STA 545/EAS 506
STATISTICAL DATA MINING 1

Final Project

University at Buffalo The State University of New York

ANALYSIS AND MODELLING OF FMINST

Group 15

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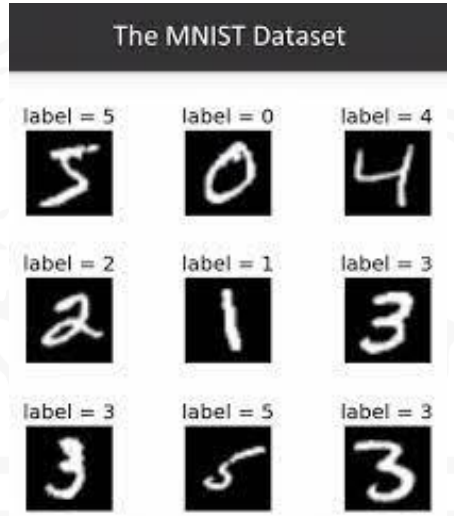
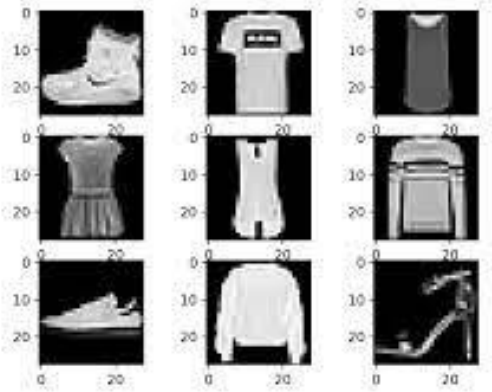
CONTENT

Introduction

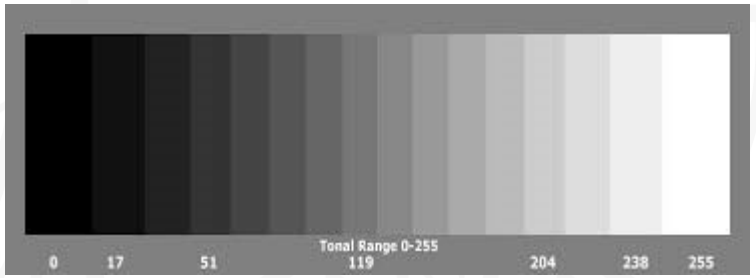
- MNIST data is popular data set for image classification machine learning algorithms.
- Initially MNIST Data set is compromising of 10 class handwritten digits later it is modified into Fashion MNIST Data.
- Every fashion product on Za-lando has a set of pictures, demonstrating different aspects of the product.
- They have used the front look thumbnail images of 70,000 unique products to build Fashion-MNIST dataset. Those products come from different gender groups: men, women, kids and neutral.





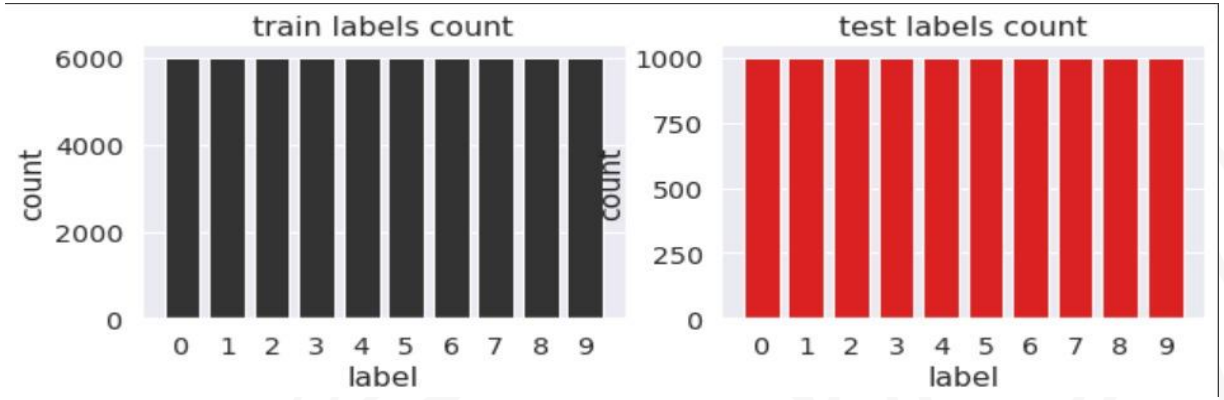
Data Understanding

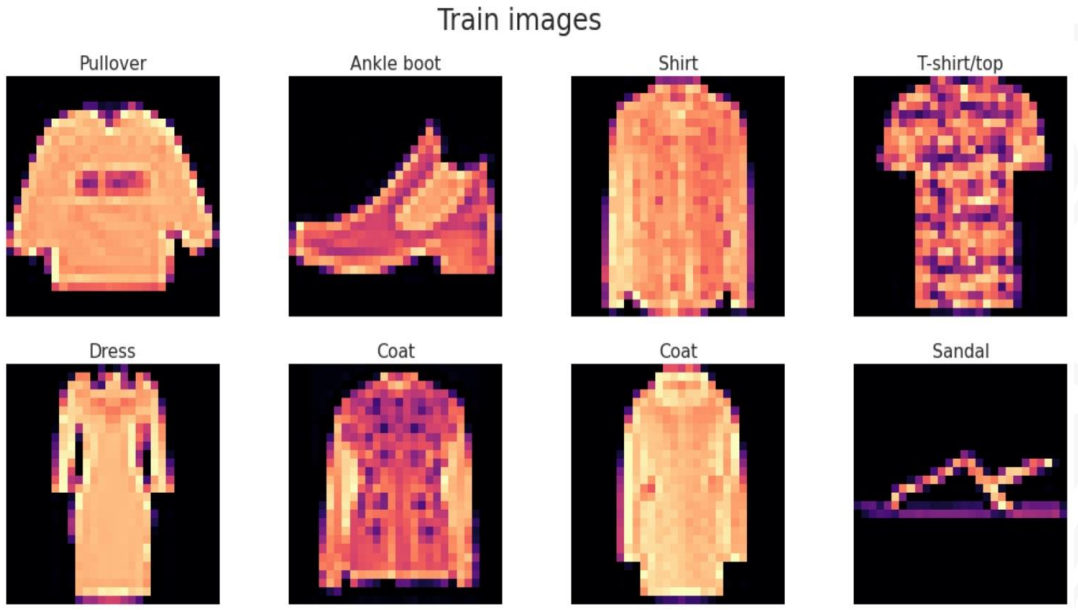
- Each image is 28 pixels in width and 28 pixels in height and a total of 784 pixels in total.
- Each pixel is associated with a single pixel-value, indicating the lightness or darkness of that pixel
- This pixel-value is an integer between 0 and 255.
- The training and test data sets have 785 columns.
- First column contains the class label (T shirt, Trouser..)
- The Training data set has 60000 rows
- The testing data set has 10000 rows



Exploratory Data Analysis

- The data set is split into train data and test data in the ratio 0.85% and 0.15% respectively.
- From the graph it is evident that all labels are equally spread in the data set both test and train.
- Each Train and test sample is assigned to one of the following labels.
- 0 – T-shirt; 1 – Trouser etc.,
- After Reshaping and setting the Cmap to magma we would get the corresponding image to labels.





Data Cleaning and Data Pre-Processing

- The Data set has no Null values.
- The Data and the labels are separated by removing the label column from the data set.
- Considering Fashion Mnist to be an image dataset, data preprocessing is the vital step for the models to yield the expected accuracy.
- The Pixel Values are often stored as Integer Numbers in the range 0 to 255, the range that a single 8-bit byte can offer.
- Scaling all the contents in the data sets [0,1] to Optimize Algorithms to work much faster. Here, we achieve Zero Mean and Unit Variance.
- Reduction is done using PCA in order to compress the corelated and collinear data so that it can be more effectively modelled.
- Sklearn decomposition function is used to reduce the dimensionality.

Predictive Models

To predict the label of the given image data by applying machine learning models mentioned below.

- Logistic Regression
- Support Vector Machine
- Convolution Neural Network
- Decision Tree
- Random Forest
- KNN
- Naïve Bayes

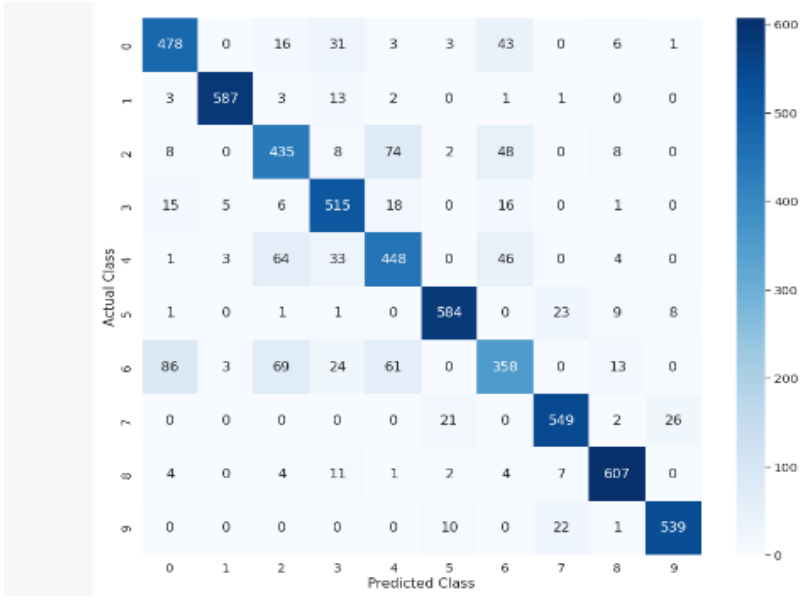
Logistic Regression

- Logistic regression is used to classify the label 0 to 9 to the corresponding pixels.
- The predefined function from sklearn is used for logistic regression and “libliner” solver is used. Since it works well for mid level data sets.
- The maximum iteration is set for 200.

Test Accuracy : 85.24%

----------THE CLASSFICATION REPORT FOR LOGISTIC REGRESSION IS----------

	precision	recall	f1-score	support
0	0.80	0.82	0.81	581
1	0.98	0.96	0.97	610
2	0.73	0.75	0.74	583
3	0.81	0.89	0.85	576
4	0.74	0.75	0.74	599
5	0.94	0.93	0.94	627
6	0.69	0.58	0.63	614
7	0.91	0.92	0.92	598
8	0.93	0.95	0.94	640
9	0.94	0.94	0.94	572
accuracy			0.85	6000
macro avg	0.85	0.85	0.85	6000
weighted avg	0.85	0.85	0.85	6000



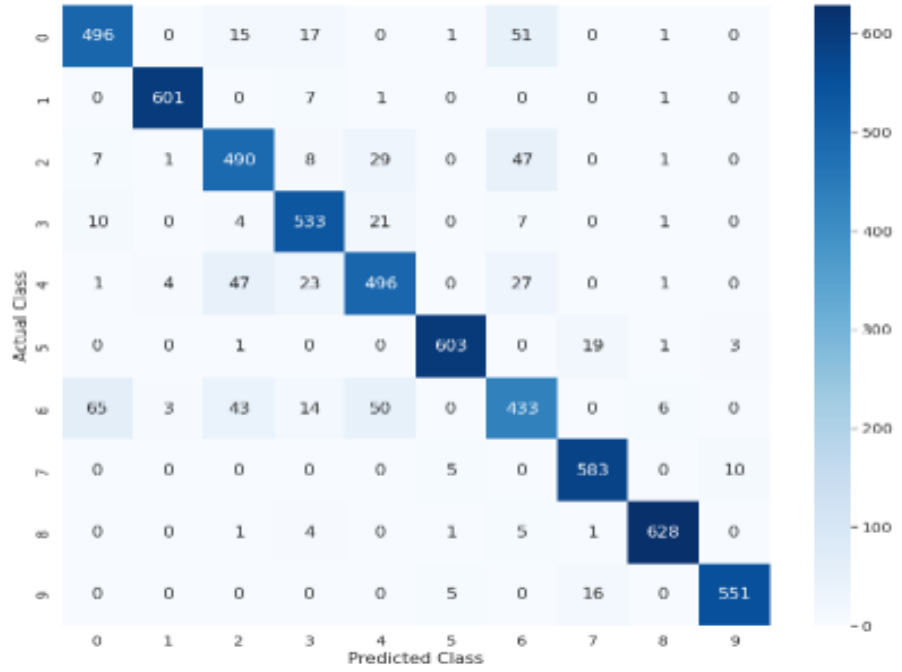
Support Vector Machine

- One common supervised learning technique, support vector machine is used here to classify the labels.
- SVC, The predefined function from sklearn is used.
- The default kernel type of rbf is used to precompute the kernel matrix to data matrix.
- Gamma is set to auto and uses 1/n where n is the number of features.

Test Accuracy : 90.05%

------THE CLASSFICATION REPORT FOR SUPPORT VECTOR CLASSIFIER IS------

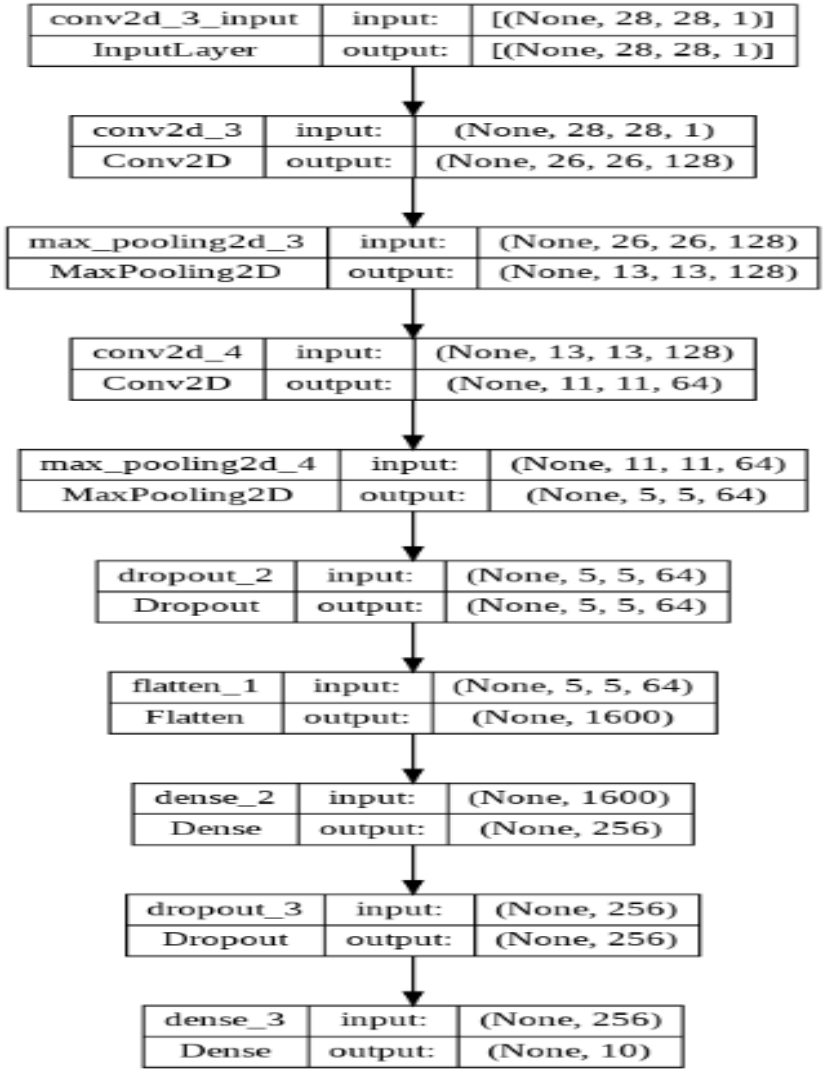
	precision	recall	f1-score	support
0	0.86	0.85	0.86	581
1	0.99	0.99	0.99	610
2	0.82	0.84	0.83	583
3	0.88	0.93	0.90	576
4	0.83	0.83	0.83	599
5	0.98	0.96	0.97	627
6	0.76	0.71	0.73	614
7	0.94	0.97	0.96	598
8	0.98	0.98	0.98	640
9	0.98	0.96	0.97	572
accuracy			0.90	6000
macro avg	0.90	0.90	0.90	6000
weighted avg	0.90	0.90	0.90	6000



Convolution Neural Network

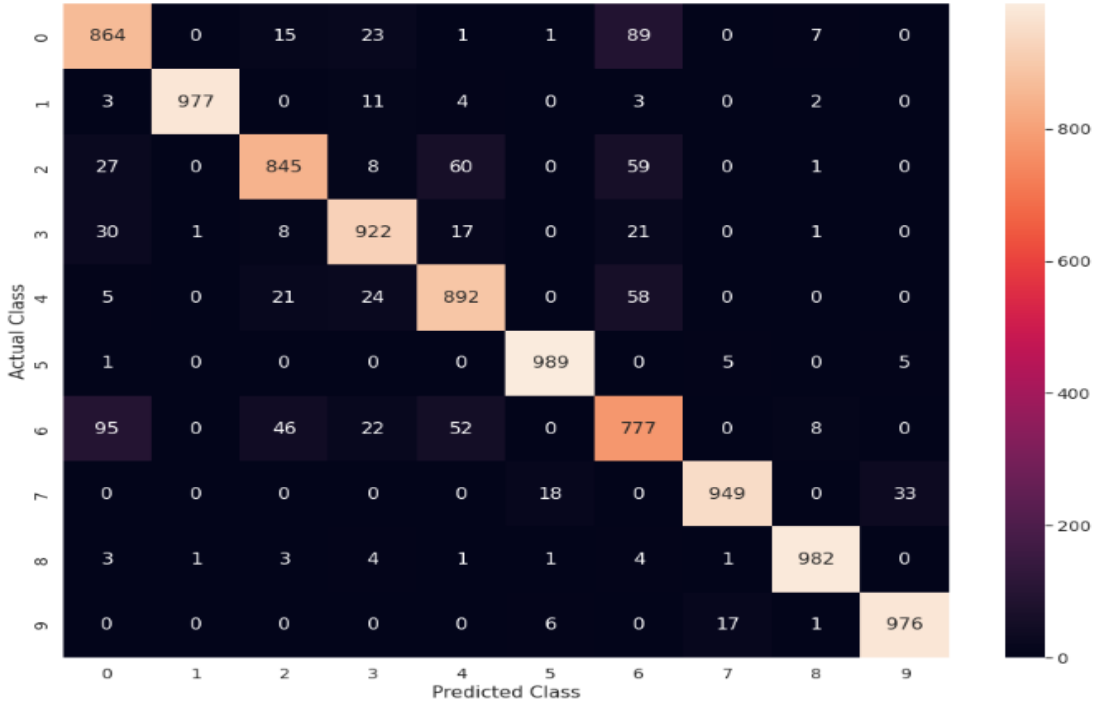
- CNN is a widely used for image classification.
- The Architecture of CNN is shown here.
- reLU is used as an Activation Function adam used as an optimizer and categorical class entropy is used as a metric to calculate the loss.
- Max-pooling, drop out value of 0.2 and flatten layer is used.

CNN Model

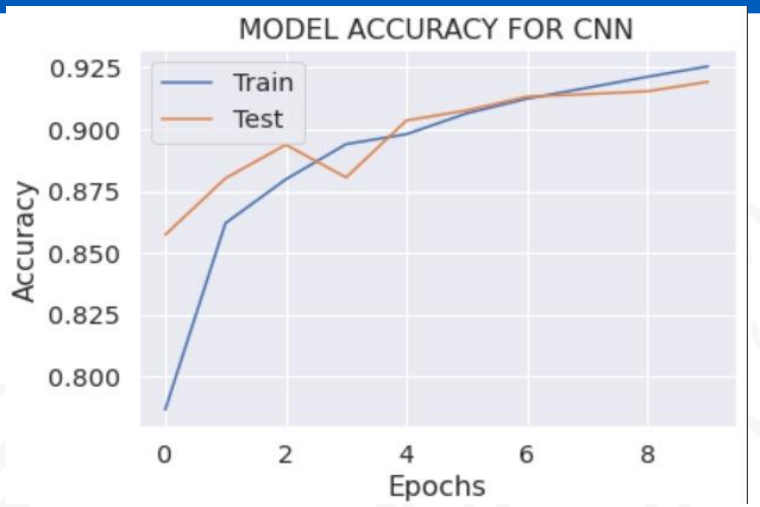


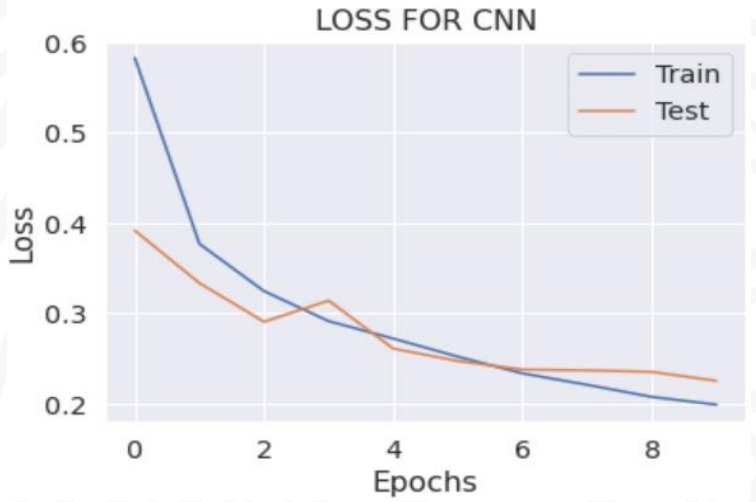
Convolution Neural Network

Confusion Matrix



	0	1	2	3	4	5	6	7	8	9
0	864	0	15	23	1	1	89	0	7	0
1	3	977	0	11	4	0	3	0	2	0
2	27	0	845	8	60	0	59	0	1	0
3	30	1	8	922	17	0	21	0	1	0
4	5	0	21	24	892	0	58	0	0	0
5	1	0	0	0	0	989	0	5	0	5
6	95	0	46	22	52	0	777	0	8	0
7	0	0	0	0	0	18	0	949	0	33
8	3	1	3	4	1	1	4	1	982	0
9	0	0	0	0	0	6	0	17	1	976






```
test_loss, test_acc = cnn_model.evaluate(X_test, y_test)
test_acc= test_acc*100
print("The test accuracy :",test_acc)
```

```
313/313 [==============================] - 1s 3ms/step -
The test accuracy : 91.8500006198883
```

Test Accuracy : 91.85%

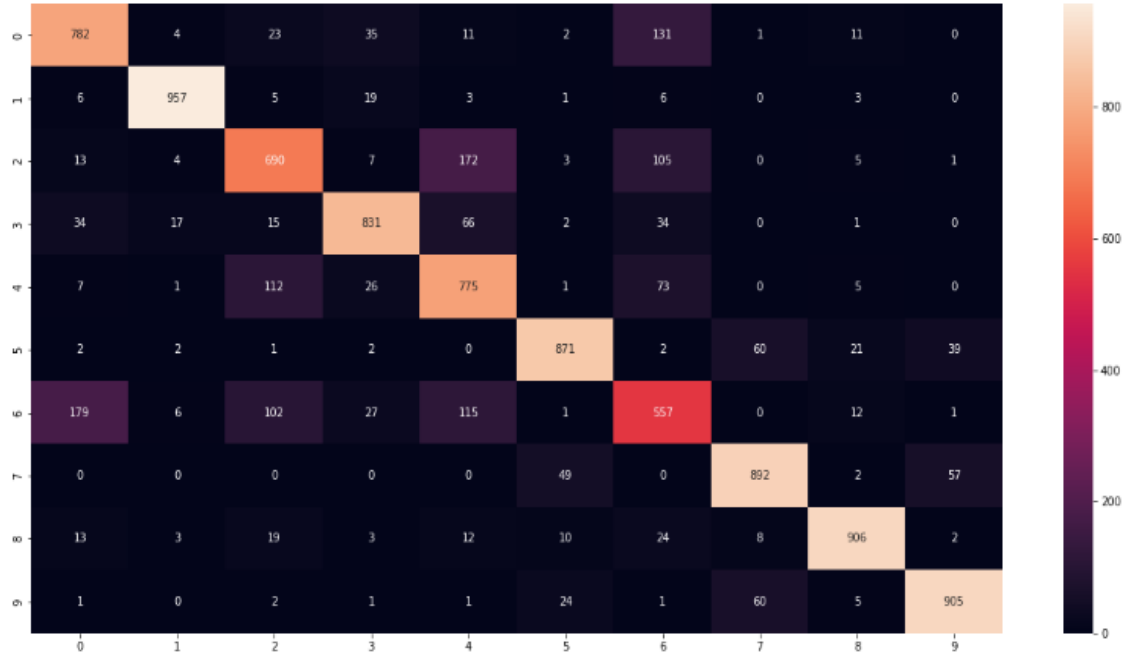
Decision Tree

- Represents upside down tree with its root at the top.
- Data is split from the root and each non-leaf node contains a condition.
- The final leaf node contains a prediction.
- we partition the data into resulting regions and repeat the same process of splitting on each region.
- We use the predefined function from sklearn (Decision Tree Classifier) to built this model.

Test Accuracy : 82.07%

----------THE CLASSFICATION REPORT FOR DECISION TREE IS----------

	precision	recall	f1-score	support
0	0.75	0.78	0.77	1000
1	0.96	0.96	0.96	1000
2	0.71	0.69	0.70	1000
3	0.87	0.83	0.85	1000
4	0.67	0.78	0.72	1000
5	0.90	0.87	0.89	1000
6	0.60	0.56	0.58	1000
7	0.87	0.89	0.88	1000
8	0.93	0.91	0.92	1000
9	0.90	0.91	0.90	1000
accuracy			0.82	10000
macro avg	0.82	0.82	0.82	10000
weighted avg	0.82	0.82	0.82	10000



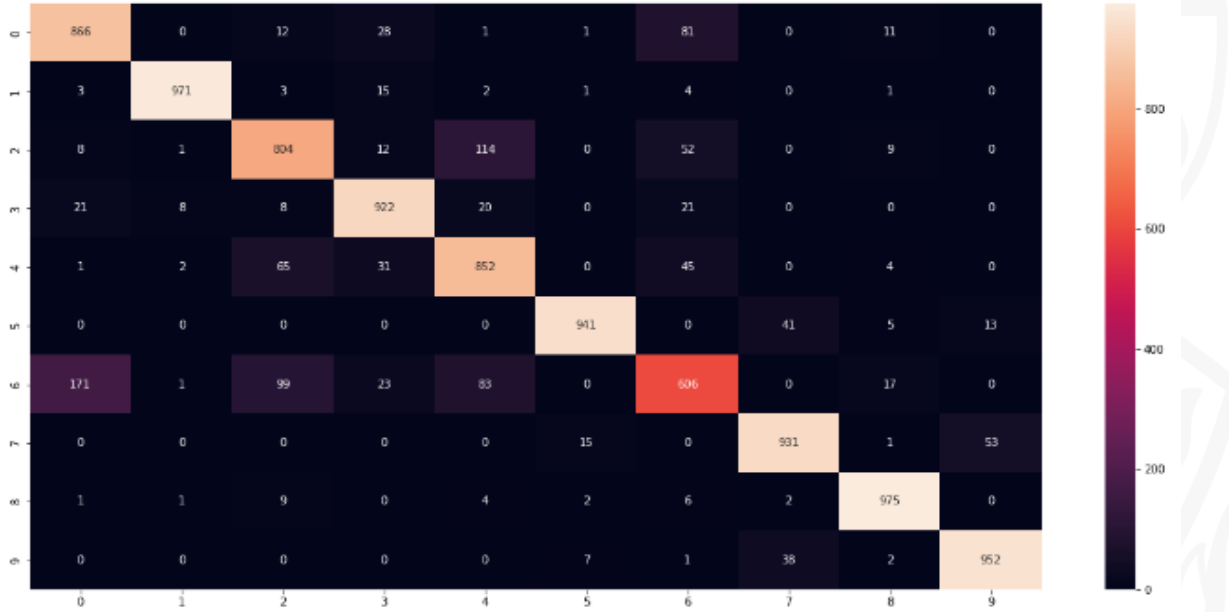
RANDOM FOREST

- Consists of a large number of individual decision trees.
- Each individual tree in this splits out a class prediction and best is considered.
- The predefined function from sklearn is used this model(Random Forest Classifier).
- Default function(gini) is used to measure the quality of a split.

Test Accuracy : 88.03%

----------THE CLASSFICATION REPORT FOR RANDOM FOREST IS----------

	precision	recall	f1-score	support
0	0.81	0.87	0.84	1000
1	0.99	0.97	0.98	1000
2	0.80	0.80	0.80	1000
3	0.89	0.92	0.91	1000
4	0.79	0.85	0.82	1000
5	0.97	0.94	0.96	1000
6	0.74	0.61	0.67	1000
7	0.92	0.93	0.93	1000
8	0.95	0.97	0.96	1000
9	0.94	0.95	0.94	1000
accuracy			0.88	10000
macro avg	0.88	0.88	0.88	10000
weighted avg	0.88	0.88	0.88	10000

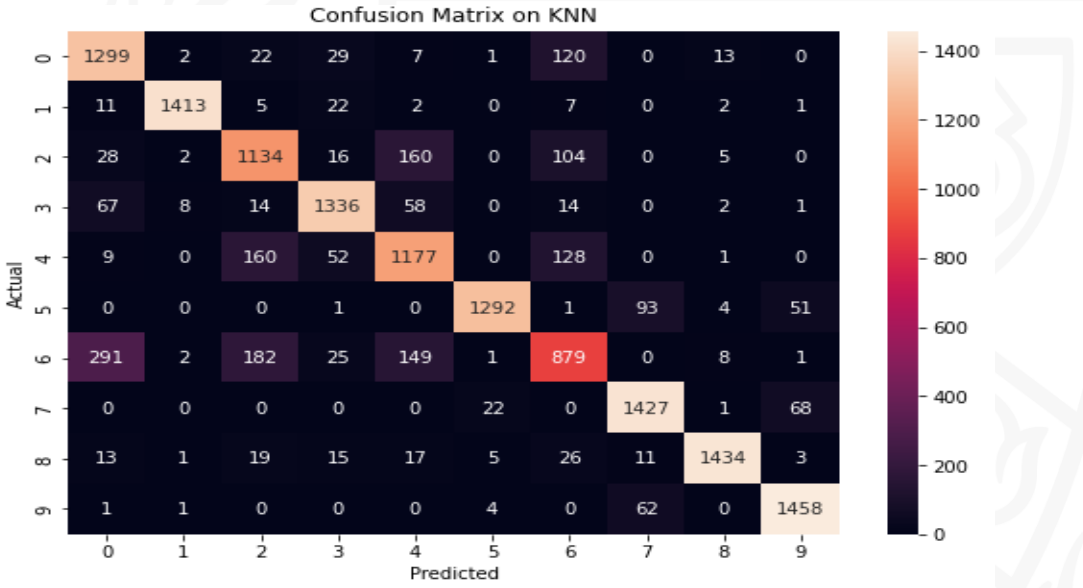


KNN

- K-Nearest neighbor algorithm is a non-parametric classification algorithm.
- Basic Idea, Given a test image(vector) find k images(vector) from train that are close to test image.
- Finding K closest vectors in Train set.
- Optimizing Parameter K.
- Classification using Euclidean Distance.
- The predefined function from sklearn is used this model(K-Neighbors Classifier)

Test Accuracy : 86.34%

	precision	recall	f1-score	support
0	0.76	0.87	0.81	1493
1	0.99	0.97	0.98	1463
2	0.74	0.78	0.76	1449
3	0.89	0.89	0.89	1500
4	0.75	0.77	0.76	1527
5	0.98	0.90	0.93	1442
6	0.69	0.57	0.62	1538
7	0.90	0.94	0.92	1518
8	0.98	0.93	0.95	1544
9	0.92	0.96	0.94	1526
accuracy			0.86	15000
macro avg	0.86	0.86	0.86	15000
weighted avg	0.86	0.86	0.86	15000

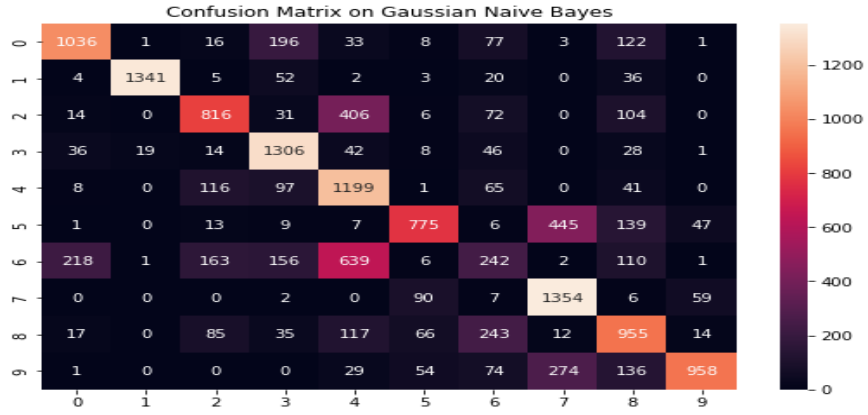


Naïve Bayes

- Naive-Bayes classifier uses Bayes theorem.
- Calculates the probability for membership of a data point to each class.
- Assumes that probability of each pixel is a gaussian distribution and probability of each digit is equal.
- The predefined function from sklearn is used this model(Gaussian NB)

Test Accuracy : 67.22%

	precision	recall	f1-score	support
0	0.78	0.69	0.73	1493
1	0.98	0.92	0.95	1463
2	0.66	0.56	0.61	1449
3	0.69	0.87	0.77	1500
4	0.48	0.79	0.60	1527
5	0.76	0.54	0.63	1442
6	0.28	0.16	0.20	1538
7	0.65	0.89	0.75	1518
8	0.57	0.62	0.59	1544
9	0.89	0.63	0.73	1526
accuracy			0.67	15000
macro avg	0.68	0.67	0.66	15000
weighted avg	0.67	0.67	0.66	15000

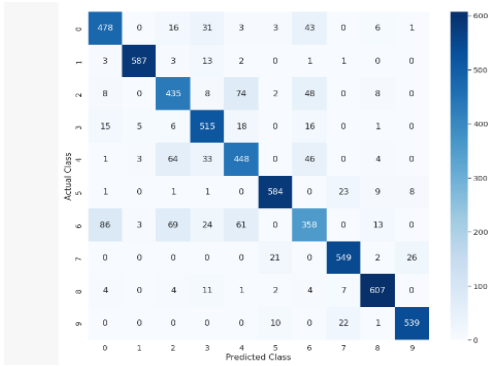


Results

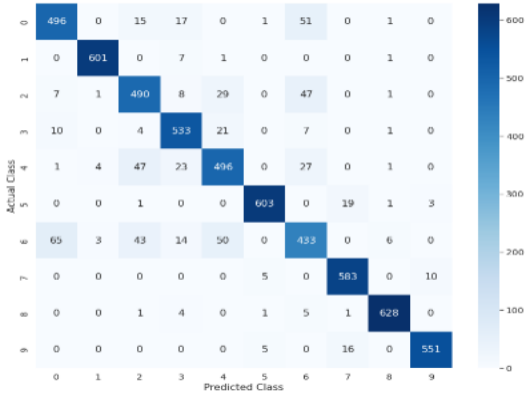
Accuracy for Fmnist Test data set.

Model	Accuracy
Logistic Regression	85.24%
KNN	86.34%
Naïve Bayes	67.22%
Decision Tree	82.07%
Random Forest	88.03%
SVM	90.05%
CNN	91.85%

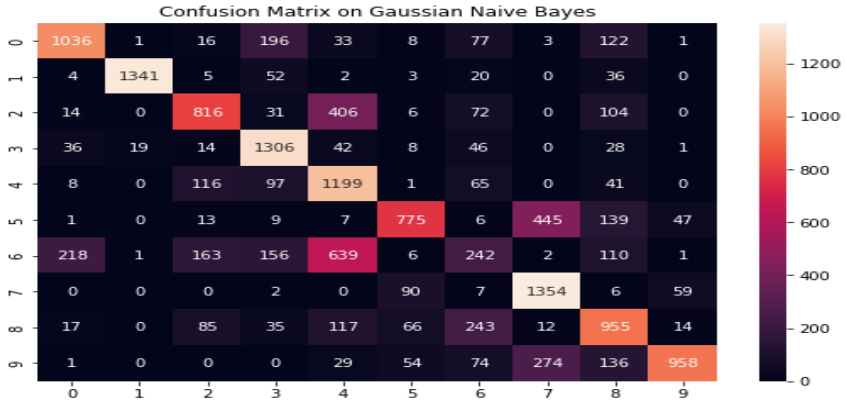
Logistic Regression



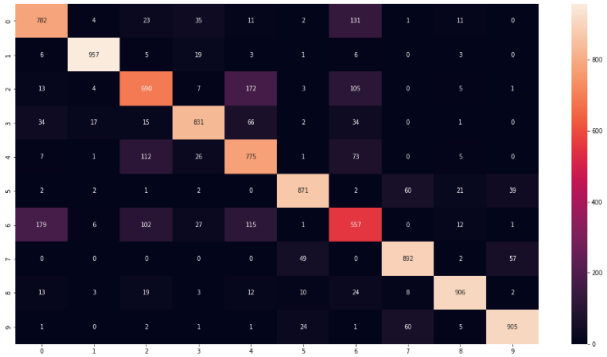
SVM



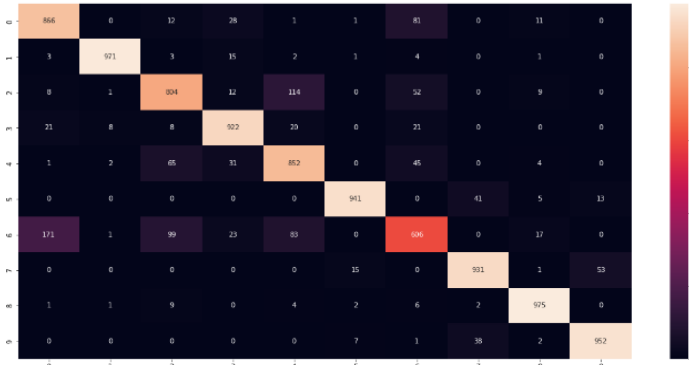
Naïve Bayes



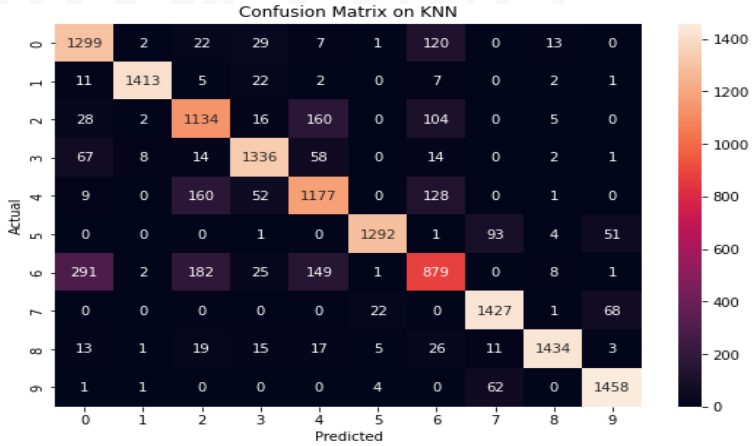
Decision Tree



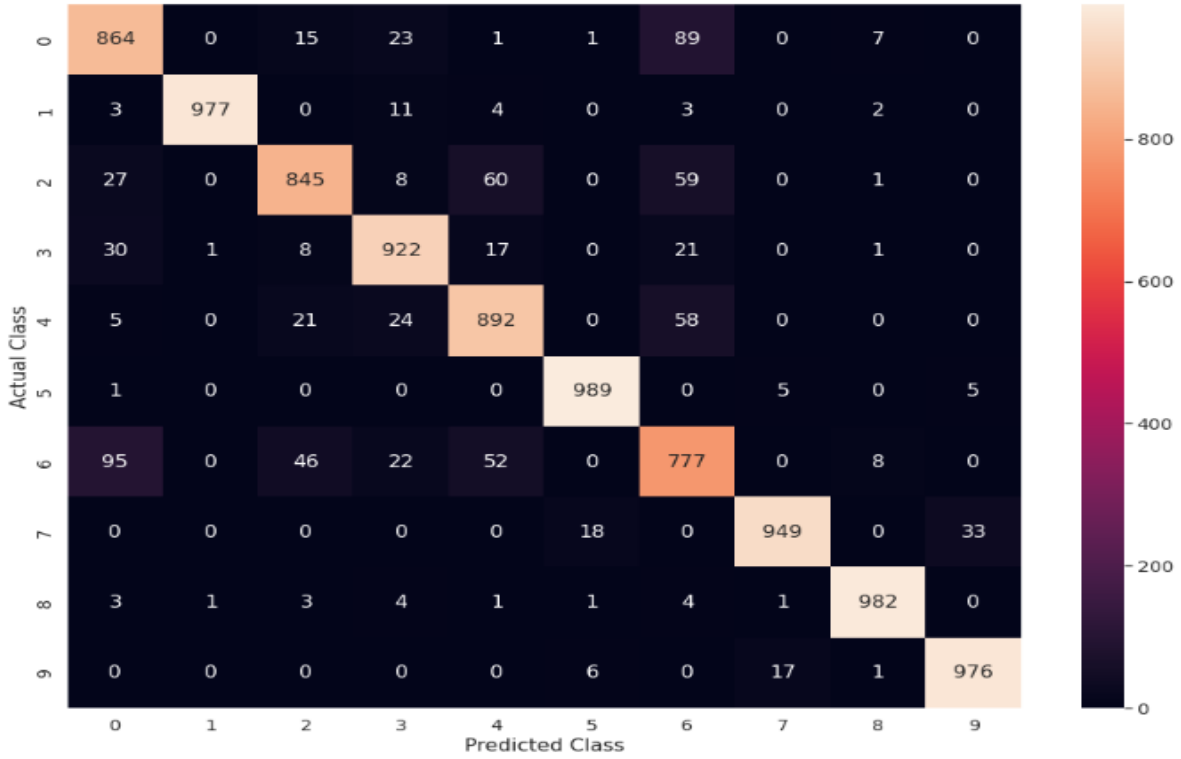
Random Forest



KNN



CNN



	0	1	2	3	4	5	6	7	8	9
0	864	0	15	23	1	1	89	0	7	0
1	3	977	0	11	4	0	3	0	2	0
2	27	0	845	8	60	0	59	0	1	0
3	30	1	8	922	17	0	21	0	1	0
4	5	0	21	24	892	0	58	0	0	0
5	1	0	0	0	0	989	0	5	0	5
6	95	0	46	22	52	0	777	0	8	0
7	0	0	0	0	0	18	0	949	0	33
8	3	1	3	4	1	1	4	1	982	0
9	0	0	0	0	0	6	0	17	1	976

- Based on the comparison of the results of the various models on the Train Data and Test Data, we can evidently say CNN is the well generalized model by **91.85%.**


THANK YOU