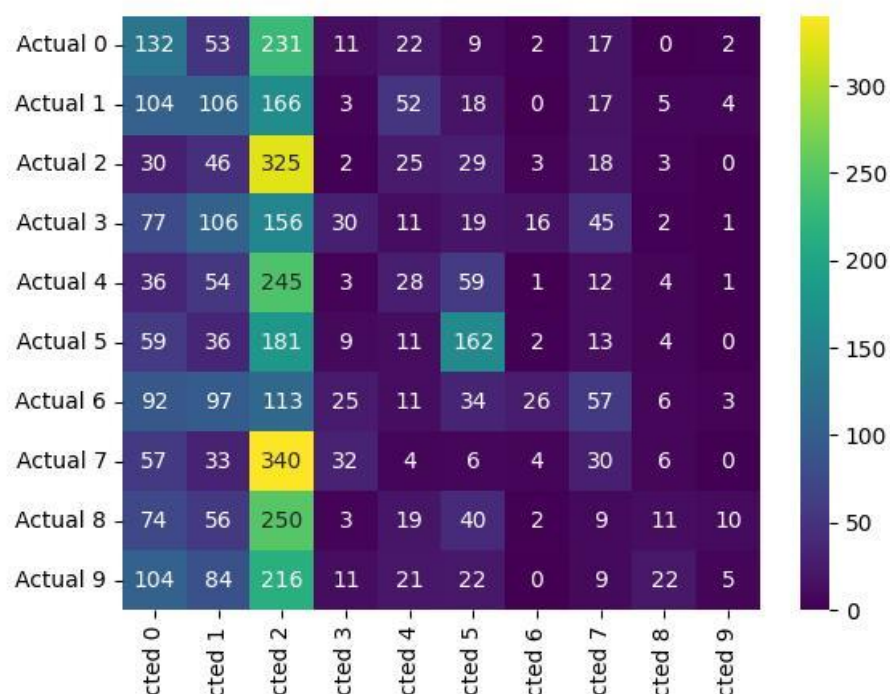


Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.029	27.341	1.416	52.016	0.505
	2	1.175	60.626	0.899	68.606	0.677
	3	0.713	75.703	0.594	79.420	0.792
0.1	4	0.470	83.998	0.489	82.990	0.828
	5	0.385	86.959	0.310	89.059	0.891
	6	0.278	90.214	0.201	92.608	0.926
	7	0.200	93.238	0.181	93.805	0.938



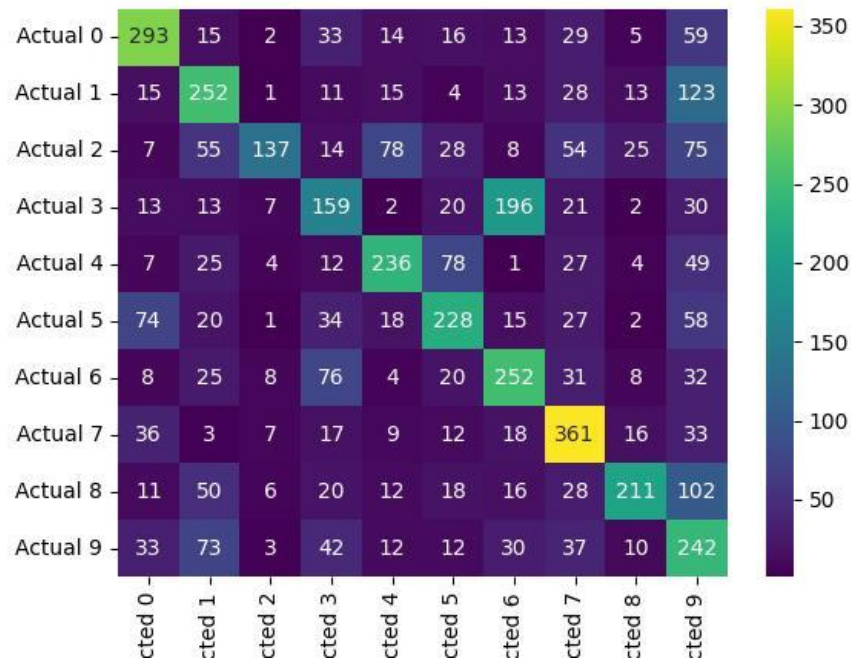
## Section B: Model-2 Results

Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.287	11.025	2.299	11.655	0.082
	2	2.285	12.243	2.297	13.314	0.102
	3	2.283	14.112	2.295	15.267	0.120
0.001	4	2.281	15.897	2.292	16.338	0.131
	5	2.279	16.464	2.290	16.968	0.135
	6	2.276	17.115	2.287	17.325	0.137
	7	2.273	17.703	2.283	17.955	0.144

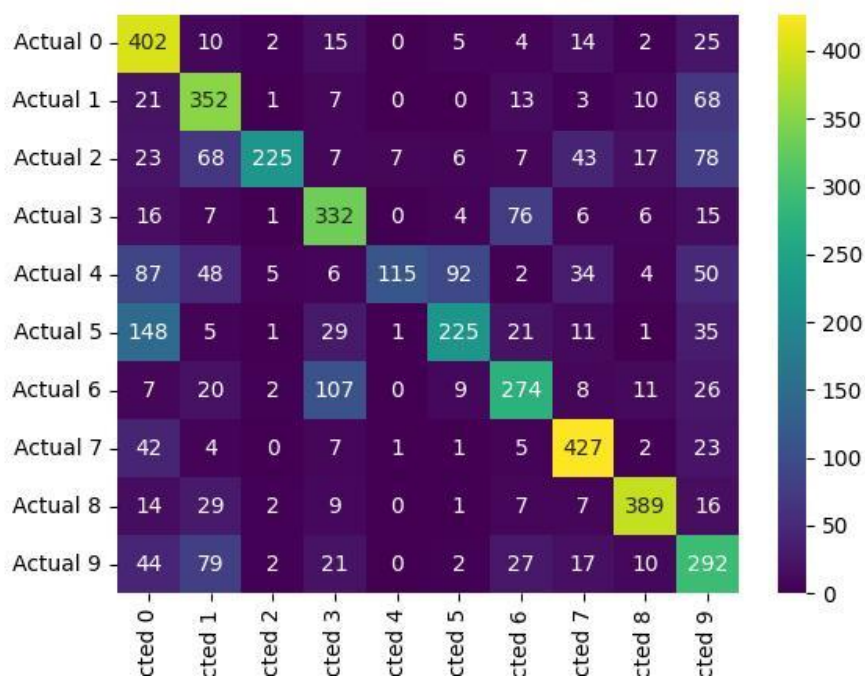




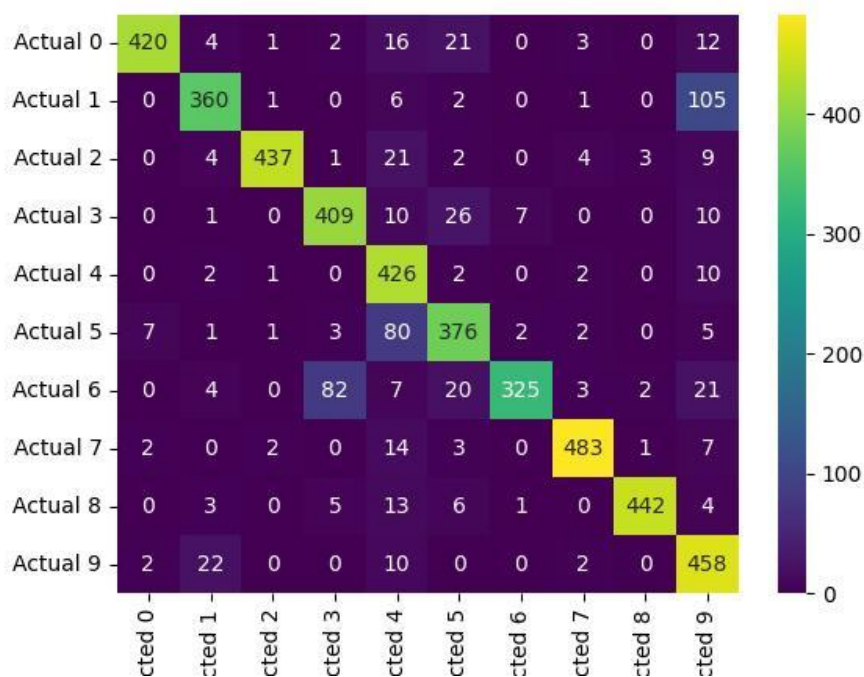
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.284	14.070	2.290	17.031	0.137
	2	2.269	18.312	2.269	20.685	0.176
	3	2.234	22.449	2.215	26.354	0.243
0.005	4	2.151	27.467	2.096	31.730	0.304
	5	1.995	34.292	1.903	37.967	0.375
	6	1.773	41.474	1.677	43.490	0.425
	7	1.577	47.648	1.491	49.790	0.498



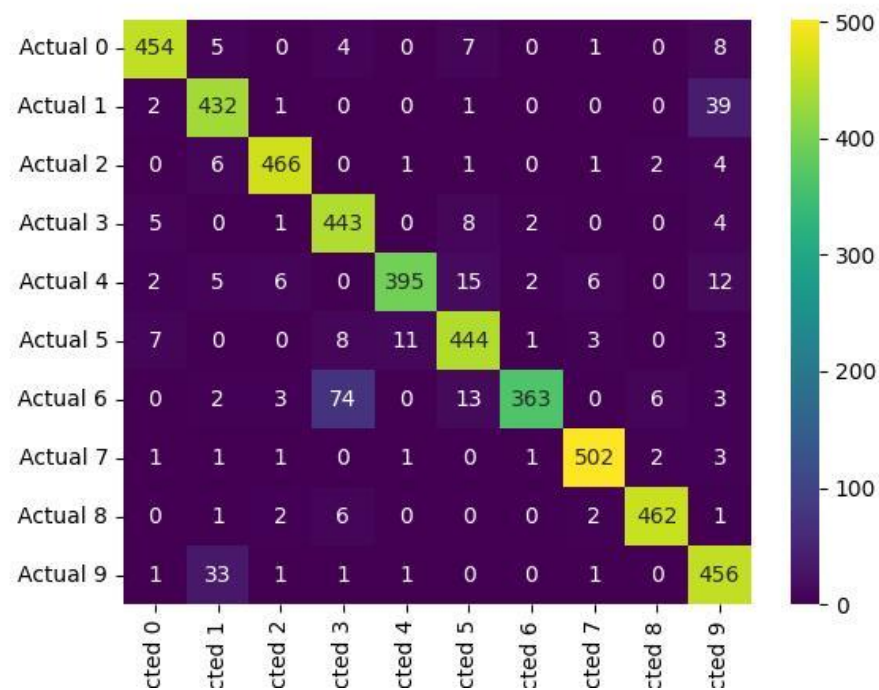
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.277	16.212	2.270	21.336	0.179
	2	2.199	24.843	2.106	31.478	0.304
	3	1.923	35.783	1.737	40.781	0.394
0.01	4	1.612	46.157	1.474	50.651	0.508
	5	1.364	54.872	1.288	56.615	0.561
	6	1.176	60.500	1.195	59.723	0.584
	7	1.026	64.931	1.065	63.692	0.627



Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.079	25.472	1.713	41.012	0.388
	2	1.482	48.614	1.281	54.158	0.532
	3	1.020	64.028	0.935	66.779	0.665
0.05	4	0.752	73.394	0.691	74.969	0.749
	5	0.581	78.790	0.478	82.423	0.825
	6	0.501	81.877	0.440	83.158	0.831
	7	0.375	86.203	0.366	86.854	0.869

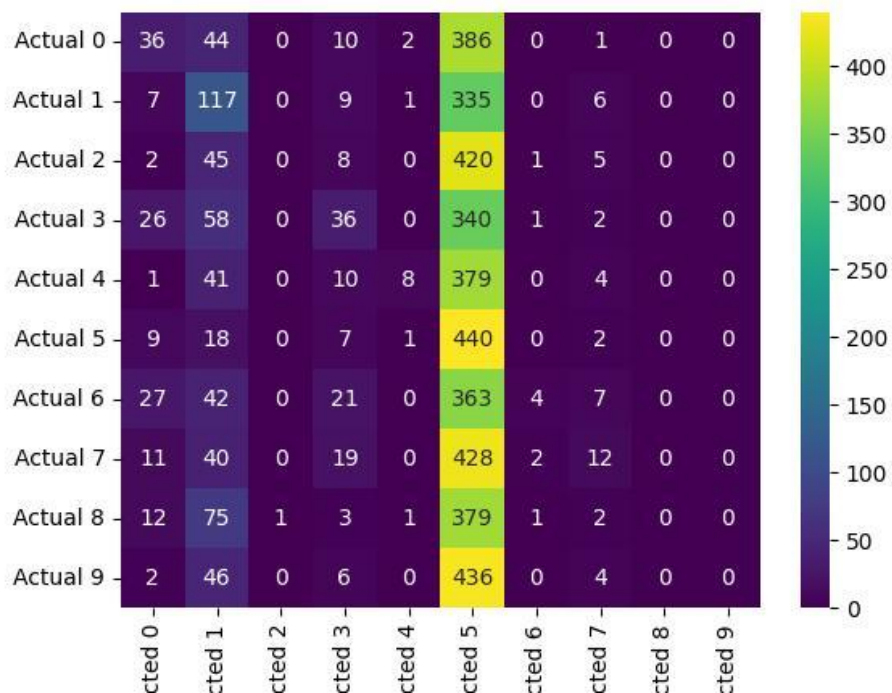


Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.017	27.908	1.466	50.336	0.496
	2	1.304	55.103	1.132	59.114	0.576
	3	0.899	69.278	0.824	72.197	0.712
0.1	4	0.587	78.441	0.432	86.308	0.864
	5	0.425	84.544	0.347	87.505	0.873
	6	0.317	88.513	0.293	89.374	0.891
	7	0.238	91.453	0.205	92.755	0.927

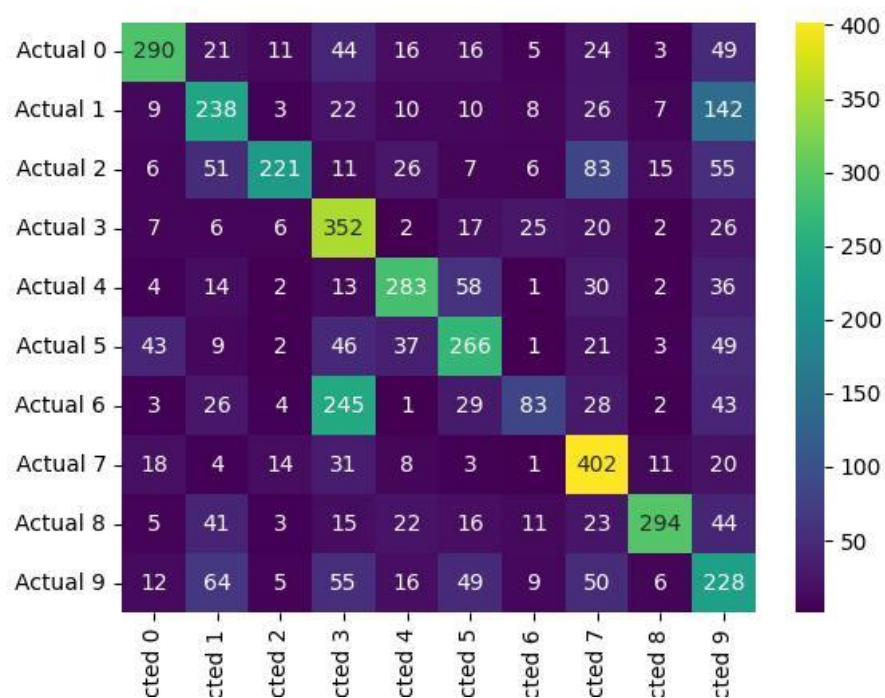


## Section C: Model-3 Results

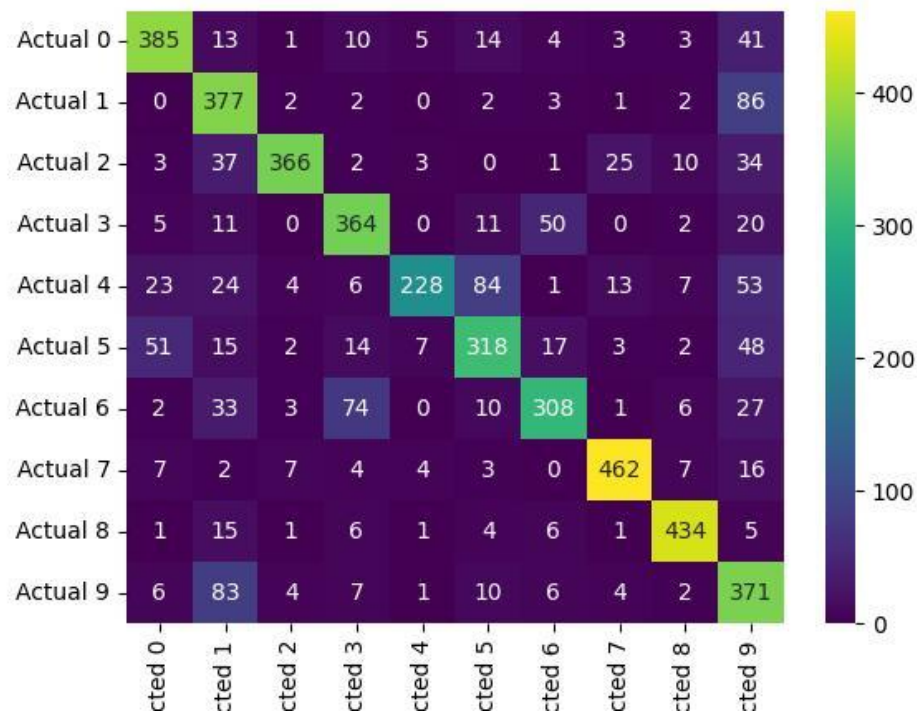
Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.289	11.256	2.301	12.915	0.080
	2	2.288	13.167	2.300	13.461	0.081
	3	2.287	13.482	2.299	13.398	0.074
0.001	4	2.286	13.755	2.298	13.377	0.069
	5	2.285	13.713	2.297	13.461	0.071
	6	2.284	13.944	2.295	13.587	0.073
	7	2.282	14.154	2.293	13.713	0.077



Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.288	12.957	2.297	13.524	0.060
	2	2.280	14.910	2.282	12.978	0.070
	3	2.235	15.120	2.186	17.703	0.145
0.005	4	2.067	28.832	1.959	33.095	0.318
	5	1.841	37.568	1.761	41.075	0.399
	6	1.652	44.708	1.569	47.774	0.469
	7	1.467	50.924	1.354	55.796	0.554

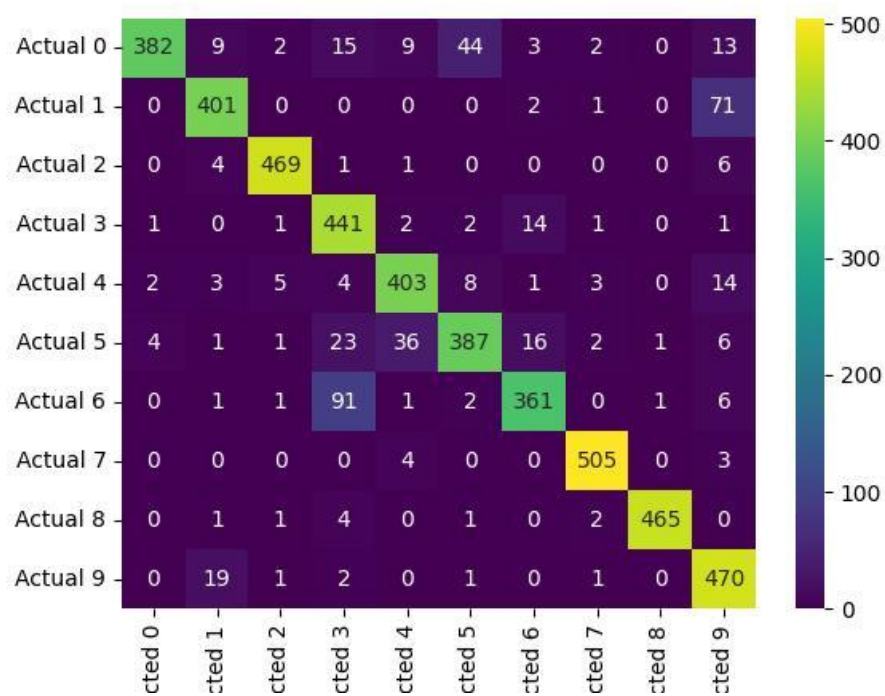


Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.284	13.860	2.282	12.852	0.069
	2	2.162	20.664	2.002	29.819	0.275
	3	1.839	37.505	1.672	44.456	0.433
0.01	4	1.511	49.811	1.298	56.930	0.570
	5	1.202	59.786	1.030	67.073	0.671
	6	0.966	67.766	0.867	72.008	0.719
	7	0.812	72.806	0.738	75.871	0.759



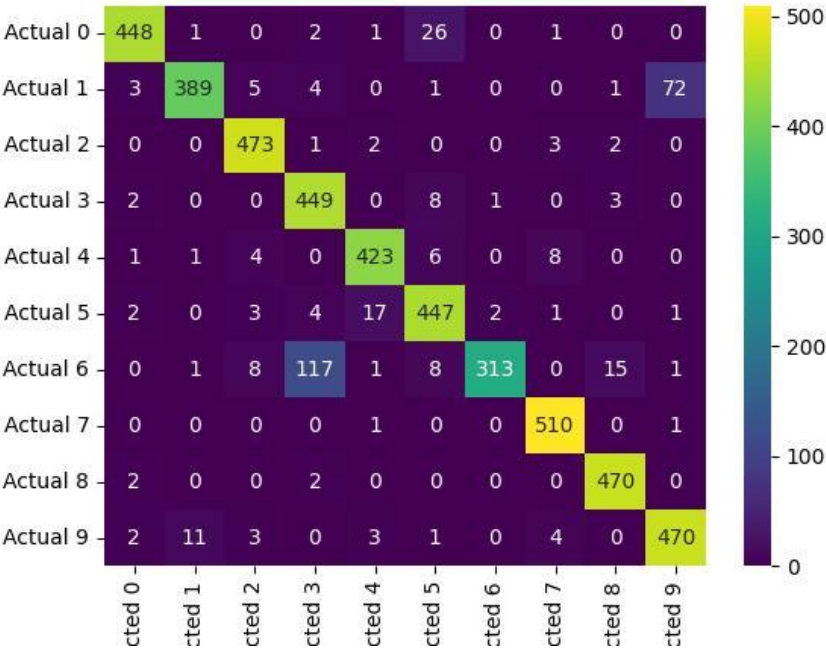


Learning rate	Epoch	Training loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.146	20.412	1.751	40.550	0.380
	2	1.497	49.412	1.256	57.749	0.565
	3	0.913	68.564	0.707	75.535	0.753
0.05	4	0.645	77.089	0.573	79.777	0.796
	5	0.468	83.305	0.411	85.468	0.852
	6	0.353	87.484	0.341	88.135	0.879
	7	0.255	90.949	0.281	89.962	0.889





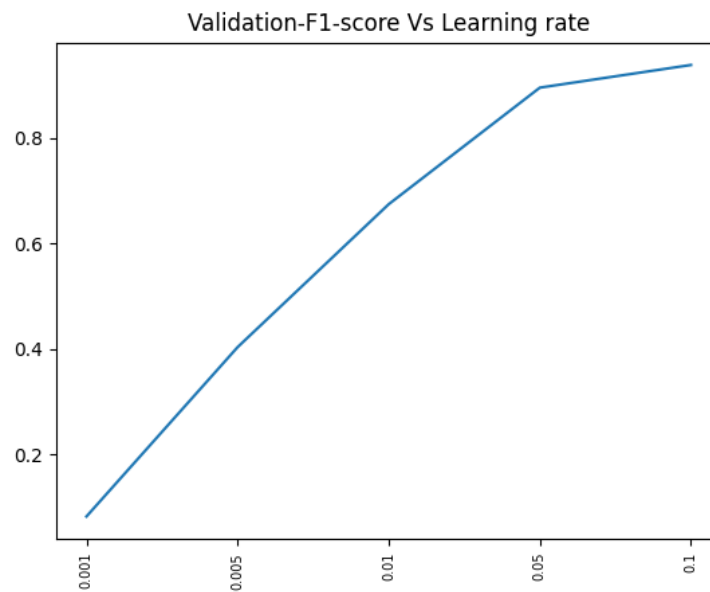
Learning rate	Epoch	Training Loss	Training accuracy	Validation loss	Validation accuracy	Validation f1-score
	1	2.187	18.522	1.819	36.749	0.341
	2	1.459	49.370	0.898	69.278	0.695
	3	0.846	69.761	0.659	76.648	0.766
0.1	4	0.534	80.995	0.439	84.460	0.844
	5	0.289	84.225	0.439	90.088	0.900
	6	0.295	89.143	0.438	85.027	0.852
	7	0.186	93.133	0.244	92.230	0.920



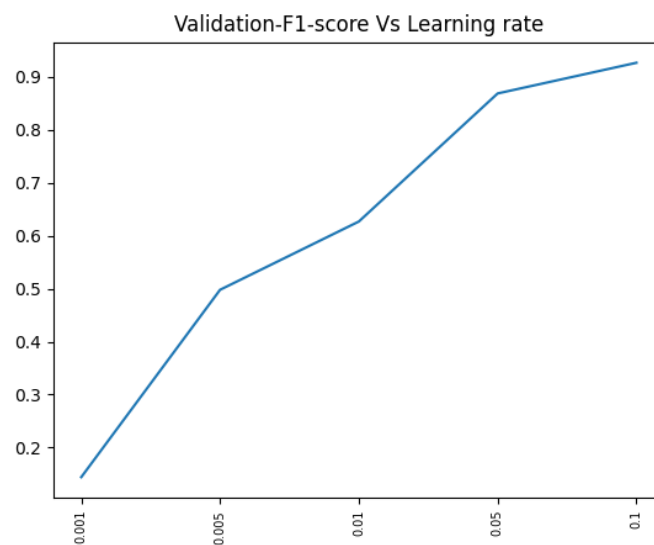
## Section D: Comparison Between Models

### A. Graphs of Validation-F1-Score Vs Learning rate

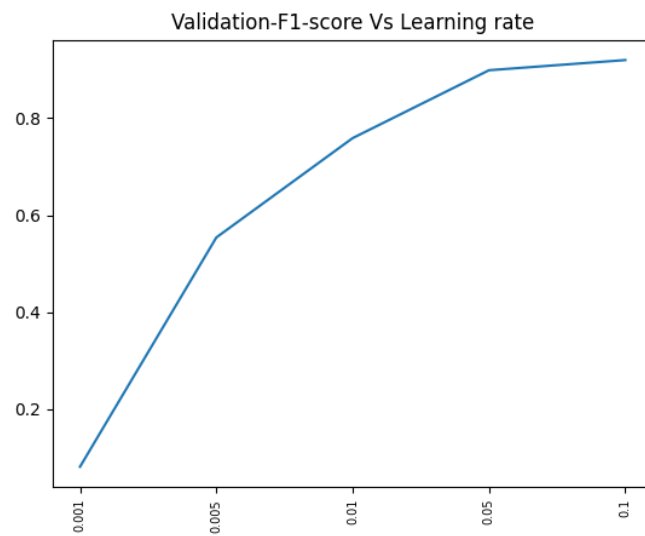
#### 1) Model-1



#### 2) Model-2



### 3) Model-3



### ***B. Table***

Learning rate	Model-1 Validation f1-score	Model-2 Validation f1-score	Model-3 Validation f1-score
0.001	0.082	0.144	0.081
0.005	0.403	0.498	0.554
0.01	0.674	0.627	0.759
0.05	0.895	0.869	0.899
0.1	0.938	0.927	0.920

### **C. Chosen Model --- (Model-3):**

#### **Configuration:**

- Convolution -> ReLU -> MaxPool -> Convolution -> ReLU -> Convolution -> ReLU -> Flattening -> FC -> FC -> ReLU -> FC -> Softmax
- Learning rate = 0.005
- Epoch = 7

#### **Performance Metrics:**

1. Training loss = **0.255 %**
2. Training accuracy = **90.949 %**
3. Validation loss = **0.281 %**
4. Validation accuracy = **89.962 %**
5. Validation macro-f1 score = **0.889**

# Section E: Independent Test Results

Performance Metrics:

- 1. Test loss = **0.692 %**
- 2. Test accuracy = **77.851 %**
- 3. Test macro-f1 score = **0.781**

