Classification of the MNIST dataset

Pattern Recognition
ICP

Sajina Pathak

Supervisor: Dr. Georgios Anagnostopoulos

FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

Outline

1. Dataset source
2. Data Visualization
3. Classification Algorithms implemented
4. Comparision with baseline methods
5. Conclusion

Objective

- Implement classification algorithm taught in the Pattern Recognition class.
- Image Classification on sign language.

Approach

- Image Classification using
  - LDA (Linear Discriminant Analysis)
  - LDA with PCA (Principal Component Analysis)
  - SVM (Support Vector Machine)
  - CNN (Convolutional Neural Network)

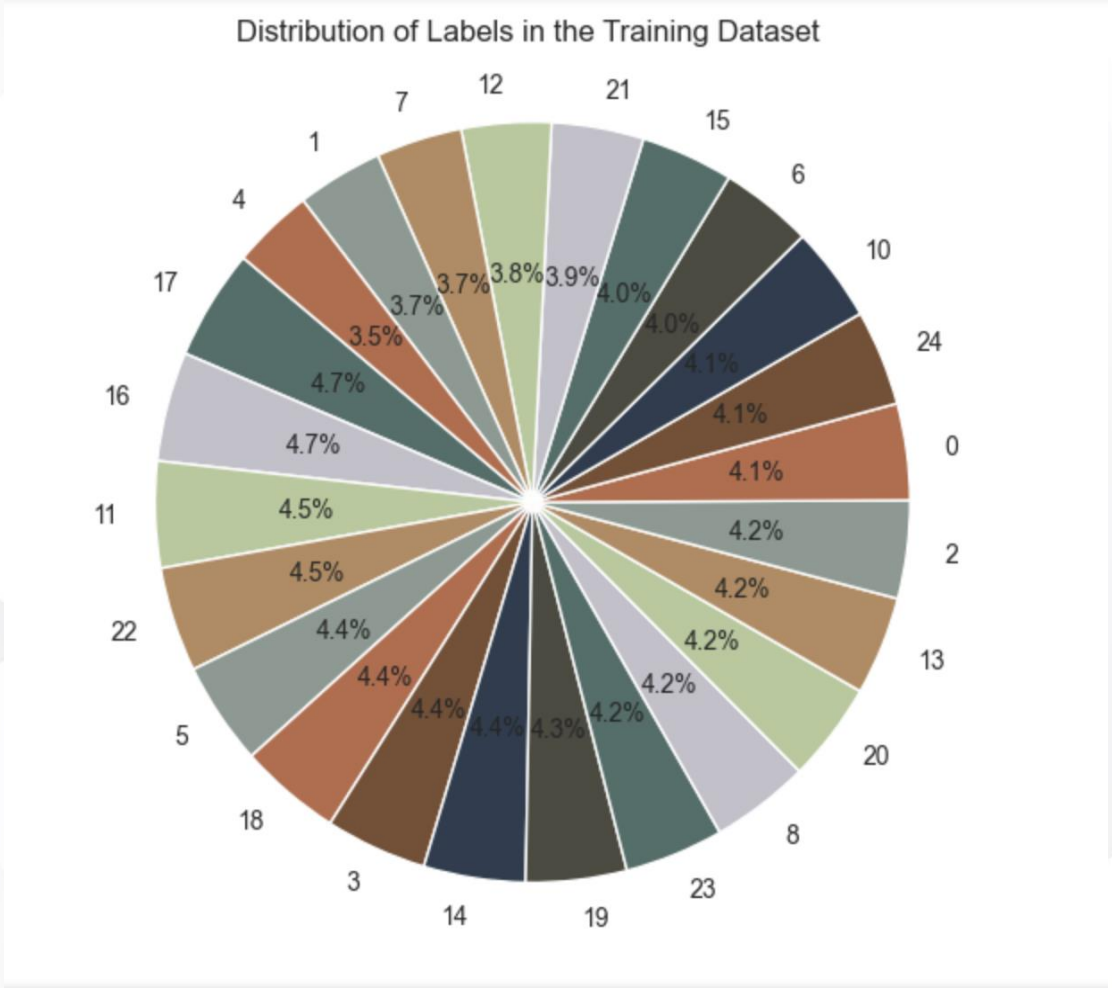
DATASETS

- MNIST(Modified National Institute of Standards and Technology) image dataset.
- The American Sign Language letter database of hand gestures represent a multi-class problem with 24 classes of letters (excluding J and Z which require motion).
- Training data (27,455 cases) and Test data (7172 cases).
- Pixel to pixel 784 which represent a single 28x28 pixel image with grayscale values between 0-255.
- https://www.kaggle.com/datasets/datamunge/sign-language-mnist

FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

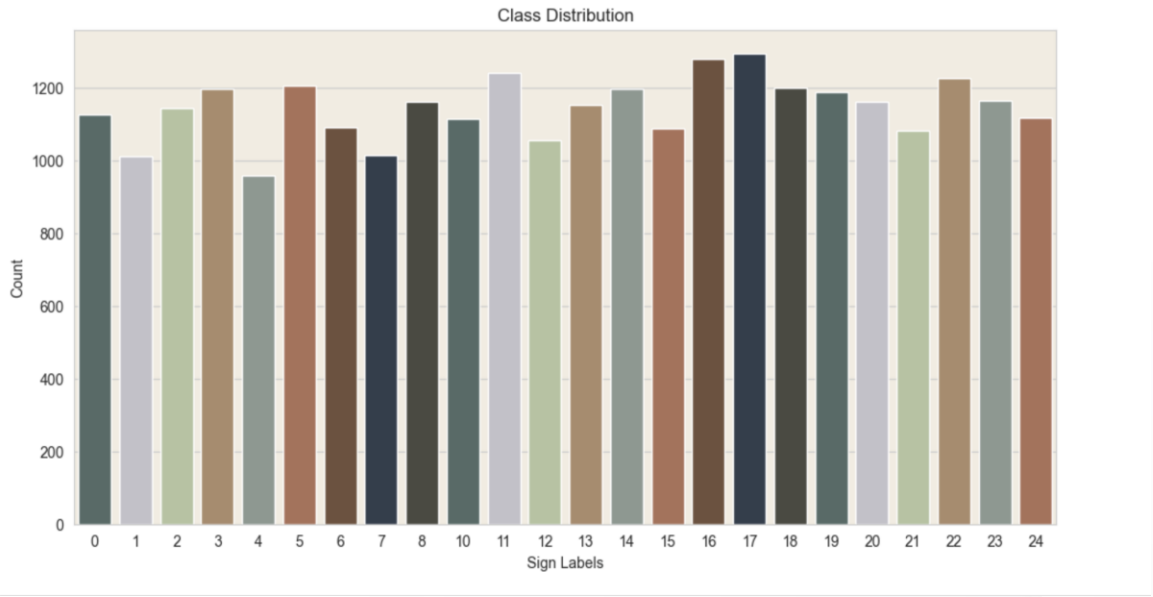
Data Visualization

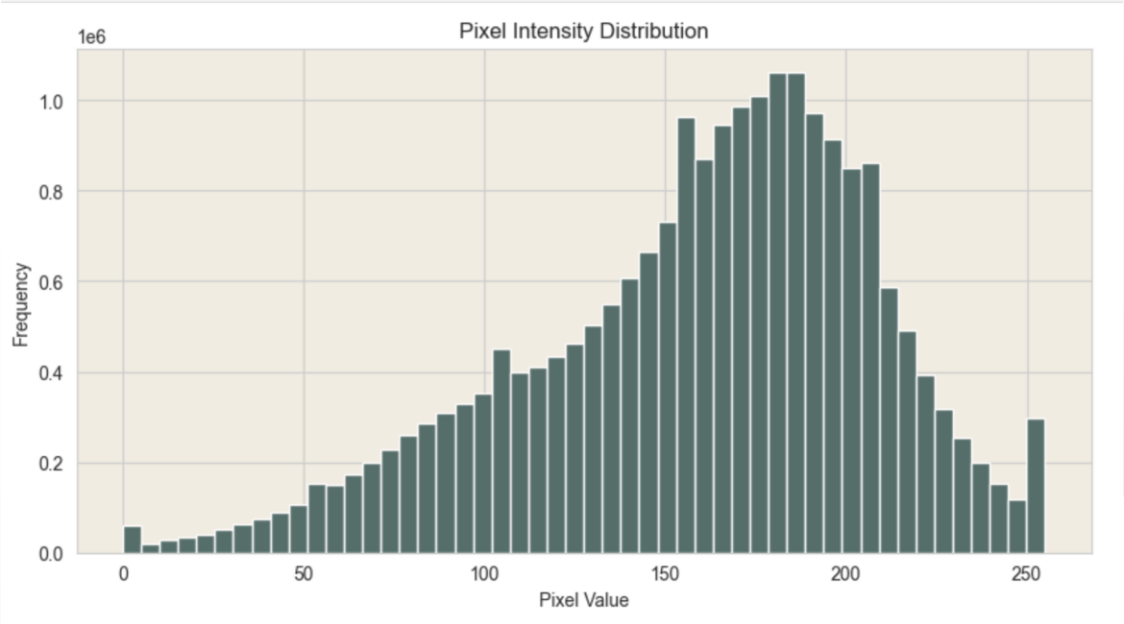
- Number of data per label.



FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

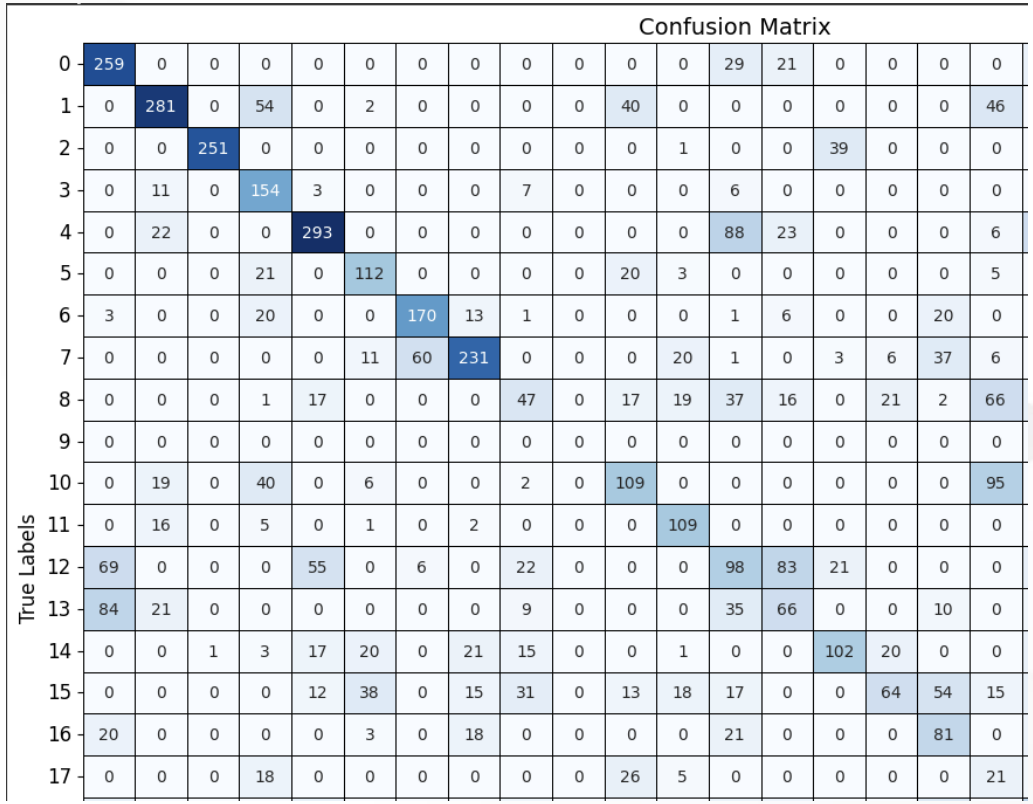
Data Visualization





FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

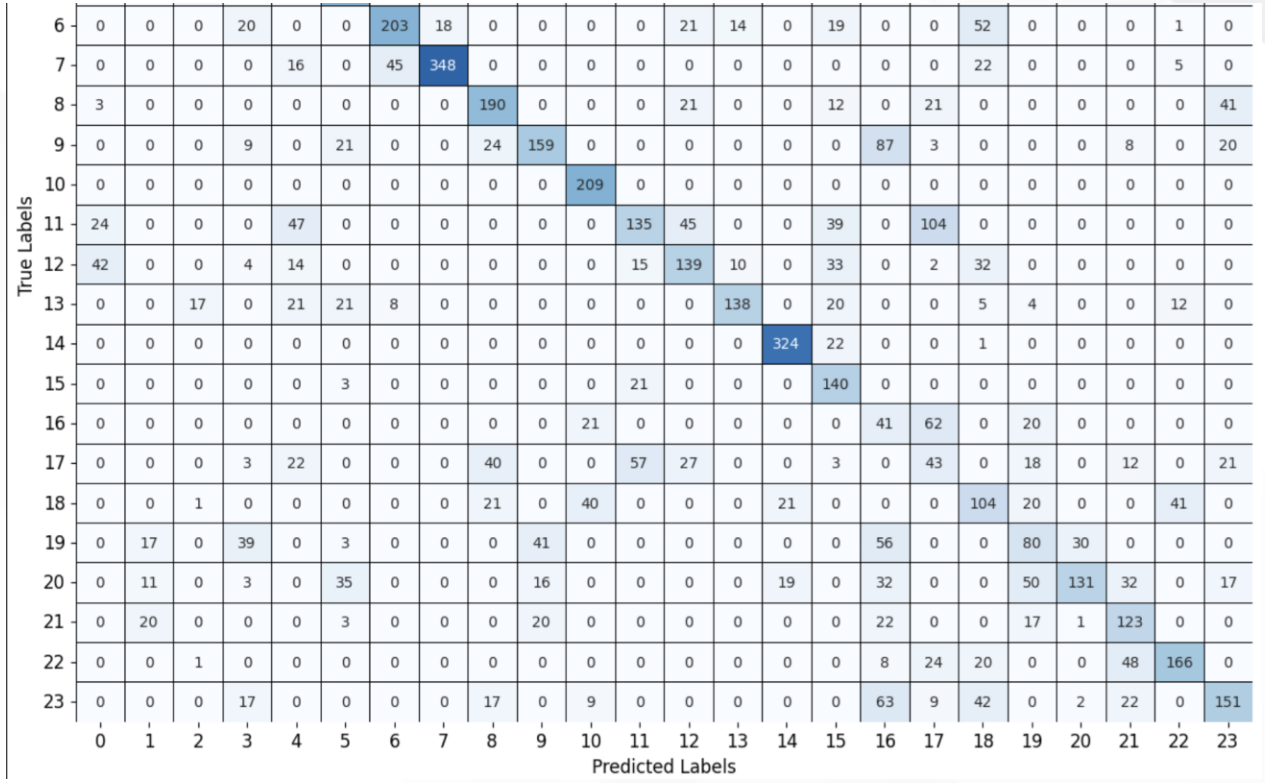
Linear Discriminant Analysis



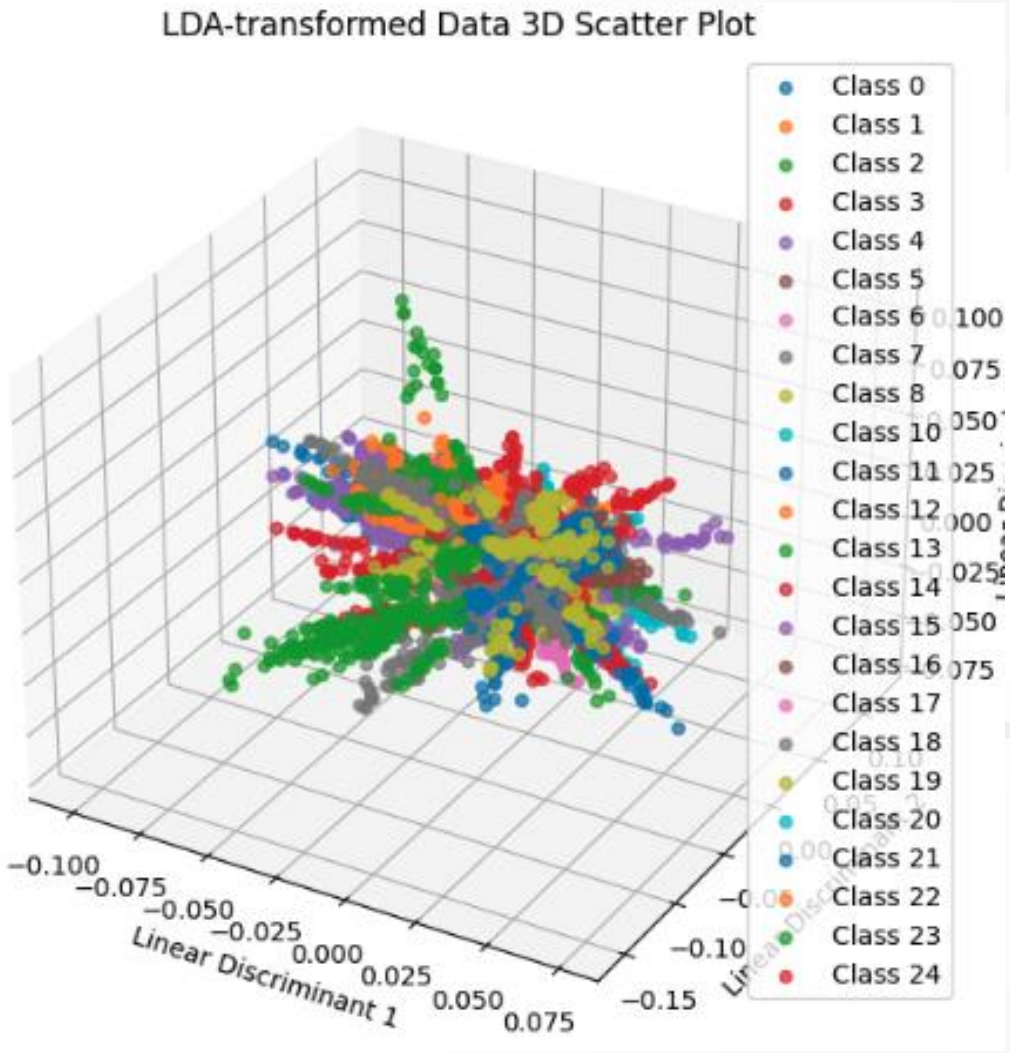

```
Accuracy:  0.4337702175125488
              precision    recall  f1-score   support
0              0.565502  0.782477  0.656527    331.0
1              0.682039  0.650463  0.665877    432.0
2              0.940075  0.809677  0.870017    310.0
3              0.383085  0.628571  0.476043    245.0
4              0.694313  0.588353  0.636957    498.0
5              0.500000  0.453441  0.475584    247.0
6              0.627306  0.488506  0.549273    348.0
7              0.770000  0.529817  0.627717    436.0
8              0.265537  0.163194  0.202151    288.0
9              0.000000  0.000000  0.000000      0.0
10             0.339564  0.329305  0.334356    331.0
11             0.516588  0.521531  0.519048    209.0
12             0.276836  0.248731  0.262032    394.0
13             0.267206  0.226804  0.245353    291.0
14             0.618182  0.414634  0.496350    246.0
15             0.566372  0.184438  0.278261    347.0
16             0.305660  0.493902  0.377622    164.0
17             0.049881  0.145833  0.074336    144.0
18             0.243094  0.357724  0.289474    246.0
19             0.275785  0.495968  0.354467    248.0
20             0.264516  0.308271  0.284722    266.0
21             0.373541  0.277457  0.318408    346.0
22             0.200000  0.393204  0.265139    206.0
23             0.461538  0.337079  0.389610    267.0
24             0.616766  0.310241  0.412826    332.0
macro avg      0.432135  0.405585  0.402486      NaN
weighted avg   0.484798  0.433770  0.442672      NaN
```

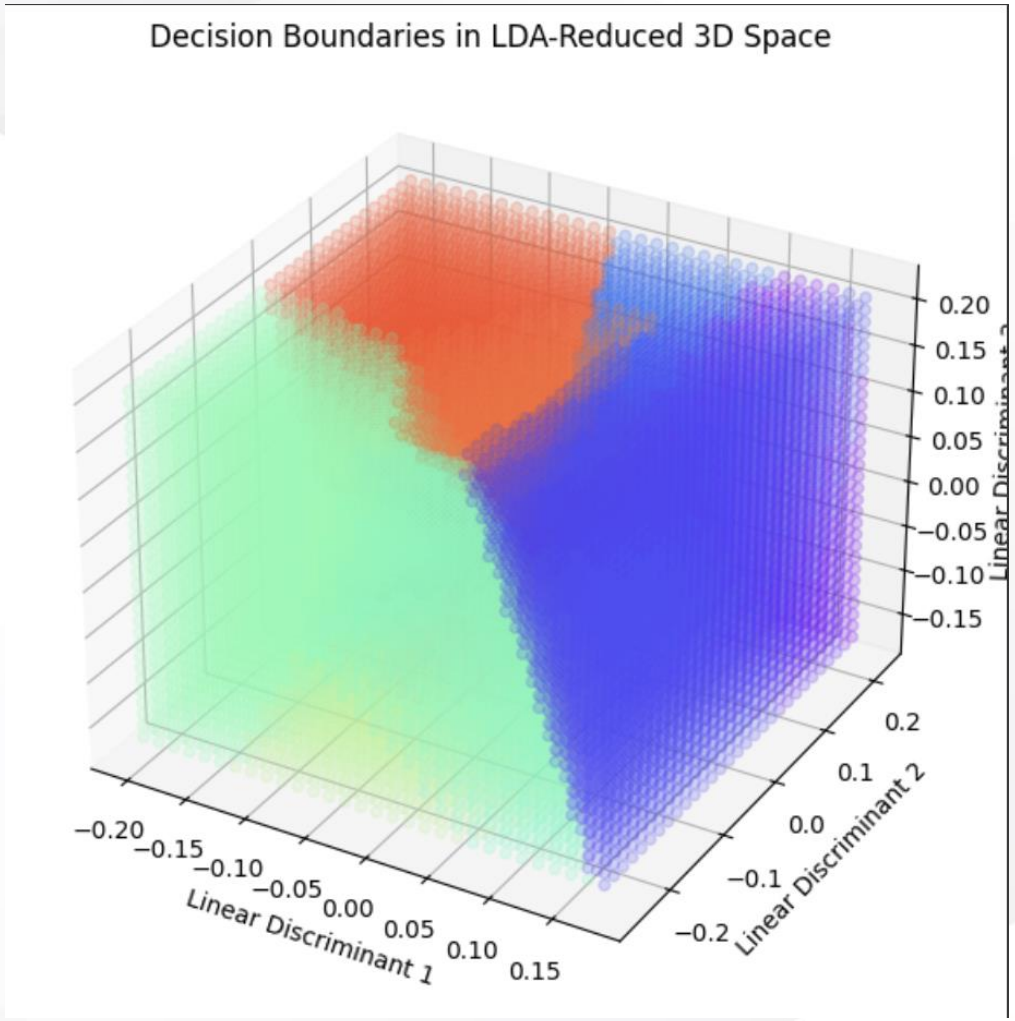

FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

LDA with PCA



3	0.59	0.57	0.58	245
4	0.78	0.87	0.82	498
5	0.67	0.83	0.74	247
6	0.71	0.58	0.64	348
7	0.95	0.74	0.83	436
8	0.66	0.63	0.64	288
10	0.47	0.50	0.48	331
11	0.73	1.00	0.84	209
12	0.66	0.31	0.42	394
13	0.51	0.45	0.48	291
14	0.81	0.57	0.67	246
15	0.89	0.94	0.91	347
16	0.47	0.85	0.60	164
17	0.11	0.28	0.16	144
18	0.19	0.29	0.23	246
19	0.37	0.46	0.41	248
20	0.43	0.31	0.36	266
21	0.82	0.33	0.47	346
22	0.44	0.52	0.48	206
23	0.59	0.63	0.61	267
24	0.65	0.45	0.53	332
accuracy			0.63	7172
macro avg	0.63	0.62	0.61	7172
weighted avg	0.67	0.63	0.63	7172





FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

Hyper parameter tuning

	19	0.37	0.46
	20	0.43	0.31
	21	0.82	0.33
	22	0.44	0.52
	23	0.59	0.63
	24	0.65	0.45
accuracy			
macro avg		0.63	0.62
weighted avg		0.67	0.63

Summary of Best Model:
Best Hyperparameters:
  Learning Rate: 0.1
  Number of Iterations: 2000
  Regularization Strength: 0.01
Best Testing Accuracy: 62.98%

```
Training with learning_rate=0.01, num_iterations=5000, reg_strength=0.005
Testing accuracy: 56.05%

Training with learning_rate=0.01, num_iterations=5000, reg_strength=0.01
Testing accuracy: 55.69%

Training with learning_rate=0.01, num_iterations=5000, reg_strength=0.02
Testing accuracy: 55.05%

Training with learning_rate=0.02, num_iterations=2000, reg_strength=0.005
Testing accuracy: 55.28%

Training with learning_rate=0.02, num_iterations=2000, reg_strength=0.01
Testing accuracy: 55.09%

Training with learning_rate=0.02, num_iterations=2000, reg_strength=0.02
Testing accuracy: 54.56%

Training with learning_rate=0.02, num_iterations=3000, reg_strength=0.005
Testing accuracy: 56.76%

Training with learning_rate=0.02, num_iterations=3000, reg_strength=0.01
Testing accuracy: 56.09%

Training with learning_rate=0.02, num_iterations=3000, reg_strength=0.02
Testing accuracy: 55.31%

Training with learning_rate=0.02, num_iterations=5000, reg_strength=0.005
Testing accuracy: 61.60%

Training with learning_rate=0.02, num_iterations=5000, reg_strength=0.01
```

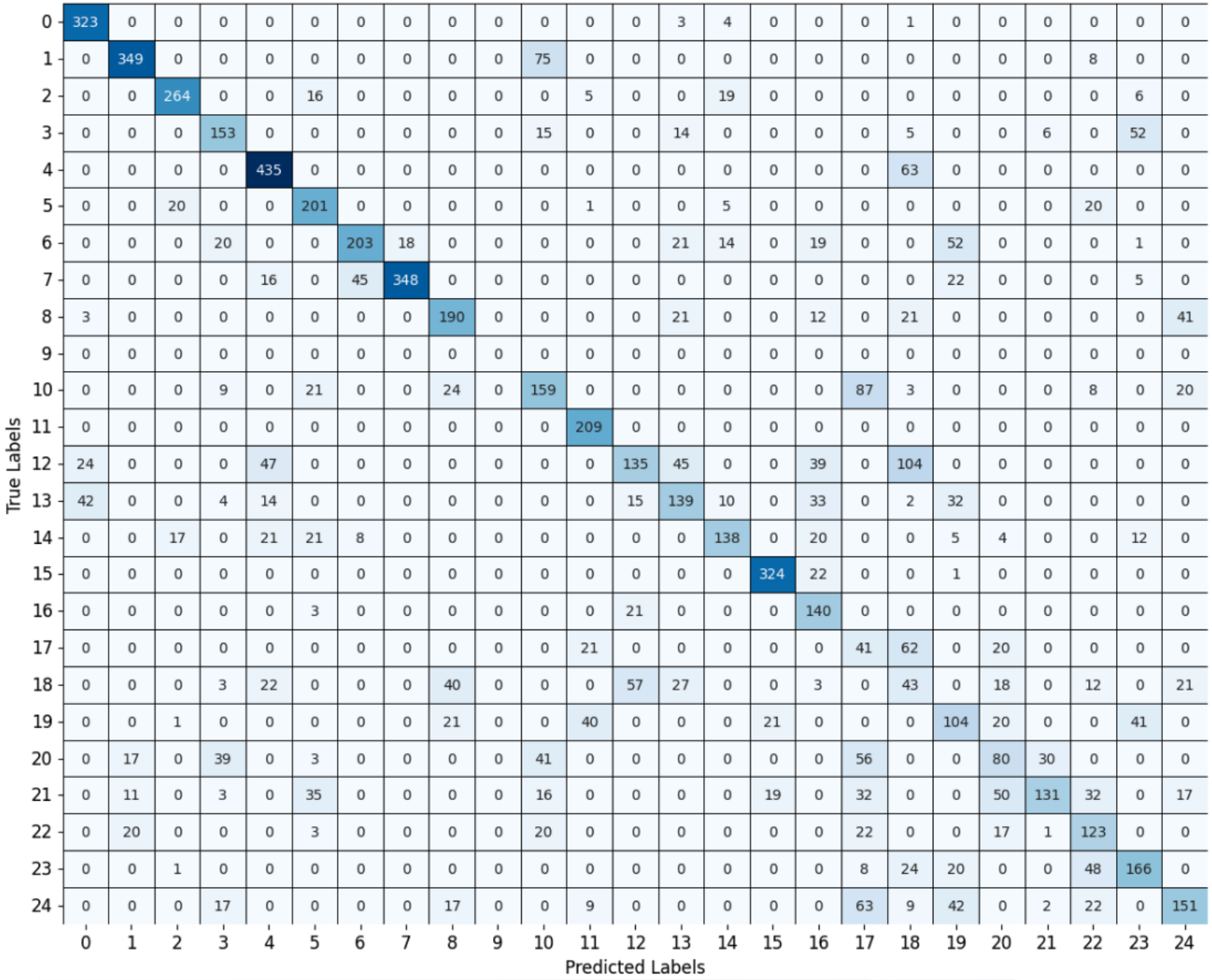
Logistic Regression Model

```
Iteration 0, Loss: 3.1781
Iteration 100, Loss: 2.3069
Iteration 200, Loss: 1.9253
Iteration 300, Loss: 1.7007
Iteration 400, Loss: 1.5470
Iteration 500, Loss: 1.4323
Iteration 600, Loss: 1.3419
Iteration 700, Loss: 1.2679
Iteration 800, Loss: 1.2056
Iteration 900, Loss: 1.1520
Training Accuracy: 76.39%
Testing Accuracy: 63.43%
```

SVM

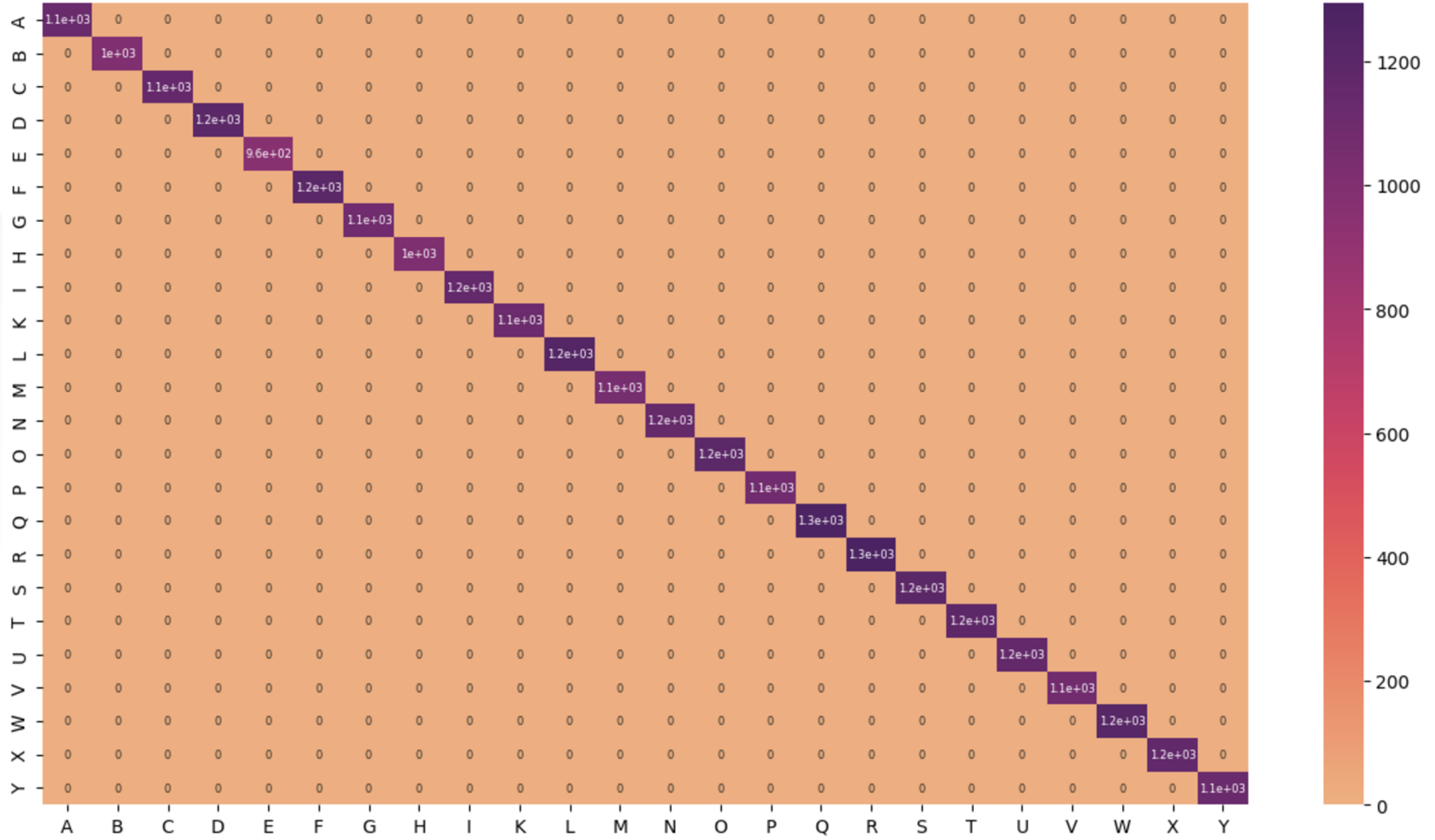
Classification Report:

	precision	recall	f1-score	support
0	0.82	0.98	0.89	331
1	0.88	0.81	0.84	432
2	0.87	0.85	0.86	310
3	0.62	0.62	0.62	245
4	0.78	0.87	0.83	498
5	0.66	0.81	0.73	247
6	0.79	0.58	0.67	348
7	0.95	0.80	0.87	436
8	0.65	0.66	0.66	288
10	0.49	0.48	0.48	331
11	0.73	1.00	0.85	209
12	0.59	0.34	0.43	394
13	0.51	0.48	0.50	291
14	0.73	0.56	0.63	246
15	0.89	0.93	0.91	347
16	0.49	0.85	0.62	164
17	0.13	0.28	0.18	144
18	0.13	0.17	0.15	246
19	0.37	0.42	0.40	248
20	0.38	0.30	0.34	266
21	0.77	0.38	0.51	346
22	0.45	0.60	0.51	206
23	0.59	0.62	0.60	267
24	0.60	0.45	0.52	332
accuracy			0.63	7172
macro avg	0.62	0.62	0.61	7172
weighted avg	0.66	0.63	0.64	7172



FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

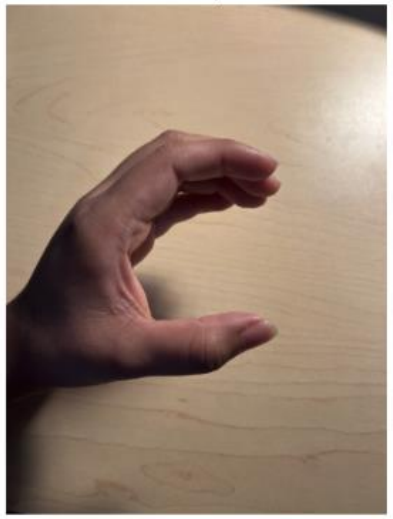
CNN



FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

Testing

Predicted: 6, True: 6



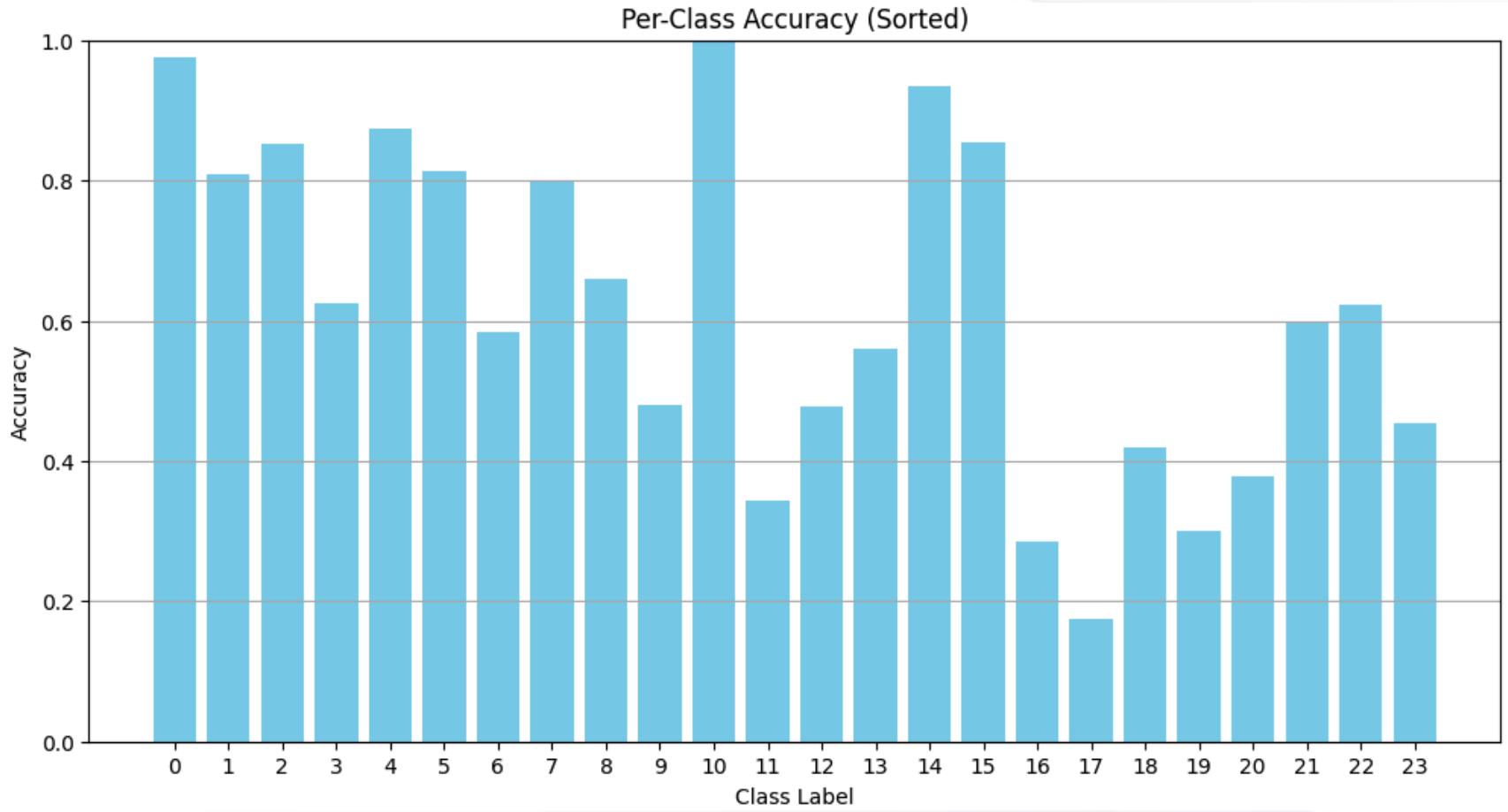
Predicted: 13, True: 0

Predicted: 7, True: 14

Predicted: 19, True: 19

Predicted: 19, True: 10

Prediction Accuracy



FLORIDA TECH
FLORIDA'S STEM UNIVERSITY

Observation

Model	Implementation	Metrics			
		Accuracy	Precision	Recall	F1 Score
LDA	Custom	43.38%	0.48	0.43	0.40
LDA with PCA	Custom	61.88%	0.66	0.62	0.63
Logistic Regression	Custom	62.98%	0.67	0.63	0.63
SVM	Library	63%	0.66	0.63	0.64
CNN (Baseline)	Library	100%	1	1	1

Conclusion

- Implement and test various Classifier model and classify Images in American Sign Language.
- Construct the model with accuracy above 76%.
- Hyper parameter tuning, PCA can increase the performance of a model.

References

- https://www.youtube.com/watch?v=YYEJ_GUguHw
- https://github.com/vaibhavbichave/American-Sign-Language/blob/master/Sign%20Language%20MNIST.ipynb