Implementing Machine/Deep Learning Algorithms on Different Hardware Architectures

In this project, Convolutional Neural Networks and Support Vector Machines have been implemented on the CIFAR 10, Fashion and Mnist dataset on both CPU and GPU architectures.

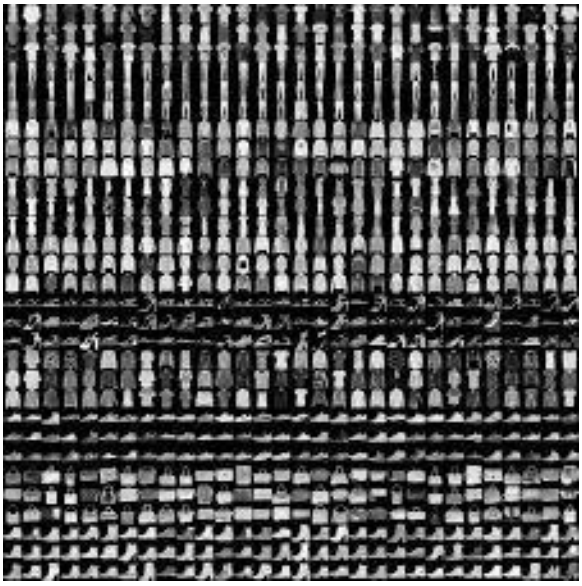
Our objective: Evaluating the performance of CNN and SVM using available CPU's and GPU's and check whether there is a boost in accuracy or program execution time.

Following are the explanations of the datasets used:

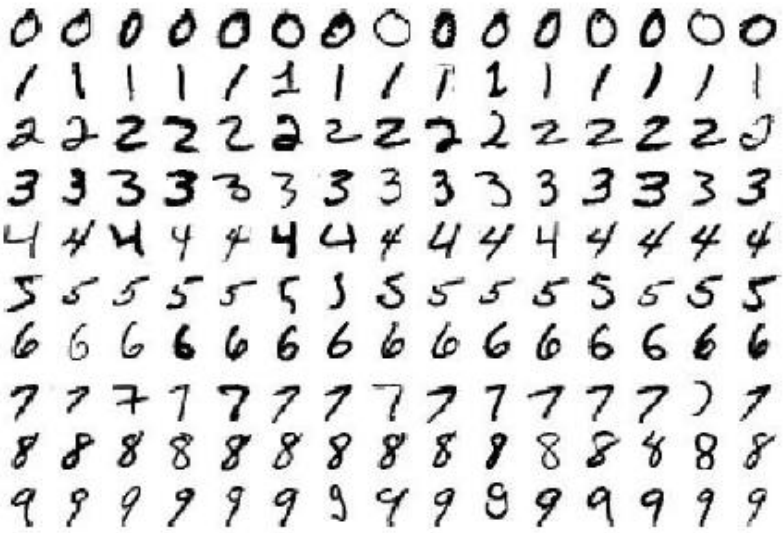
1. CIFAR 10
    a. Contains 60000 images of 10 different classes (6000 per class).
    b. Each image has a dimension of 32 by 32.
    c. 50000 images are used for training and 10000 for testing.
    d. This dataset is a labeled subset of the 80 million tiny images dataset.

2. Fashion
    a. Contains 70000 grayscale images of 10 classes.
    b. Each image has a dimension of 28 by 28.

c. 60000 images are used for training and 10000 for testing.
d. This dataset is a part of Zalando's article images.



3. Mnist
    a. Contains 70000 images of letters and digits
    b. Each image has a dimension of 28 by 28.
    c. This is a large database of handwritten digits used for training image processing systems.

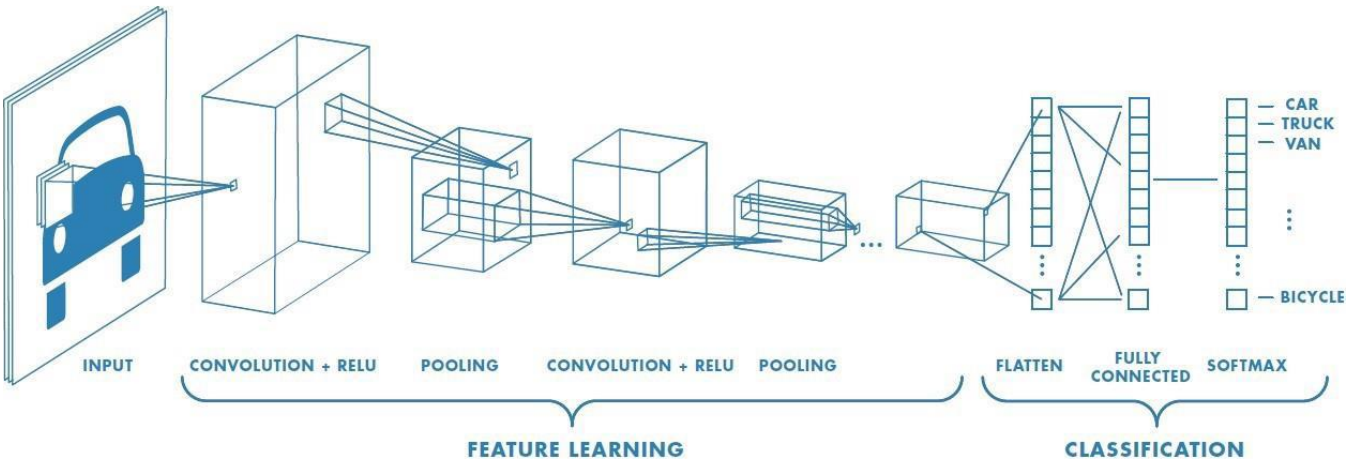


Further on, the accuracy (test and train) and losses will be plotted for 100 epochs using the Matplotlib library.

Convolutional Neural Networks:

(Source: https://en.wikipedia.org/wiki/Convolutional_neural_network)

The project evaluates a Convolutional Neural Network to classify images into distinct categories and subcategories. The CNN model evaluation is based on comparing accuracy and loss by making slight changes to the model architecture (hyper-parameters, activation function, number of layers, learning rate and number of epochs). To obtain desirable results, we have tried and tested several versions of the CNN base model by changing the number of convolution layers, hidden layers in the feed forward network, other hyper parameters such as pool size, strides, drop out, batch normalization and number of filters. The architecture of the CNN model comprises of a given number of convolution layers (inclusive of batch normalization, max pooling, and dropout) followed by multi-layer neural networks. This enhances the learning curve of the Convolutional Neural Network, gives a better accuracy, and prevents overfitting on the training set. In terms of performing multi class classification, the output layer of the multi-layer neural network is generally taken with a SoftMax activation function, and the remaining are generally taken as ReLu.



A diagram representing how Convolutional Neural Networks work

(Image source: https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53)

Support Vector Machine

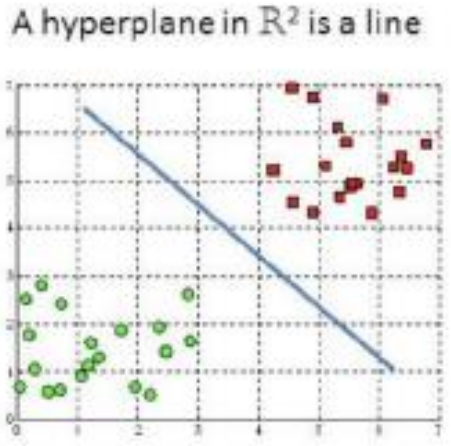
(Source: https://en.wikipedia.org/wiki/Support-vector_machine)

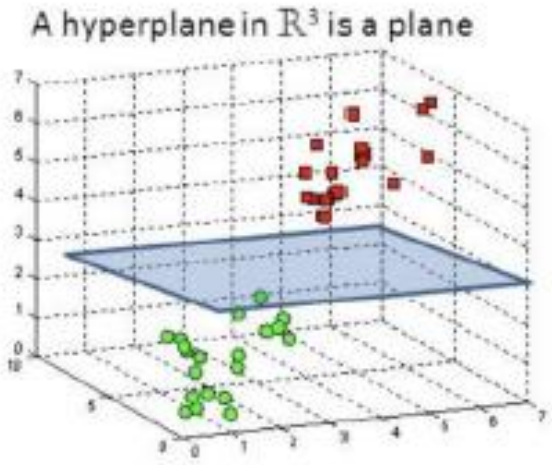
In machine learning, support-vector machines (SVMs, also support-vector networks) are supervised learning models with associated learning algorithms that analyze data for classification and regression analysis.

Algorithm explanation-

(Source: https://towardsdatascience.com/support-vector-machine-introduction-to-machine-learning-algorithms-934a444fca47)

The objective of the support vector machine algorithm is to find a hyperplane in an N-dimensional space (N — the number of features) that distinctly classifies the data points. Hyperplanes are decision boundaries that help classify the data points. Data points falling on either side of the hyperplane can be attributed to different classes. Also, the dimension of the hyperplane depends upon the number of features.

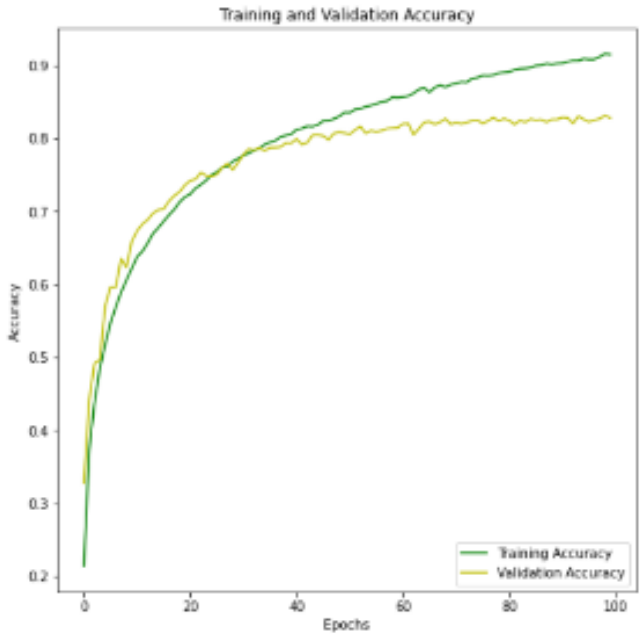


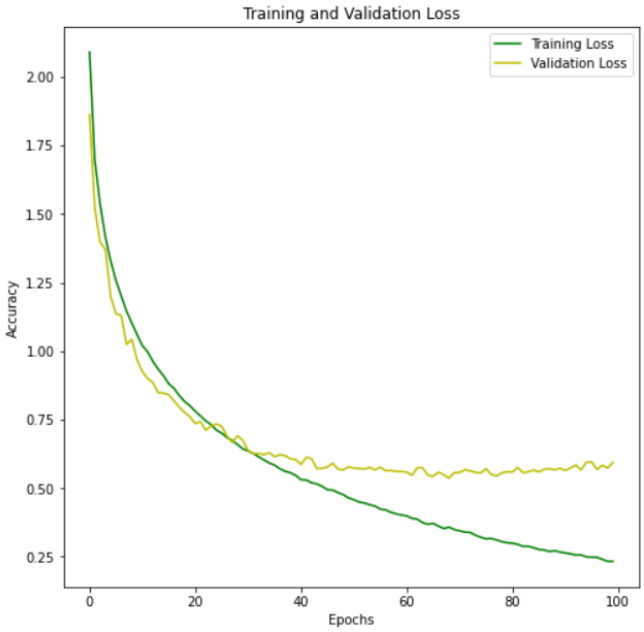


Results and Observations:

1. CNN
    a. CPU
        i. CIFAR 10

```
Model Test Accuracy:  82.84000158309937  %
```

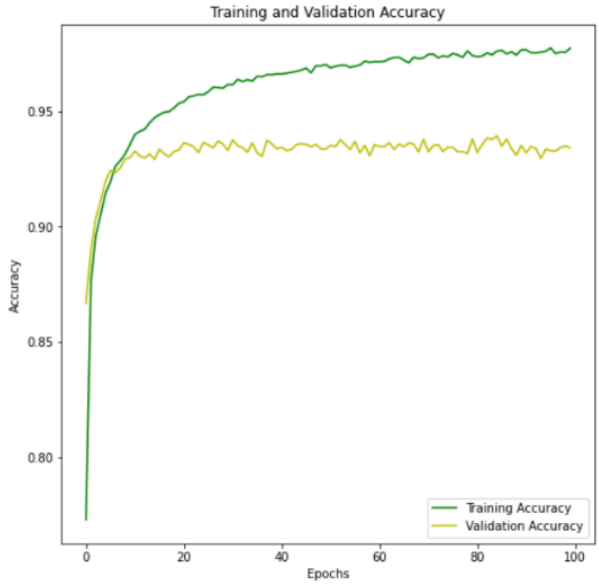


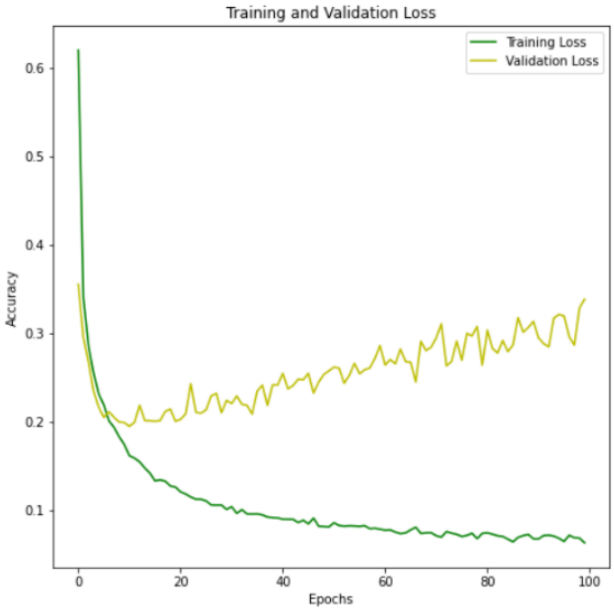



```
Program Execution Time (CPU):  19661.047607898712  seconds
```

ii. Fashion

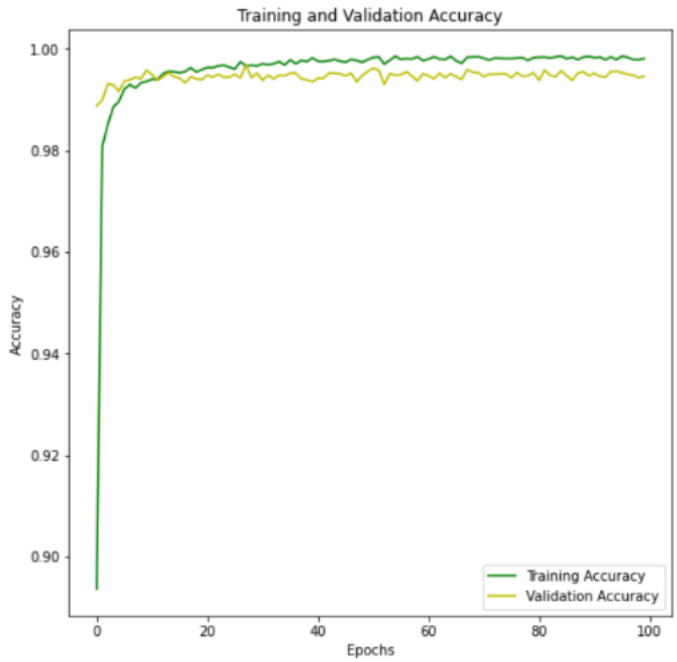
```
Model Test Accuracy:  93.40999722480774  %
Program Execution Time (CPU):  16357.364956855774  seconds
```

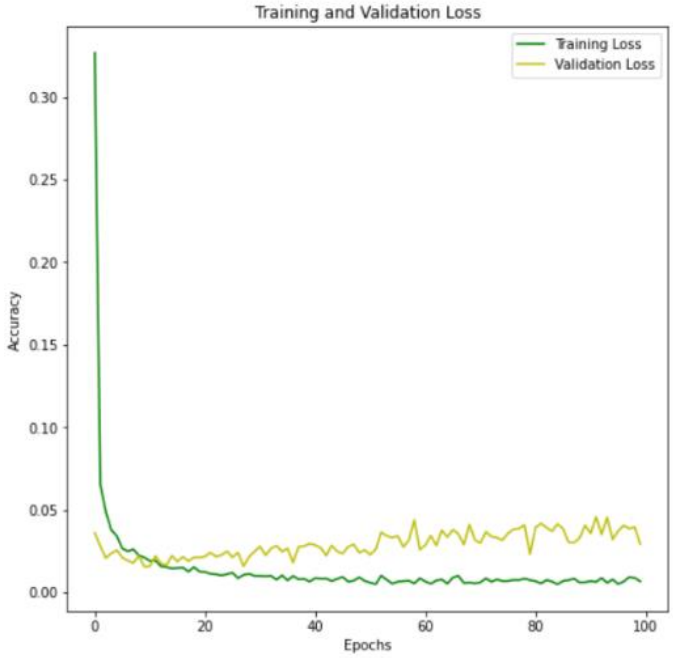




iii. Mnist

```
Model Test Accuracy:  99.4599997997284  %
Program Execution Time (CPU):  17673.238629102707  seconds
```

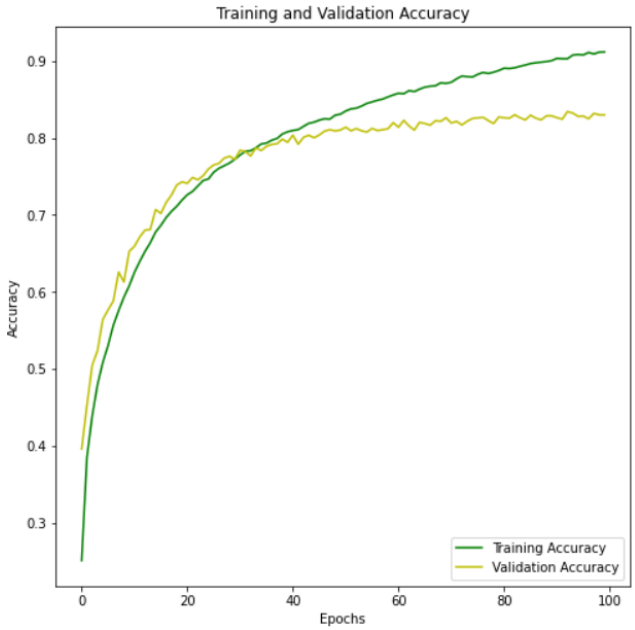


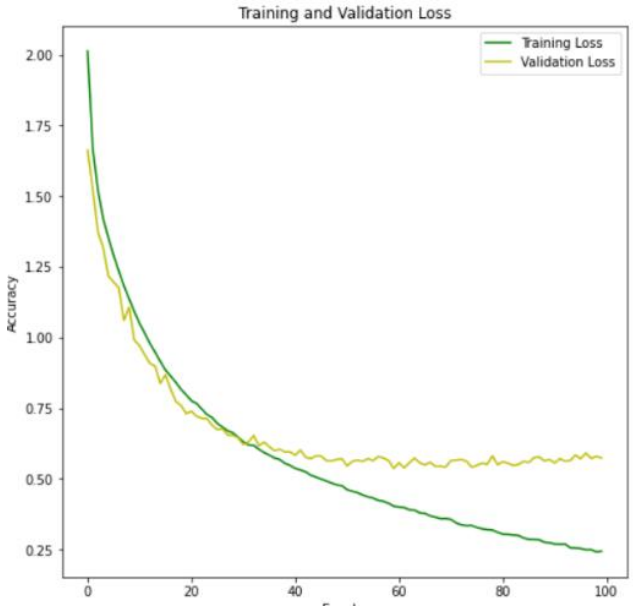


b. GPU

i. CIFAR 10

```
Model Test Accuracy:  82.99000263214111  %
```

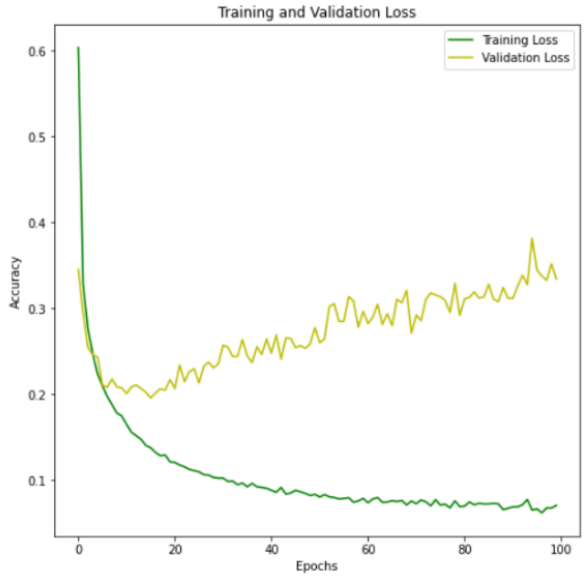





```
Program Execution Time (GPU):  545.7492320537567  seconds
```

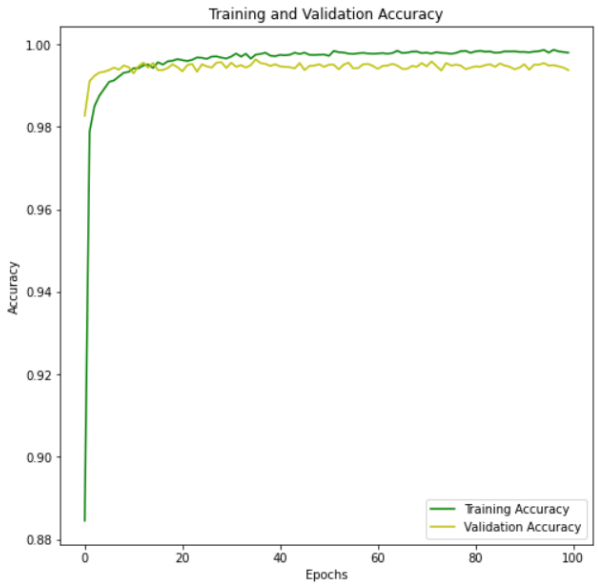
ii. Fashion

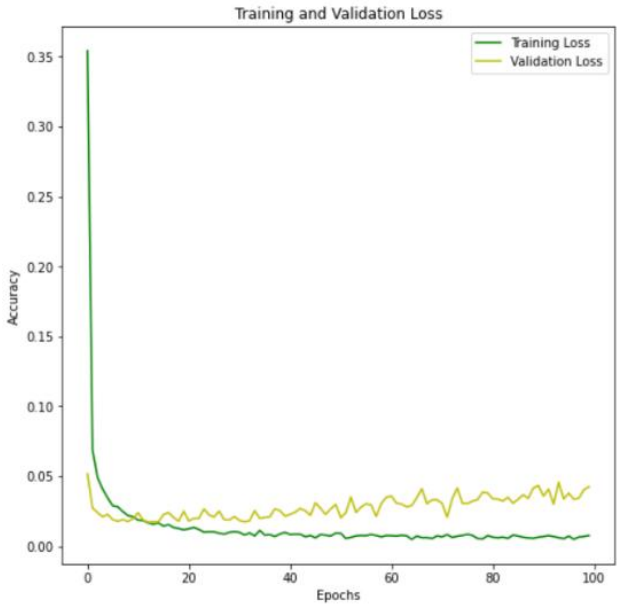
```
Model Test Accuracy:  93.62000226974487  %
Program Execution Time (GPU):  436.3112635612488  seconds
```



iii. Mnist

```
Model Test Accuracy:  99.37999844551086  %
Program Execution Time (GPU):  364.62790727615356  seconds
```





2. SVM

    a. CPU

        i. CIFAR 10

```
Training accuracy:   35.912244897959184 %
Validating accuracy: 35.5 %
Testing accuracy:    35.160000000000004 %
Program Execution Time(CPU): 9.601240873336792 seconds
```

ii. Fashion

```
Training Accuracy:  93.24 %
Test Accuracy:  87.7 %
Program Execution Time(CPU): 223.22363877296448 seconds
```

iii. Mnist

```
Training Accuracy:  99.35000000000001 %
Test Accuracy:  96.89999999999999 %
Program Execution Time(CPU): 174.87029218673706 seconds
```

b. GPU

i. CIFAR 10

```
Training accuracy:   35.68775510204082 %
Validating accuracy: 36.199999999999996 %
Testing accuracy:    35.099999999999994 %
Program Execution Time(GPU): 6.611586570739746 seconds
```

ii. Fashion

```
Training Accuracy:  93.24 %
Test Accuracy:  87.7 %
Program Execution Time(GPU): 149.04493975639343 seconds
```

iii. Mnist

```
Training Accuracy:  99.35000000000001 %
Test Accuracy:  96.89999999999999 %
Program Execution Time(GPU): 105.87819480895996 seconds
```

Following is a tabular representation of the time taken and accuracy obtained for CNN's :

Architecture Used	CPU			GPU		
	Cifar 10	Mnist	Fashion	Cifar 10	Mnist	Fashion
Accuracy Obtained	82.84 %	99.45 %	93.4 %	82.99 %	99.37 %	93.62 %
Time taken (seconds)	19661	17673	16357	545	364	436

Following is a tabular representation of the time taken and accuracy obtained for SVM's :

Architecture Used	CPU			GPU		
	Cifar 10	Mnist	Fashion	Cifar 10	Mnist	Fashion
Accuracy Obtained	35.91 %	99.35 %	93.24 %	35.09 %	99.35 %	93.24 %
Time taken (seconds)	9.6	174.87	223.22	6.61	105.878	149.04