IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141230

SVM vs CNN in Handwritten Digits Classification

Er. Harjasdeep Singh[1], Udit Kumar Mishra[2], Rohit Kumar[3], Shidhanshu Jaiswal[4]

Assistant Professor, Department of CSE, MIMIT, Malout, Punjab, India[1]

Student, Department of CSE, MIMIT, Malout, Punjab, India[2]

Student, Department of CSE, MIMIT, Malout, Punjab, India[3]

Student, Department of CSE, MIMIT, Malout, Punjab, India[4]

Abstract: Image classification has always been one of the most used and highly researched application of machine learning, while it is very easy for us to easily understand and classify the things we see every time. But, for machines to understand and categorize the same things with near human level accuracy, it requires training on large number of images of those objects and lots of internal calculations.

Handwritten digits classification is one part of the whole spectrum of the types of images and their categorizations machines are made to do. This research aims to compare the accuracy of a machine learning algorithm i.e. Support Vector Machine (SVM) with that of a deep learning algorithm Convolutional Neural Networks in handwritten digits classification.

In this research, we fed in same dataset containing numerous labelled images of handwritten digits to both Support Vector Machine (SVM) and Convulational Neural Network (with 3 CNN layers). The outcome shows that the cnn algorithm outperforms the svm.

Keywords: Image classification, Machine learning, Support Vector Machine (SVM), Convolutional Neural Network (CNN), Handwritten digits classification, Deep learning, Accuracy comparison, Pattern recognition, MNIST dataset, Image recognition.

I. INTRODUCTION

One of the characteristics of handwritten records is that they may or may not contain the same information but they still may vary in appearance as generally everyone has different writing style. In today's digital world where it is more efficient to hold and process the information in digital manner, it has become a widespread application of machine and deep learning in image processing to recognize that handwritten information into editable group of fonts, digits or both corresponding to the information with highest accuracy as: -

Handwriting is the most typical and systematic way of recording facts and information. The handwriting of an individual is idiosyncratic and unique to individual people. The capability of software or a device to recognize and analyse human handwriting in any language is called a handwritten character recognition (HCR) system. Recognition can be performed from both online and offline handwriting. [1] .The recognition of handwritten digits (RCM) is part of the Optical character recognition (OCR) among its applications: the postal sorting where every day thousands of items are automatically sorted, moreover there is the reading of the numerical amount of bank checks.[2] .Human interpretation of these digits is effortless, but automating the process demands sophisticated pattern recognition capabilities. As a result, ML and deep learning techniques have become central to the development of robust handwritten digit recognition systems.[8] .Machine learning and deep learning techniques have transformed diverse fields such as computer vision, natural language processing, and pattern recognition. These algorithms enable systems to automatically learn features from raw data and make predictions without being explicitly programmed. Image classification is an important application area that has benefited immensely from advances in deep neural networks.[7]

II. LITERATURE REVIEW AND RELATED WORKS

OVERVIEW

Handwritten digit recognition has been one of the most popular and important problems in computer vision and pattern recognition. Over the years, researchers have mainly used two types of approaches to solve it traditional machine learning models like Support Vector Machines (SVM), k-Nearest Neighbours (KNN), and Random Forests (RF), and modern deep learning models such as Convolutional Neural Networks (CNNs). Most comparative studies use standard benchmark datasets like MNIST to test and evaluate these models based on factors like accuracy, error rate, robustness

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141230

to noise, and scalability. Across almost all studies, CNNs have shown better accuracy because they can automatically learn useful features directly from raw images. On the other hand, SVMs still perform well when given carefully designed, handcrafted features, making them a strong choice for simpler or smaller datasets.

RELATED WORK

This research [4] paper has implemented some models namely Support Vector Machine Classifier, KNN Classifier, Random Forest Classifier, Multilayer Perceptron Classifier, Multi-Layer Perceptron and Convolutional Neural Network for handwritten digit recognition using MNIST datasets. It compared them based on their working accuracy. After a simple setup, all these algorithms demonstrated almost the same accuracy of handwritten digit recognition, differing within +1%. It was found that CNN gave the most accurate results for handwritten digit recognition, but the only drawback is that it took an exponential amount of computing time.

Authers of paper [6] stated: The goal of our work is to create a model that will be able to recognize and classify the handwritten digits from images by using concepts of Convolution Neural Network. Though the goal of our research is to create a model for digit recognition and classification, it can also be extended to letters and an individual's handwriting. The major goal of the proposed system is understanding Convolutional Neural Network, and applying it to the handwritten digit recognition system by working on the dataset created.

In this [7] research endeavour focused on handwritten digit recognition using MNIST datasets, we systematically implemented and compared three distinct models based on deep and machine learning algorithms. Evaluating their characteristics, we aimed to identify the most accurate model for this task. Among the classifiers, Support Vector Machines (SVM) emerged as a fundamental and efficient choice, demonstrating a commendable training accuracy rate.

In Paper [13] the author has used three machine learning algorithms (SVM, KNN, RFC) and one deep learning algorithm (CNN). After implementing these four algorithms, we compare their accuracy and finding the best algorithm which gives the most accuracy in our model. After executing all the algorithm, it has found that CNN has the highest accuracy 98.76% and less than 0.1% loss in our model and the rest three algorithm SVM, RFC, KNN has the accuracy 97.38%, 96.50%, 96.38% respectively.

In this paper,[14] the performances of the algorithms like SVM, KNN, and CNN are analysed and compared. Using TensorFlow, CNN has achieved an accuracy of 99.4% on trained set whereas 98.4% on test data. Similarly, it is observed that KNN has yielded the least accuracy of about 97.1% on the trained data and 96.7% on the test data.

III. METHODOLOGY

DATASETS

This research uses a dataset that contains 21555 images of handwritten digits 0 to 9 in 10 folders each named after the labelled digit it contains. All images in the dataset are coloured with size of 90×140 pixels. But these images are resized to 28×28 pixels and converted to grayscale in our experiment. The dataset is divided in training and testing set in ratio of 0.8 train and 0.2 test sets. From the output of dataset preparation code below are some printed results. Found 21555 files belonging to 10 classes. Using 17244 files for training. Found 21555 files belonging to 10 classes.

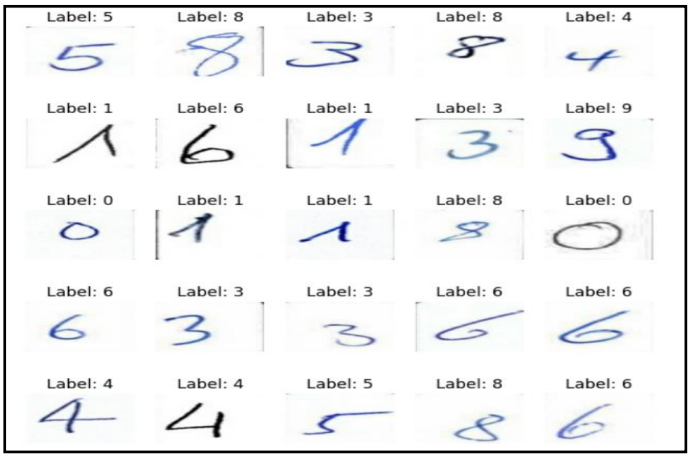


Fig. 1 Some labelled images from the dataset

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141230

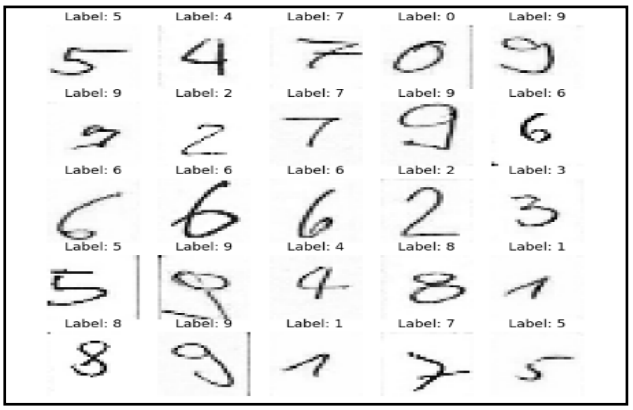


Fig. 2 Some more labelled images from the dataset

IV. ARCHITECTURAL OVERVIEW

SUPPORT VECTOR MACHINE (SVM):

Support Vector Machine is a powerful Machine Learning algorithm that belongs to supervised learning subcategory. It is commonly used for classification purposes, the core idea behind SVM is to plot the data items on a 2D or 3D graph and finding the best boundary line that can separate different groups in the data. Margin: it is the perpendicular distance between the hyperplane and the nearest data points to it in all the classes. Support Vectors closest data points to a margin.

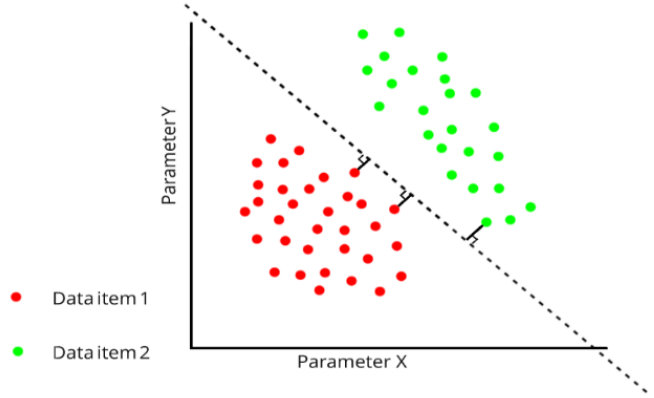


Fig. 3 Diagram of SVM

CONVOLUTIONAL NEURAL NETWORKS(CNN):

A CNN is basically one of the deep learning algorithms meant to process the data with generally grid like structure like images, or time series data. It generally used in image classification, pattern detection, and computer vision. Convolutional Neural Networks (CNNs) are analogous to traditional ANNs in that they are comprised of neurons that self-optimise through learning. Each neuron will still receive an input and perform a operation (such as a scalar product followed by a non-linear function) - the basis of countless ANNs. From the input raw image vectors to the final output of the class score, the entire of the network will still express a single perceptive score function (the weight).[3]

The only notable difference between CNNs and traditional ANNs is that CNNs are primarily used in the field of pattern recognition within images. This allows us to encode image-specific features into the architecture, making the network more suited for image-focused tasks - whilst further reducing the parameters required to set up the model.[3]. Convolutions are small kernel/filters of grid size 2x2; 3x3; etc which slide over the input data and calculate the dot product of the kernel weight and corresponding input patch. Activation Layer: When a preceding layer is followed by activation layer, non-linearity is added to the network. These consists of activation functions. A commonly used type of CNN, which is similar to the multi-layer perceptron (MLP), consists of numerous convolution layers preceding sub-sampling (pooling) layers, while the ending layers are FC layers.[12]

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

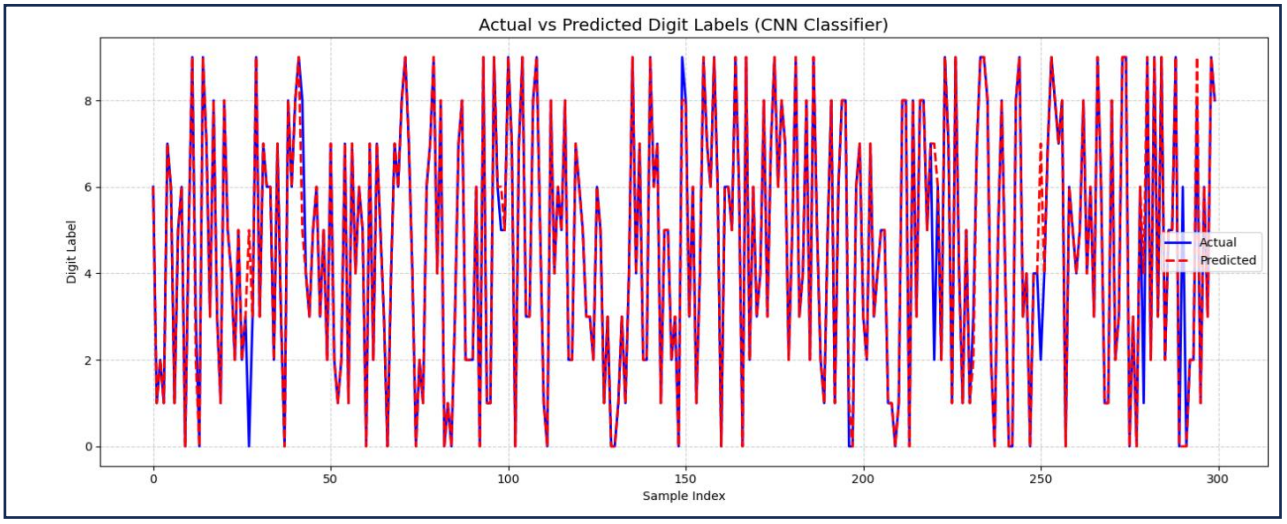
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141230

V. RESULT

SVM ALGORITHM

On the dataset we used. With the regularization parameter, C of 10. The model gave the result of about 0.90768 in accuracy. The accuracy was above 90% in our experiment. This can be seen in result snapshots below:




```
Loaded 21555 images successfully.
Training SVM model...
Evaluating model...

Classification Report:
              precision    recall  f1-score   support

           0       0.95      0.97      0.96       447
           1       0.95      0.97      0.96       448
           2       0.90      0.93      0.91       447
           3       0.85      0.85      0.85       441
           4       0.93      0.91      0.92       436
           5       0.93      0.91      0.92       425
           6       0.90      0.93      0.91       424
           7       0.88      0.91      0.89       423
           8       0.89      0.86      0.87       417
           9       0.90      0.84      0.87       403

    accuracy                           0.91      4311
   macro avg       0.91      0.91      0.91      4311
weighted avg       0.91      0.91      0.91      4311
```

```
Confusion Matrix:
 [[434   0   0   0   0   2   7   0   1   3]
 [  0 434   0   1   4   0   2   6   1   0]
 [  1   2 414   5   1   0   1  18   2   3]
 [  4   4  14 374   1   8   0  13  12  11]
 [  1   8   3   3 396   3  17   1   1   3]
 [  0   0   4   9   2 385  10   5   5   5]
 [  7   2   0   0   6   4 395   0  10   0]
 [  0   4  20   8   0   2   0 383   1   5]
 [  5   1   4  21   4   4   8   2 360   8]
 [  3   3   2  21  11   4   1   7  13 338]]
Accuracy: 0.9076780329389933
```

Fig 4. Classification report and Confusion matrix

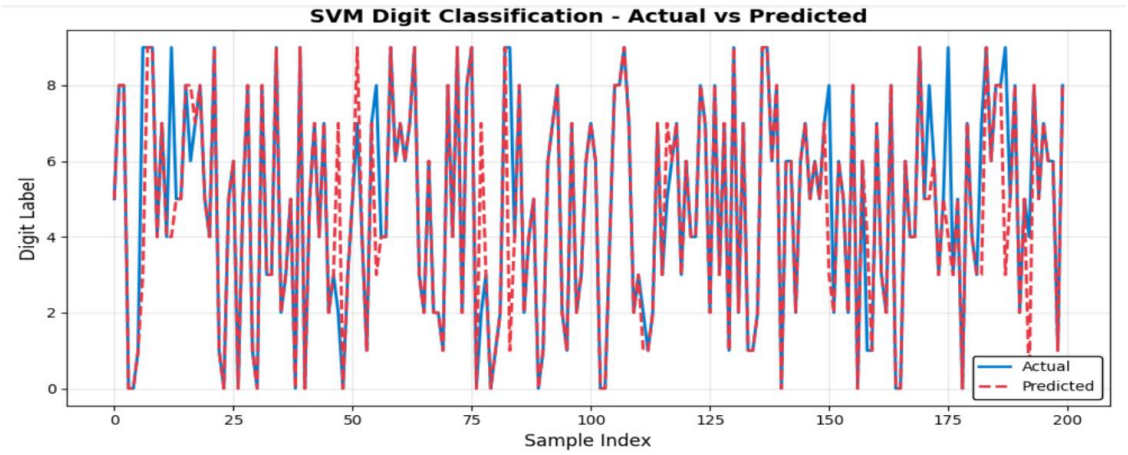


Fig.5 Graph actual vs predicted (SVM)

CNN ALGORITHM

From the dataset we used and the algorithm through 10 epochs our observed output is the validation accuracy of 0.9569. Hence, from the observed readings, the accuracy of the algorithm came out to be between 95 to 96 % in our test.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025

DOI: 10.17148/IJARCCE.2025.141230

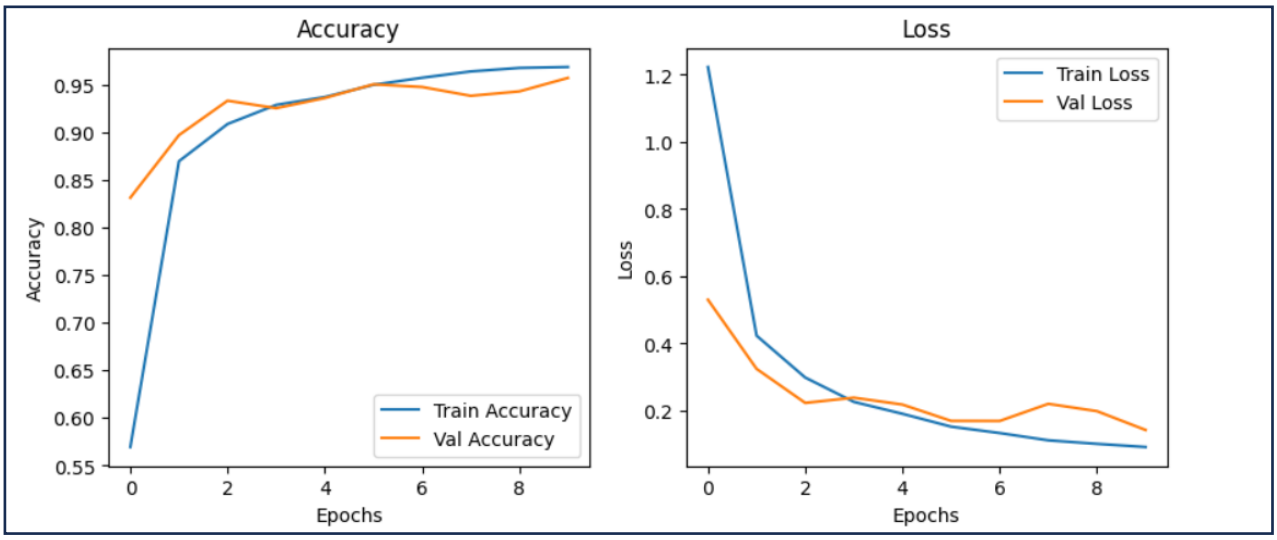


Fig 6. Graph actual vs predicted cnn

Fig 6. Graph accuracy and loss

VI. DISCUSSION

From the results of both the SVM and CNN in our study we found that SVM gave test accuracy of about 0.90768 which is somewhere between 90 to 91% while the CNN algorithm kept the test accuracy of 0.9569 which is more between 95 to 96% of accuracy on the same data set with same train-test split ratio. The results are hence showing that CNN can achieve higher accuracies than the SVM algorithm in handwritten digit recognition task. SVM: Accuracy is about 0.90768 between 90 to 90%. CNN: Accuracy is 0.9569 between 95 to 96% Our study hence concludes that CNN algorithms are a better than SVM in image classification tasks This shows the superiority of a deep learning algorithms over a traditional machine learning algorithm in performing complex tasks especially in pattern recognition.

Table 1. CNN and SVM

Constraints	**CNN**	**SVM**
Type	Deep-Learning	Machine-Learning
Dataset: Total images	21555	21555
Train-Test Split	80% -20%	80% -20%
Accuracy (Test Result)	0.9569	0.907678(Approx.)
Percentage Accuracy (Test Result)	Between 95 to 96%	Between 90 to 91%

VII. CONCLUSION

This paper compares the accuracies of two different approaches in handwritten digits recognition. It fulfils its objectives by showing that Convolutional Neural Networks (CNN), a deep learning approach can do prediction with higher accuracies compared to Support Vector Machines (SVM), a machine-learning algorithms, while also giving a brief description of the architectures and approaches implemented in both the methodologies. The study also gives a brief view of data processing to make it ready to be fed according to each approach. Overall, as per the name “SVM vs CNN in Handwritten Digits Classification” the major focus is to study and compare SVM and CNN and this focus seems to have been attained given the procedures followed, outcomes and results of this study.

REFERENCES

[1]. Nazmus Saqib, Khandaker Foysal Haque, Venkata Prasanth Yanambaka, and Ahmed Abdelgawad “Convolutional-Neural-Network-Based Handwritten Character Recognition: An Approach with Massive Multisource Data” Link 1

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 12, December 2025
DOI: 10.17148/IJARCCE.2025.141230

[2]. Yousra Berrich and Zouhair Guennoun"Handwritten Digit Recognition System Based On Cnn And Svm" Signal & Image Processing: An International Journal (SIPIJ) Vol.13, No.6, December 2022 DOI: 10.5121/sipij.2022.13602 11 Link 2
[3]. Keiron O'Shea[1] and Ryan Nash[2] "An Introduction to Convolutional Neural Networks" [1]Department of Computer Science, Aberystwyth University, Ceredigion, SY23 3DB [2]School of Computing and Communications, Lancaster University, Lancashire, LA14YW Link 3
[4]. Yevhen Chychkarov, Anastasiia Serhiienko, Iryna Syrmamiikh, Anatolii Kargin "Handwritten Digits Recognition Using SVM, KNN, RF and Deep Learning Neural Networks" Link 4
[5]. Vladimir N. Vapnik "The Nature of Statistical Learning" Theory Second Edition With 50 Illustrations Link 5
[6]. Kollukuluru Sai Tharun (38130108) K.Sudheer Kumar Reddy (38130103) "HANDWRITTEN DIGITS CLASSIFICATION WITH CONVOLUTION NEURAL NETWORK" Submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering Department Of Electronics And Communication Engineering School Of Electrical And Electronics Engineering Sathyabama Institute Of Science And Technology (Deemed To Be University) Accredited With Grade "A" By Naac Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119 May – 2022 Link 6
[7]. Anukriti Rajput[1] and Anish Kumar Singh[2] "Handwritten Digit Recognition Accuracy Comparison Using Knn, Cnn And Svm."Computer Science and Engineering Galgotias University Gr. Noida, India . Citation: Anukriti Rajput (2024, Handwritten Digit Recognition Accuracy Comparison Using Knn, Cnn And Svm. Educational Administration: Theory And Practice, 30(2), 638-643 Doi:10.53555/kuey.v30i2.1676 Link 7
[8]. Yash Kumar [1], Bhawna [1], Anupama [1], Gaurav [1], Md Danish [1] "Handwritten Digit Recognition Using Machine Learning and Deep Learning Techniques: A Comparative Study of SVM, KNN, RFC, and CNN Models " [1] Computer Science & Engineering, Echelon Institute of Technology, Faridabad, India Link 8
[9]. Lokesh Rathore , Dr. Ramji Yadav "Handwritten Digit Recognition: Comparative Analysis of Machine Learning and Deep Learning Algorithms on the MNIST Dataset"Institute of Computer Science, Vikram University Ujjain Link 9
[10]. Chang, C.-C. & Lin, C.-J. (2011). "LIBSVM: A library for support vector machines. ACM Transactions on Intelligent Systems and Technology (TIST)." Link 10
[11]. Christopher J. C. Burges — "A Tutorial on Support Vector Machines for Pattern Recognition" Link 11
[12]. Laith Alzubaidi, Jinglan Zhang, Amjad J Humaidi, Ayad Al-Dujaili, Ye Duan, Omran Al-Shamma, J Santamaría, Mohammad A Fadhel, Muthana Al-Amidie, Laith Farhan "Review of deep learning: concepts, CNN architectures, challenges, applications, future directions" Link 12
[13]. Susmita Majee "Comparative Analysis of Handwritten Digit Recognition Techniques: CNN, SVM, KNN, and RFC" Department of Computer Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India 221005 Link 13
[14]. Meer Zohra, D.Rajeswara Rao "A Comprehensive Data Analysis on Handwritten Digit Recognition using Machine Learning Approach"
[15]. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-6, April 2019Link 14