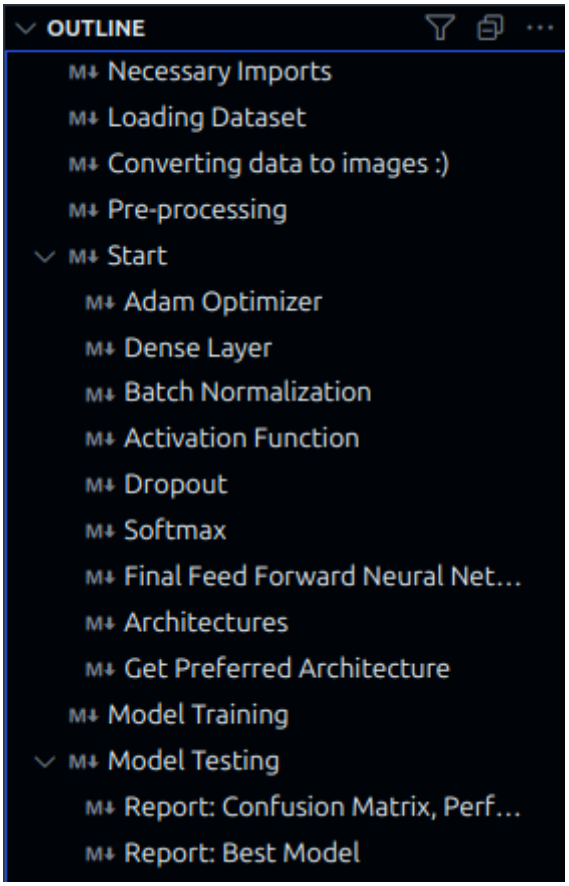
Report

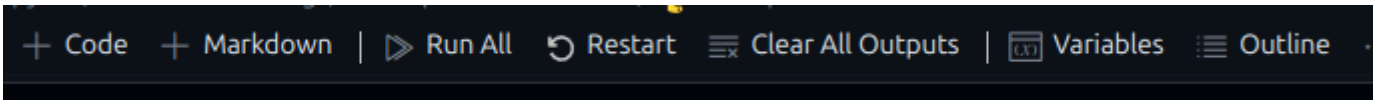
1905096

Outline ----------



Running the Script ----------

Simply click **run all** in vscode



- **run all**
  - Train **12** models
  - Save model weights in weights directory
  - Test **12** models
  - Test the best model according to validation macro f1 score

Weights Directory: 'weights'

Save Format **:** model-type_weights_learning-rate.pkl

About the Architectures

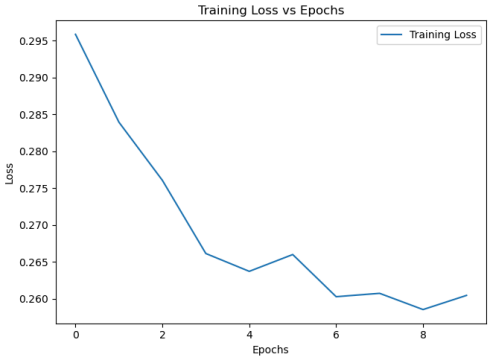
Large Architecture 1	Large Architecture 2	Small Architecture
- Layer 1: - Dense Layer (784 → 1024) - Batch Normalization (1024) - ReLU Activation - Dropout (50%) **- Layer 2:** - Dense Layer (1024 → 512) - Batch Normalization (512) - ReLU Activation - Dropout (50%) **- Layer 3:** - Dense Layer (512 → 256) - Batch Normalization (256) - ReLU Activation - Dropout (50%) **- Layer 4:** - Dense Layer (256 → 128) - Batch Normalization (128) - ReLU Activation - Dropout (50%) **- Layer 5:** - Dense Layer (128 → 10) - Softmax Activation	**- Layer 1:** - Dense Layer (784 → 512) - Batch Normalization (512) - ReLU Activation - Dropout (50%) **- Layer 2:** - Dense Layer (512 → 256) - Batch Normalization (256) - ReLU Activation - Dropout (50%) **- Layer 3:** - Dense Layer (256 → 128) - Batch Normalization (128) - ReLU Activation - Dropout (50%) **- Layer 4:** - Dense Layer (128 → 64) - Batch Normalization (64) - ReLU Activation - Dropout (50%) **- Layer 5:** - Dense Layer (64 → 10) - Softmax Activation	**- Layer 1:** - Dense Layer (784 → 128) - Batch Normalization (128) - ReLU Activation - Dropout (50%) **- Layer 2:** - Dense Layer (128 → 64) - Batch Normalization (64) - ReLU Activation - Dropout (50%) **- Layer 3:** - Dense Layer (64 → 10) - Softmax Activation

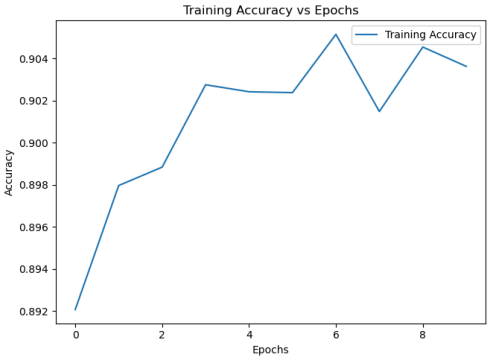
Reporting Metrics

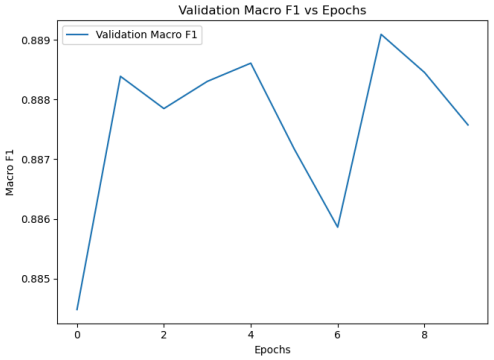
Training Loss, Training Accuracy, Validation Loss, Validation Accuracy, Validation Macro F1-Score

Training **"small"** model with **learning rate: 0.005**

Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1	0.2958	0.8921	0.3628	0.8842	0.8845
2	0.2839	0.898	0.358	0.8885	0.8884
3	0.276	0.8988	0.3643	0.8878	0.8878
4	0.2661	0.9027	0.3617	0.8881	0.8883
5	0.2637	0.9024	0.3594	0.8882	0.8886
6	0.266	0.9024	0.3625	0.8872	0.8872
7	0.2603	0.9051	0.3618	0.8862	0.8859
8	0.2607	0.9015	0.3638	0.8885	0.8891
9	0.2585	0.9045	0.3654	0.8878	0.8885
10	0.2604	0.9036	0.366	0.8868	0.8876

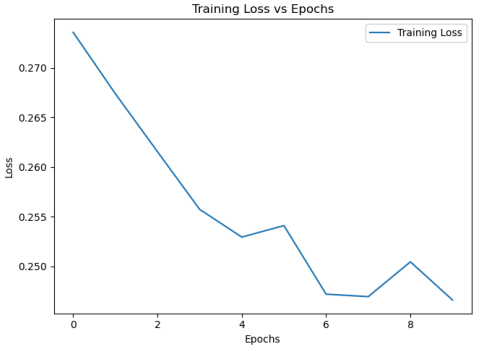


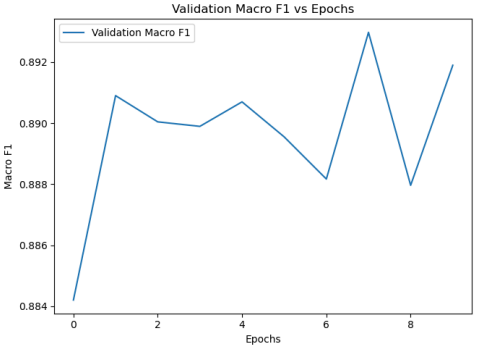




Training **"small"** model with **learning rate: 0.004**

Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1	0.2736	0.8987	0.366	0.8841	0.8842
2	0.2674	0.9026	0.3645	0.8905	0.8909
3	0.2616	0.9054	0.3683	0.8896	0.89
4	0.2557	0.9069	0.3614	0.8889	0.8899
5	0.2529	0.9072	0.3608	0.8899	0.8907
6	0.2541	0.9085	0.368	0.8895	0.8895
7	0.2472	0.9091	0.3681	0.8874	0.8882
8	0.2469	0.9096	0.3716	0.8922	0.893
9	0.2505	0.9095	0.3711	0.8874	0.888
10	0.2466	0.9097	0.3666	0.8914	0.8919





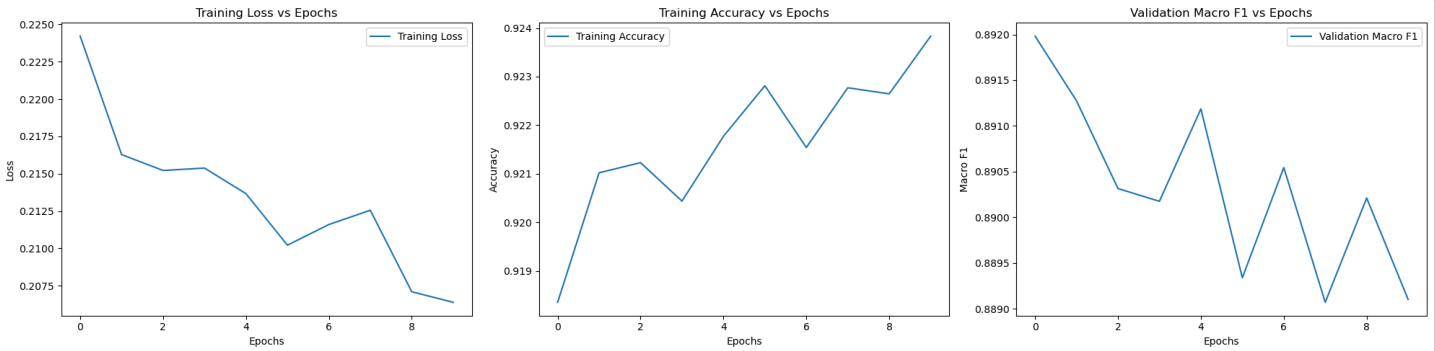
Training **"small"** model with **learning rate: 0.003**

Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1

1 / 10	0.2581	0.9073	0.3717	0.8881	0.8885
2 / 10	0.2452	0.9116	0.3689	0.8895	0.89
3 / 10	0.2407	0.9107	0.3742	0.8882	0.8886
4 / 10	0.2361	0.914	0.3809	0.8897	0.8903
5 / 10	0.2356	0.9142	0.3839	0.8881	0.8889
6 / 10	0.2368	0.9138	0.3785	0.8871	0.888
7 / 10	0.2318	0.9137	0.3812	0.8894	0.8904
8 / 10	0.2318	0.914	0.384	0.8897	0.8904
9 / 10	0.2305	0.9143	0.3823	0.8901	0.891
10 / 10	0.2296	0.915	0.3832	0.889	0.8897

Training **"small"** model with **learning rate: 0.001**

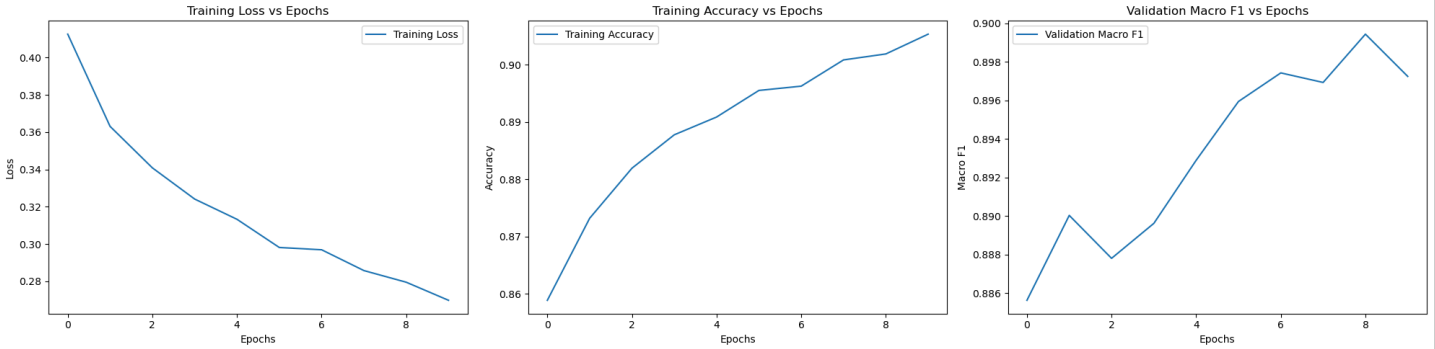
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.2242	0.9184	0.3875	0.8912	0.892
2 / 10	0.2163	0.921	0.3877	0.8903	0.8913
3 / 10	0.2152	0.9212	0.395	0.8894	0.8903
4 / 10	0.2154	0.9204	0.3876	0.8893	0.8902
5 / 10	0.2137	0.9218	0.3908	0.8901	0.8912
6 / 10	0.2102	0.9228	0.3948	0.8884	0.8893
7 / 10	0.2116	0.9215	0.3967	0.8896	0.8905
8 / 10	0.2126	0.9228	0.3936	0.8879	0.8891
9 / 10	0.2071	0.9226	0.3999	0.8892	0.8902
10 / 10	0.2064	0.9238	0.4001	0.8879	0.8891



Training **"large1"** model with **learning rate: 0.005**

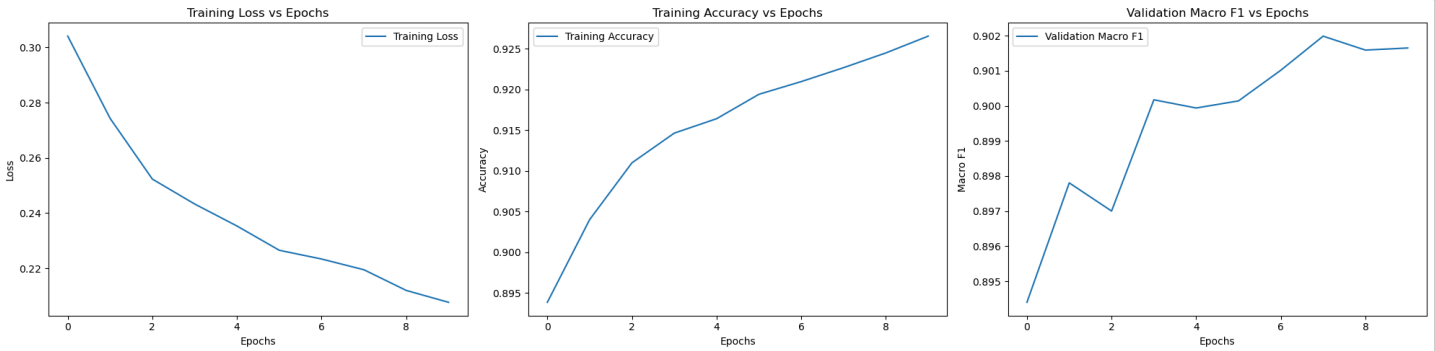
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.4126	0.8589	0.32	0.8858	0.8856
2 / 10	0.3631	0.8732	0.3126	0.8902	0.89
3 / 10	0.3409	0.8819	0.3119	0.8888	0.8878

4 / 10	0.3241	0.8878	0.3051	0.8902	0.8896
5 / 10	0.3133	0.8909	0.3028	0.8933	0.8929
6 / 10	0.2982	0.8955	0.2993	0.8958	0.8959
7 / 10	0.2969	0.8963	0.2955	0.8974	0.8974
8 / 10	0.2858	0.9009	0.2987	0.8971	0.8969
9 / 10	0.2795	0.9019	0.2949	0.8994	0.8994
10 / 10	0.2698	0.9054	0.2948	0.8971	0.8972



Training **"large1"** model with **learning rate: 0.004**

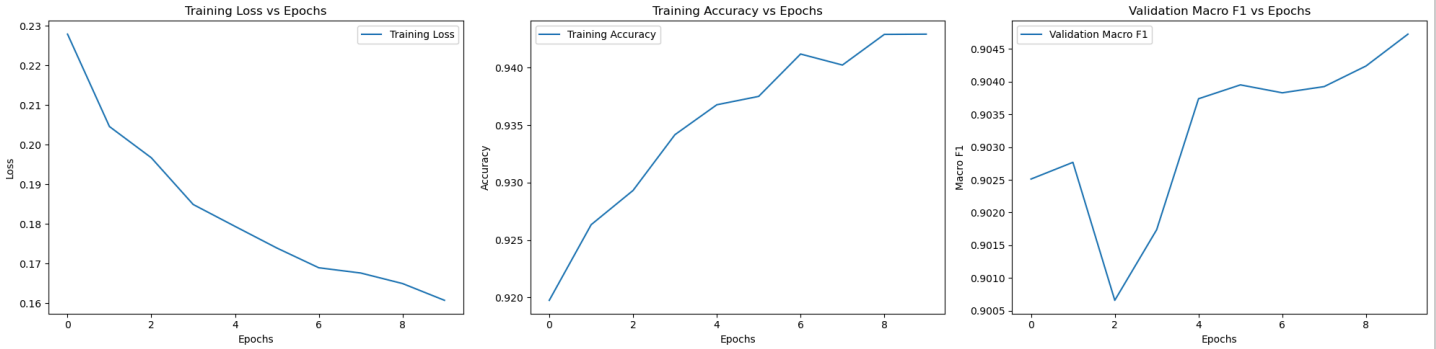
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.3041	0.8939	0.2993	0.8944	0.8944
2 / 10	0.2743	0.904	0.2991	0.8972	0.8978
3 / 10	0.2523	0.911	0.3008	0.8973	0.897
4 / 10	0.2433	0.9146	0.2952	0.9002	0.9002
5 / 10	0.2353	0.9164	0.3049	0.8997	0.8999
6 / 10	0.2265	0.9194	0.3046	0.8998	0.9001
7 / 10	0.2234	0.921	0.3022	0.9005	0.901
8 / 10	0.2195	0.9227	0.305	0.9015	0.902
9 / 10	0.212	0.9245	0.3035	0.9012	0.9016
10 / 10	0.2077	0.9266	0.3081	0.9018	0.9017



Training **"large1"** model with **learning rate: 0.003**

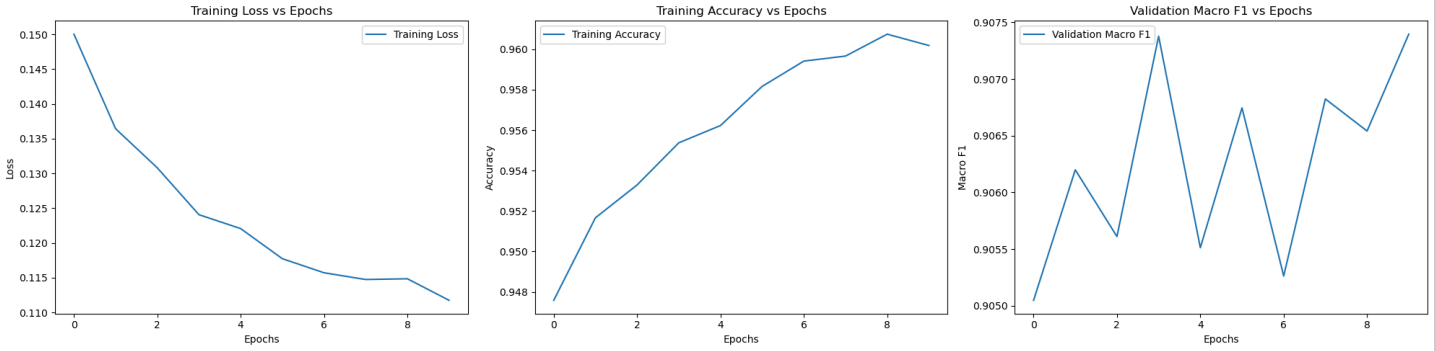
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.2279	0.9198	0.3096	0.9023	0.9025
2 / 10	0.2046	0.9263	0.3105	0.9022	0.9028
3 / 10	0.1967	0.9293	0.3196	0.9004	0.9007
4 / 10	0.1849	0.9342	0.3247	0.9015	0.9017
5 / 10	0.1794	0.9368	0.3154	0.9033	0.9037
6 / 10	0.1739	0.9375	0.3219	0.9035	0.9039

7 / 10	0.1689	0.9412	0.3302	0.9033	0.9038
8 / 10	0.1676	0.9402	0.3307	0.9033	0.9039
9 / 10	0.165	0.9429	0.3333	0.9037	0.9042
10 / 10	0.1607	0.9429	0.3328	0.9044	0.9047



Training **"large1"** model with **learning rate: 0.001**

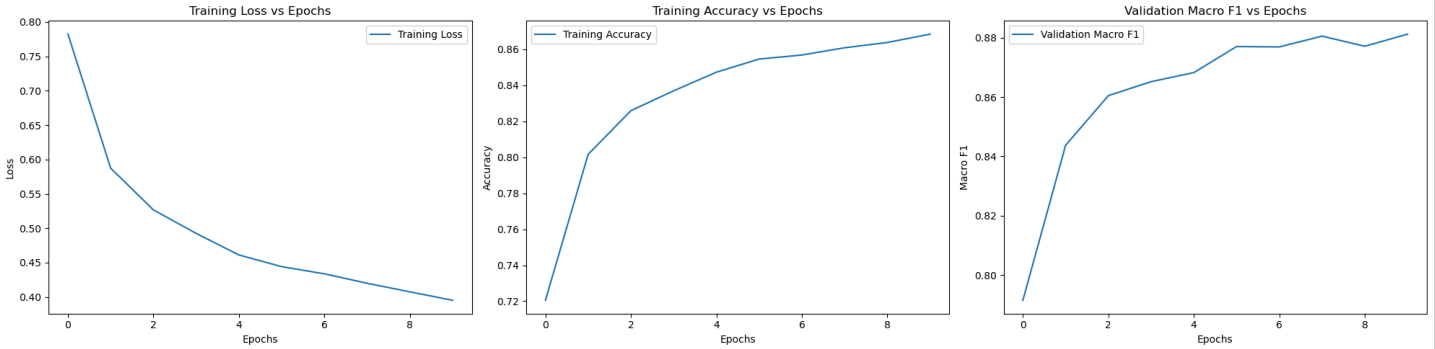
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.15	0.9476	0.3324	0.9042	0.905
2 / 10	0.1364	0.9517	0.3397	0.9052	0.9062
3 / 10	0.1308	0.9533	0.3458	0.9048	0.9056
4 / 10	0.1241	0.9554	0.3491	0.9066	0.9074
5 / 10	0.1221	0.9562	0.3506	0.9047	0.9055
6 / 10	0.1177	0.9582	0.3585	0.9058	0.9067
7 / 10	0.1157	0.9594	0.3563	0.9043	0.9053
8 / 10	0.1147	0.9597	0.3526	0.9061	0.9068
9 / 10	0.1149	0.9608	0.3559	0.9057	0.9065
10 / 10	0.1118	0.9602	0.3627	0.9066	0.9074



Training **"large2"** model with **learning rate: 0.005**

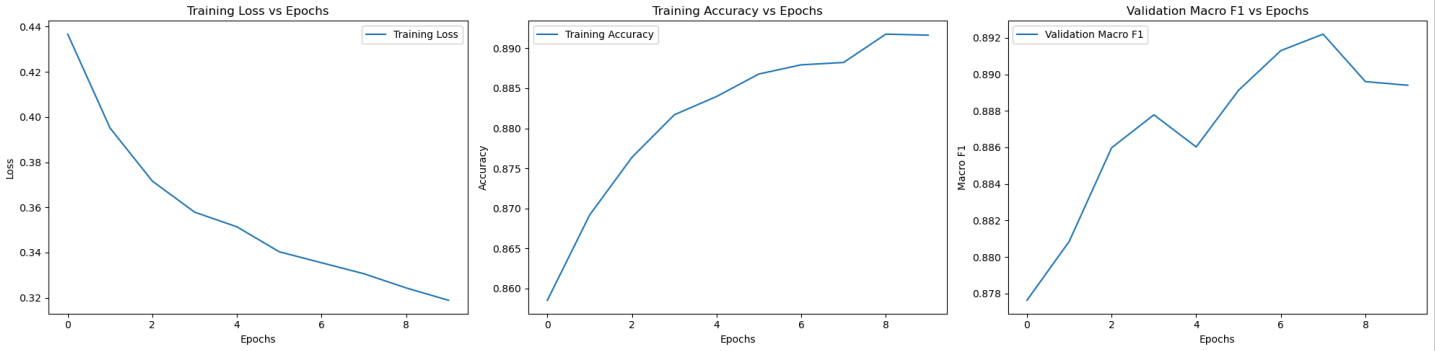
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.3254	0.8835	0.2946	0.8886	0.889
2 / 10	0.2984	0.8926	0.294	0.893	0.8928
3 / 10	0.2847	0.8977	0.2978	0.8937	0.8935
4 / 10	0.2741	0.9026	0.2982	0.8966	0.8962
5 / 10	0.2702	0.9026	0.2923	0.8969	0.8968
6 / 10	0.2634	0.9052	0.2971	0.8976	0.8976
7 / 10	0.2551	0.9075	0.2996	0.899	0.8988
8 / 10	0.2528	0.9081	0.2986	0.8981	0.898
9 / 10	0.2488	0.9108	0.2975	0.8994	0.8994

10 / 10	0.2397	0.912	0.2986	0.8998	0.8998



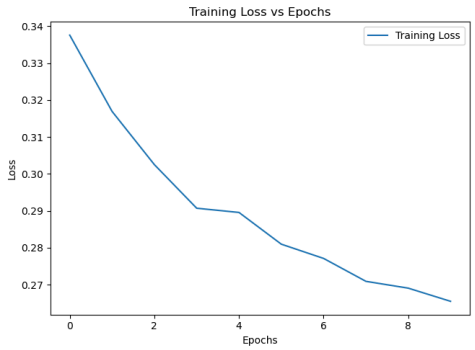
Training **"large2"** model with **learning rate: 0.004**

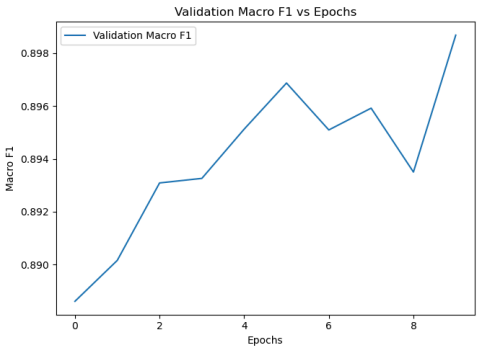
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.2454	0.9101	0.2924	0.8985	0.8989
2 / 10	0.2347	0.9156	0.2951	0.8996	0.8999
3 / 10	0.2284	0.9163	0.2978	0.899	0.8992
4 / 10	0.2219	0.9188	0.2964	0.9001	0.9004
5 / 10	0.2192	0.9193	0.2948	0.901	0.9012
6 / 10	0.2165	0.921	0.2991	0.9015	0.9019
7 / 10	0.2114	0.9228	0.2967	0.9018	0.9021
8 / 10	0.2095	0.9236	0.301	0.902	0.9025
9 / 10	0.2059	0.9252	0.2998	0.9024	0.9028
10 / 10	0.2034	0.9264	0.3026	0.9032	0.9035



Training **"large2"** model with **learning rate: 0.003**

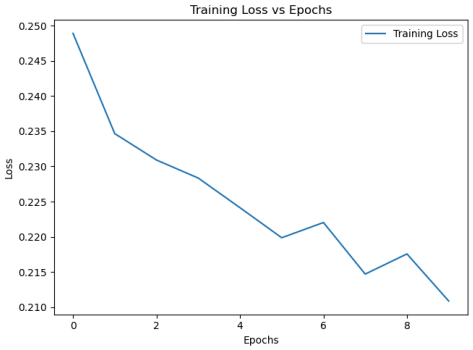
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.1924	0.9306	0.3062	0.9045	0.9052
2 / 10	0.1859	0.9335	0.3078	0.905	0.9058
3 / 10	0.1824	0.9354	0.3085	0.9058	0.9062
4 / 10	0.1781	0.9366	0.3096	0.9063	0.9069
5 / 10	0.1743	0.9378	0.3134	0.907	0.9075
6 / 10	0.1716	0.9392	0.3148	0.9078	0.9083
7 / 10	0.1683	0.9405	0.3176	0.9079	0.9082
8 / 10	0.1658	0.9416	0.3194	0.9082	0.9087
9 / 10	0.1627	0.9429	0.3187	0.9091	0.9094
10 / 10	0.1609	0.9442	0.3202	0.9095	0.9099

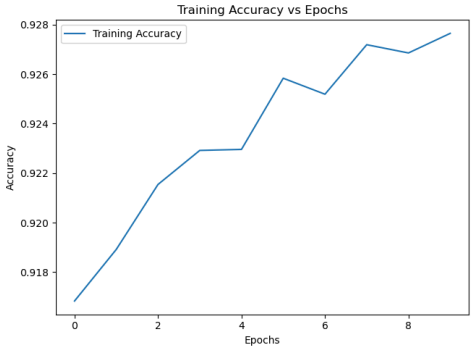


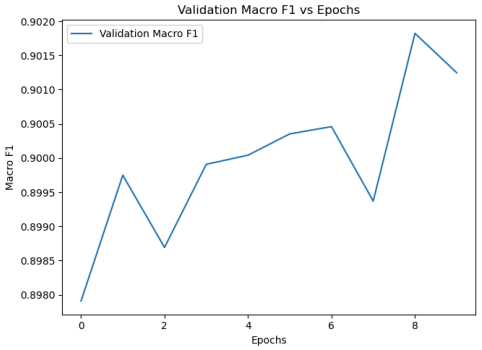


Training **"large2"** model with **learning rate: 0.001**

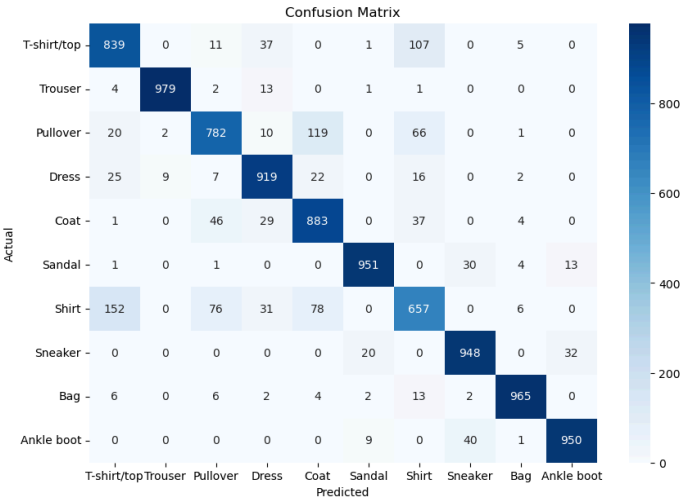
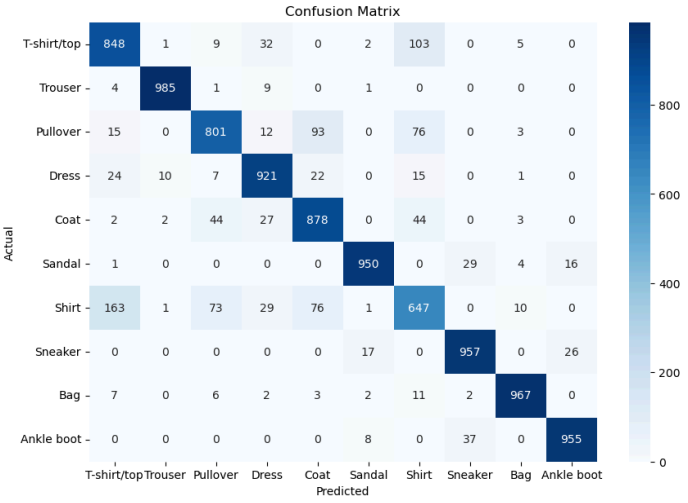
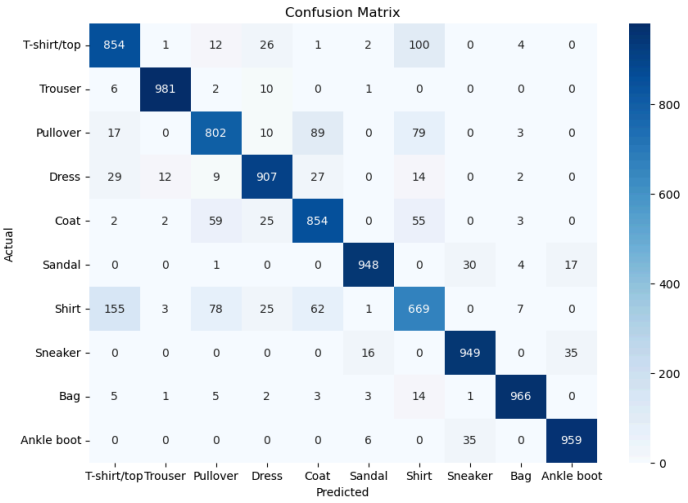
Epoch	Train Loss	Train Accuracy	Validation Loss	Validation Accuracy	Validation Macro-F1
1 / 10	0.1484	0.9503	0.3248	0.9104	0.9109
2 / 10	0.1452	0.9522	0.3267	0.9109	0.9115
3 / 10	0.1418	0.9536	0.3278	0.9114	0.9119
4 / 10	0.1387	0.9548	0.3284	0.9118	0.9121
5 / 10	0.1362	0.956	0.331	0.9123	0.9126
6 / 10	0.1331	0.9572	0.3316	0.9127	0.9129
7 / 10	0.1309	0.9584	0.3328	0.9131	0.9133
8 / 10	0.1284	0.9593	0.3345	0.9136	0.9139
9 / 10	0.1257	0.9603	0.336	0.914	0.9144
10 / 10	0.1239	0.9614	0.3378	0.9144	0.9148



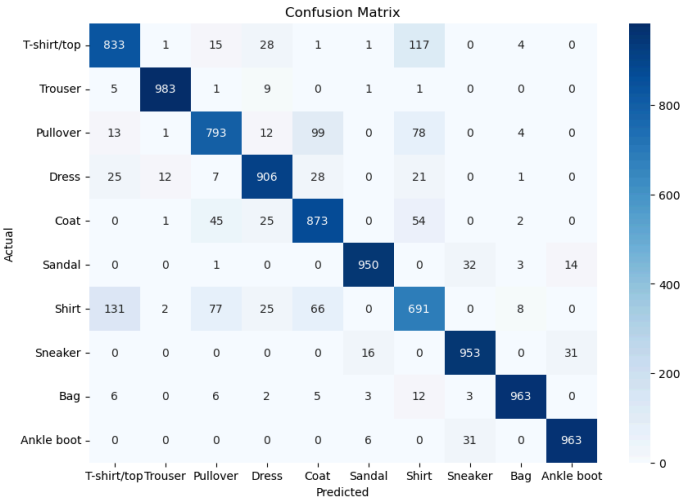




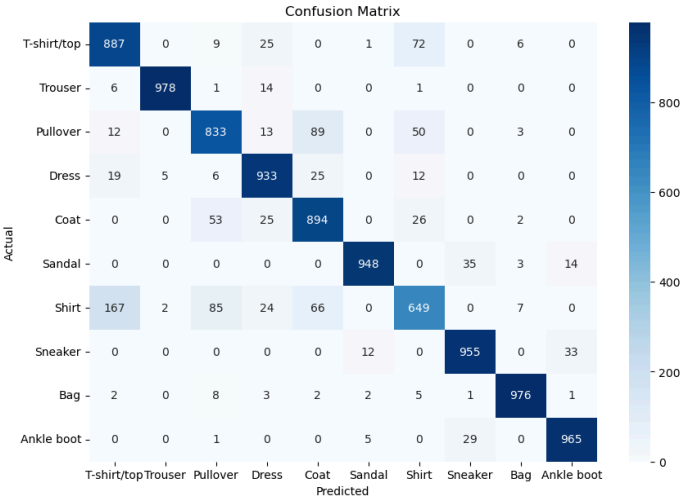
Confusion Matrix on test set ----------

Model	Confusion Matrix
Architecture small **Learning Rate** 0.005 **Test Accuracy** 0.8873	
Architecture small **Learning Rate** 0.004 **Test Accuracy** 0.8909	
Architecture small **Learning Rate** 0.003 **Test Accuracy** 0.8889	

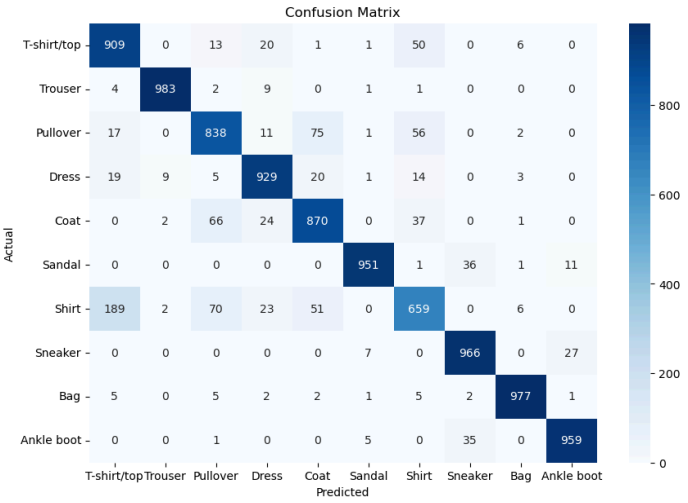
Architecture	Learning Rate	Test Accuracy
small	0.001	0.8908



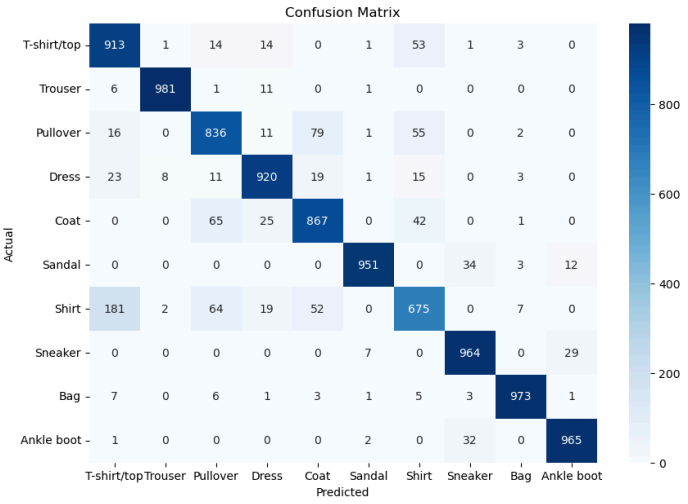
Architecture	Learning Rate	Test Accuracy
large1	0.005	0.9018



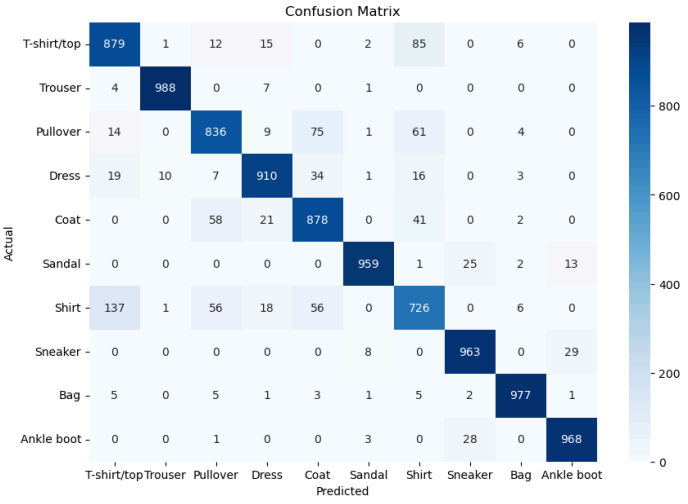
Architecture	Learning Rate	Test Accuracy
large1	0.004	0.9041



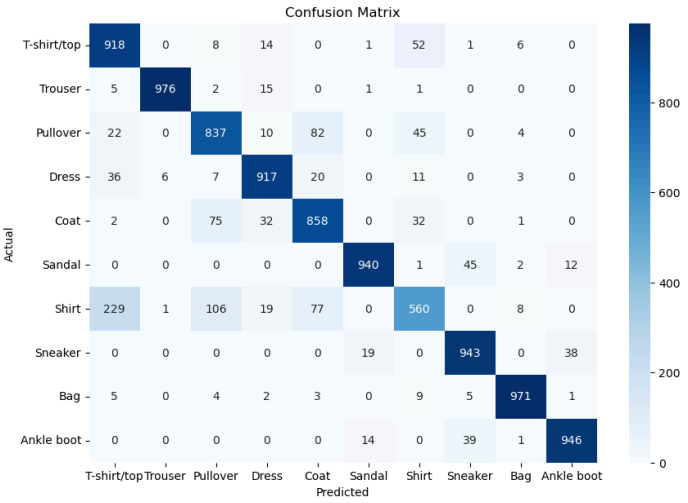
Architecture	Learning Rate	Test Accuracy
large1	0.003	0.9045



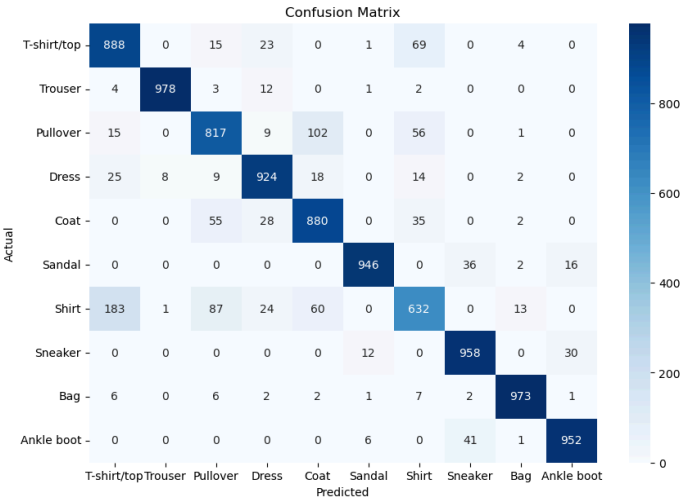
Architecture	Learning Rate	Test Accuracy
large1	0.001	0.9084



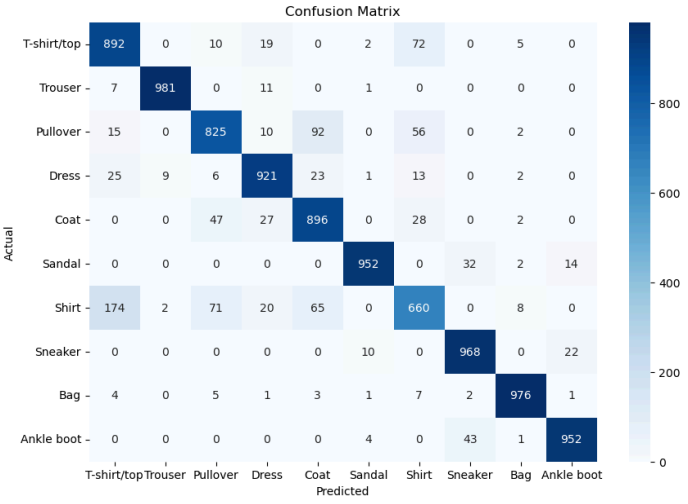
Architecture	Learning Rate	Test Accuracy
large2	0.005	0.8866



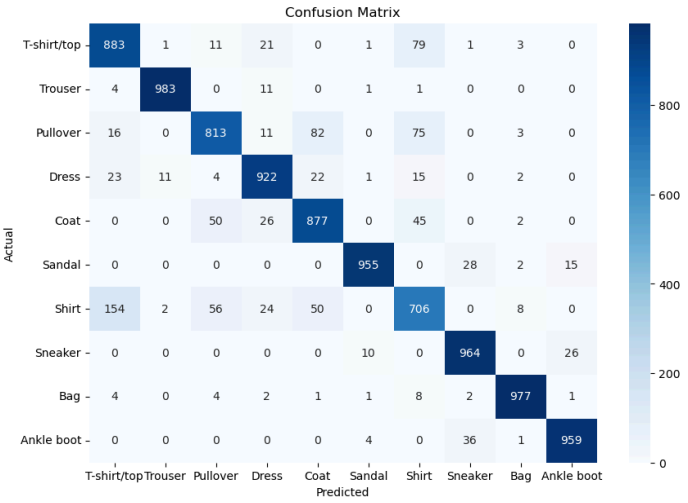
Architecture	Learning Rate	Test Accuracy
large2	0.004	0.8948



Architecture	Learning Rate	Test Accuracy
large2	0.003	0.9023

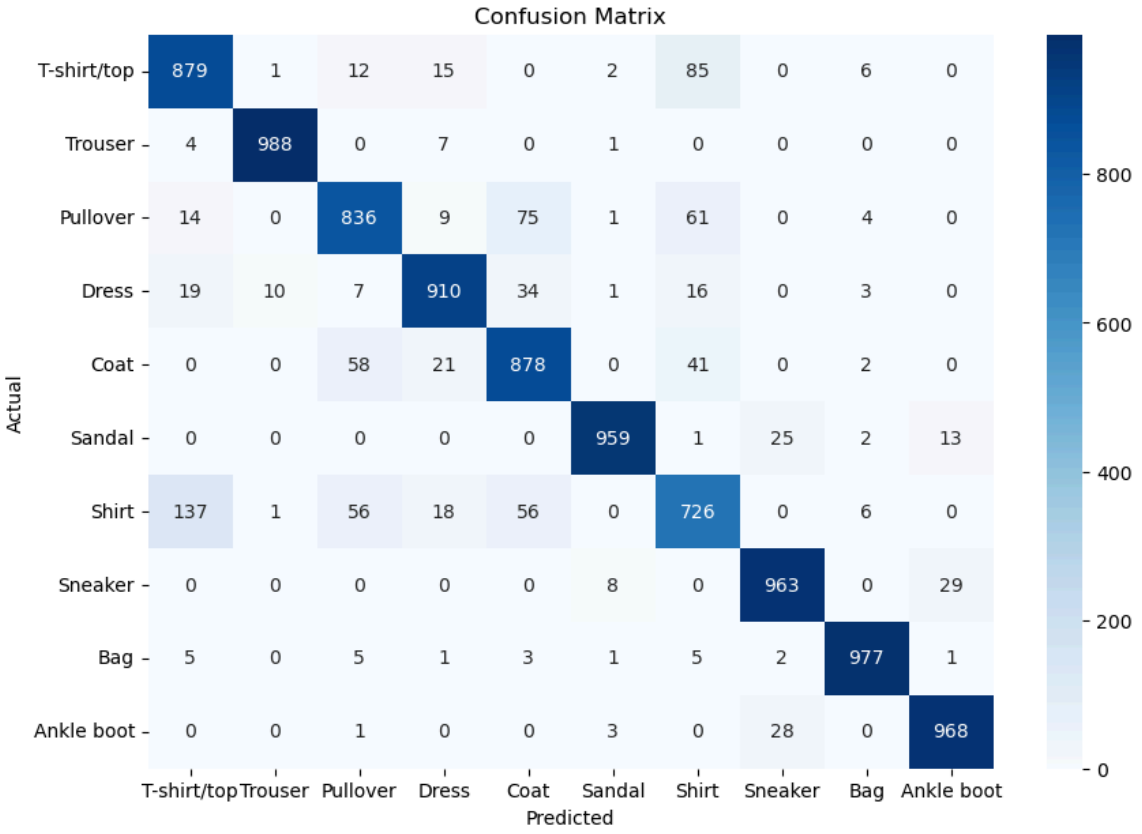


Architecture	Learning Rate	Test Accuracy
large2	0.001	0.9039



Best Model Test Performance ----------

Architecture	Learning Rate	Test Accuracy	Precision	Recall	F1 Score
large1	0.001	**0.9084**	0.9083	0.9084	**0.9081**



Report by

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Course

CSE 472 - Machine Learning Sessional