International Journal of Advanced Science and Technology
Vol. 29, No. 7s, (2020), pp. 2639-2651

Performance Metric Interpretation on Handwritten Digit Recognition Using Neural Networks

*Dinesh Kumar J.R[1], Priyadharsini.K[2], Yazhini.V[3],Shaalini.S[4] ,Swetha.G[5], Sneha.N[6]
,
[3,,4,5,6]*UG Scholar,* [1 & 2]*Assistant Professor*
Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology,
Coimbatore, Tamil Nadu ,India,
[*1]*dineshkumarjr@skcet.ac.in*

Abstract

In recent trends on up scaling of technology artificial intelligence is much needed one. The AI and ML are the widest field where all the applications and systems are implemented. This paper describes the hand written resignation and specifically to support the medical field. Due to lack of clear writing on prescription sheets, the pharmacologist may deliver the wrong the medicine at sometimes also mostly the scientific papers and land registration documents are become digitalized nowadays. The content to digitalize is high but the method used does not produce reliable values as the error rate is at maximum. Hence, the requirement arises at the research level to simplify the load and reduce the manual efforts, which could done by human. The novelty defines in the system, which can access the prescriptions sheet as image and recognize the hand written on that, and convert them as digitally connected line using different neural network. With respect to the neural network there are many ways to train the dataset and develop the systems which consists of 'n' no fo hidden layer. So we prefer implementing the machine algorithm such as SVM, KLN with ANN and CNN. The datasets to train this networks are derived from MNIST database. The train rate are very high. These algorithms compared in terms of reorganization accuracy, and it shows CNN has best of 96.2% compare to other types. The SVM classifier has the better test data accuracy and CNN has the trained data accuracy.

Keyword: *CNN, KLN, SVM, ANN, Hand written, MNIST*

1. INTRODUCTION

Increasing the demand for image processing and analyzing is increases tremendously[6], especially in medical fields. Also the no of various applications such as pattern detection, face reorganization in terms of strength the walls of cyber security. Among the various field one of the crucial is medical field and specially reading the prescription written by the medicos is still bigger and more complicated task for the pharmacologists [15], even a tiny miss spelt could cause the humans life to danger position. The hand written reorganization is still complex target in research perspective [16] since no human can copy others style of hand written. In more or less that each letter or number has to be represented in certain format. The format is known as data sets. They are plenty of datasets[5] are available in MNIST, so the system has to be developed and trained according to the data set of nearly 13000 to form a model to predict the letter or symbol and that should be more accurate and the error rate is low. Hence this field has to be redefined in the grown technology. The more no of techniques have been developed to recognize the hand written techniques such as text translation slack, text reader, imaginary analysis of visual but bankruptcy due to the tedious processing methods. So the field is wider open to recognize the handwritten. This cogitation tends to the use of most promising methodology ie.., using of Neural network.The analogy and function of neural networks are closely interconnected to the function of human brain where it consists of billions of neurons (axioms). Every NN has been divided into 3 layers as input, output and hidden layer. There may be 'n' no

of hidden layers between input and output. Each layers and each lines on connection carries weights. The output is calculated as the sum of products of weights with the bias and learning rate.

If Sum $w_{ij} * x_i > 0$ the output of unit c is calculated as

$f(C) = c_0 + \sum_{n=1}^{\infty} \text{Wij} * \text{Xi}$ → (1.1)

Co – Bias. The output Y= { 1 if f(c) > 0
otherwise Y=0. → (1.2)

So the output of the each node is calulated as the SOP on weights and with neurons. The perceptron and sinle neuron network is differed. The NN method is also used to quantify the deviation from the expected one, which is also know as error. The ANN based feedforward method has less level of error sensitivity in back propagation. The back progation error is calculated from the output layer towards the input layes and this is propagation based on tie up of all perceptron in a flow. The gradients and the weights are updated automatically. Modern trand is implementing the machine laeraing and deep learning algorithms along with the neural network. The beast example of this type is convolution neural networks which is very popular technique in face recognization and patten detection with object identification, even this techniques are used in E mail sevices to secregate the spam mail and catagorizion. Henceforward in implementing the [3]CNN in deep learning improves the level of accuracy, in other words the leve of error rate in recognizing particular leteer is more perfect, this is inspiredd by th famous visual system develpoed by Hubel where the recognization of the field is called s receptive field. The various backward propagation algorithm and gradient descent is adapted build the CNN, which the CNN has the same pattern of archortecture ike ANN as desciped in Fig 1.1.

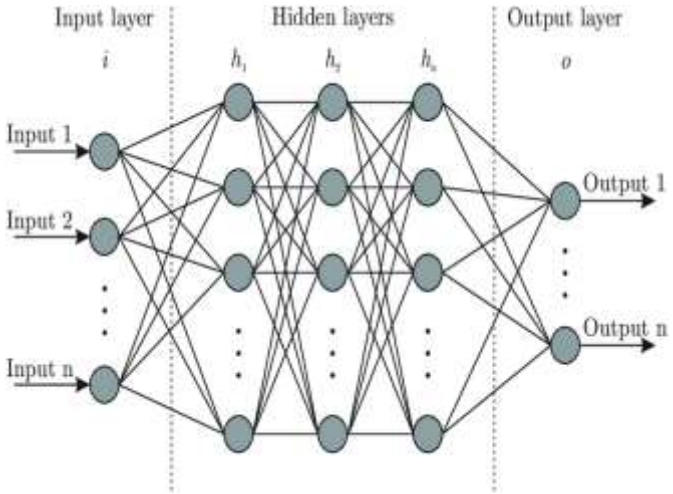

Fig 1.1 : General blocks Artificial Neural Network

ANN is two dimensional layer netwrok wherethe CNN follows the 3D view, means all the neurons of CNN conneted to the any one of the ocal receptive field and the training of the network is done thriugh cost functions as represented in fig 1.2. Each time the signals from the receptive field is propageted towards bacck and upadtes the weights of the field along with the chanes in the fields. Hence the repetive storage on back propagation the network performance increased in predicting, which helps to improve the effeciency on recognization of handwritten using cnn compare to ANN.

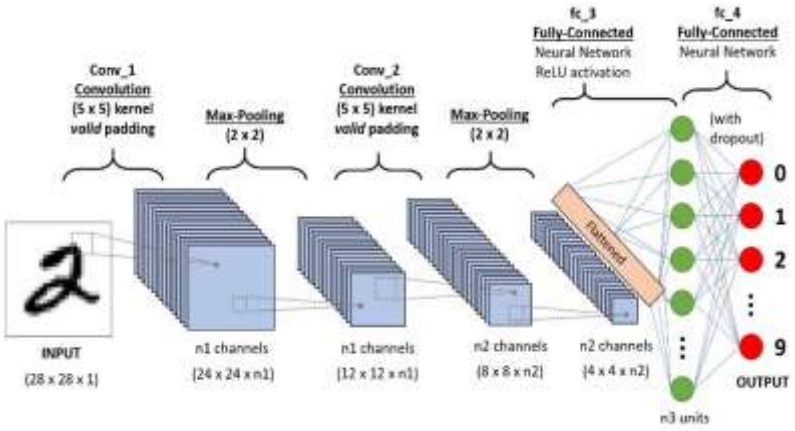

Fig 1.2 : CNN in Handwritten recognize

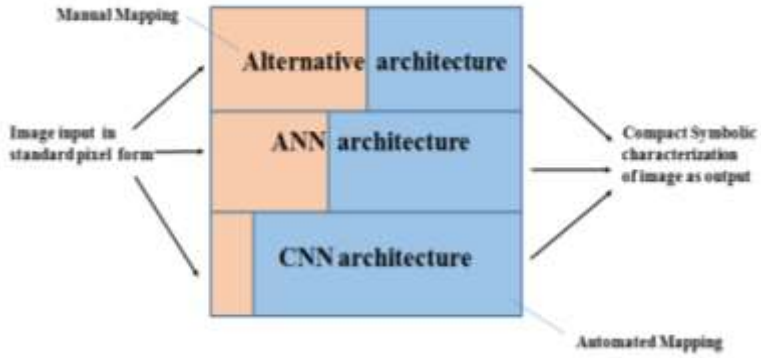

Fig 1.3: Image recognization

Fig 1.3 illutrate the way in which the image recognization is processed through ANN, CNN and other architectures and the images picked up that the autmated mapping level is more in CNN since[14] MNIST (Modifiedneural Institute Standard Technology) dataset is used to train them.CNN uses limited level of pre processing technique and it learnt from filter and it follows the mathematical model of convolution, one of the advantage is it required very low level on prior knowledge and feature extraction is good with minimal rate of human efforts,.The following sections describes the existing methodology and its analysis and the proposed model analysis at end the comparative analysis of accuracy on recognization of hand written

2. Article Survey

2.1)Using ANN

The digital encoding scheme is one of the most rapidly growing technologies to detect the hand writing in various fields. The paper [1] developed the concept on to implement the neural network concept based on MLP to identify and perceive the digital numbers upto 9. This author [1] takes a data sample of 4500-500 which are generated by other algorithms in MNIST .The forward method with feedback algorithm was used to analyze the data sample based those were trained on gradient descent methodology. This system has the certain corns in identifying the digits and also its not suitable to predict the letter and added to this the gradient descent method with feed – forward method does not produce the efficiency of more than 90

%. Hence the implementation of the algorithm and network leads to the misidentification of digits, if the digits has discontinuity

2.2)Using Kohonen's self organization

Another article[2] in connection to the idea of paper [1] was helped to develope the algorithm to next level in recognize few letters. The author [2] narrates how the artificial network on processed to identify the hand written letters. Thid paper uses kohonens model on self organization. As this NN follows the KSO models which has the orns on cluster formation which is defined by the necessary data and available dataset, also the datasets are formed and classified based on the weights assciated with hidden layer. Through the feedforawrad and backward mechanism the weight updation process becomes more complex and it dose not give the visualization of hand written recognization. This algorithm gave the predicion rate of 92 % for the digits[2] and used in developing of general application such as recongization of task levels (numbers). The data set is taken aroung 5000 for consructing the network.

2.3) Using ML algorithm

Another author who prefers to implement the ANN with machine learning algorithm [3] based on the probability of an occurrences. Hence the ML based systems improves the efficiency as it falls to the category on detecting between various level. These were truncated based on fuzzy sets and fuzzy variables. The implementing system which works on the probability of identification could cause the observation error, since fault tolerant and fault identification techniques were no incorporated. The four corners True positive, negative & False negative, positive gives high level on prediction. This paper [3] projects the algorithm which effectively increase the percentile of reorganization and predication of characters. However this article gives the comparative analysis on different schemes on ML. This paper gives results based on NB, MLP & SVM methods and its found that the results of these papers are 50 % higher than the article [12] which defines the algorithm based on J48 and RT techniques based on the data set WEKA.

2.4) Using Digital recognition – ANN

Handwritten digits are varying for different people because each one has their own style of scribbling [4], means the same digit or character/word written by different writer will be different even in different time [13]. Recognizing the letters and digits written by user must be recognized [5] in order to simplify the work of human and improve the system by giving an additional capability of user written instruction.The different methodology has been proposed to perceive the hand writing, among this development of ANN & CNN [6] plays a vital role on classifying the characters and numbers based on the datasets trained from MNIST. The digital recognition is much important one, where it can be used to predict the contents and decodes the results on various vouchers on banks, prescription sheets and mainly to avoid creation of pretend signature on documents and other things. The era of digitalization is still struggling to identify the more precise digital encoders, which follows an effective algorithm on implementing them. The most probability on detection getting more complex in the detection and decoding of letters or characters which are marked and represented in Japanese, chines and even in arabic letters . our proposed methodology is compendium of different mechanism. Certain pros of ANN and SVM has taken and the data sets are derived from the universal data set on hand written recognize using MINST.

3. PROPOSED SYSTEM

3.1)Block diagram

The proposed model follows the CNN with classifier as SVM and KNN. Every novelty on the system produced from defining the existing methodology in the neoteric model. Hence the old methods on image processing also used here along with the classification and précised algorithms were preferred towards the achievement of the accuracy on recognition. The first block is pre processing block which performs the prior methods to change the image which is free from the noise and remove the irregularity and minimize the hand written pattern-identifying space which is converted as vectors and the facture extraction of image

is done. The feature extraction with CNN uses the feed forward network which will directly calculate the weights of neurons on a particular network and this weight are mapped to the final layer weights where it can transmit the knowledge on extracting the feature through the variation in density of layer and the dimension of desire. The feature extraction based on CNN will follows the both kind of propagation and updating of weights in forward and backward propagation models

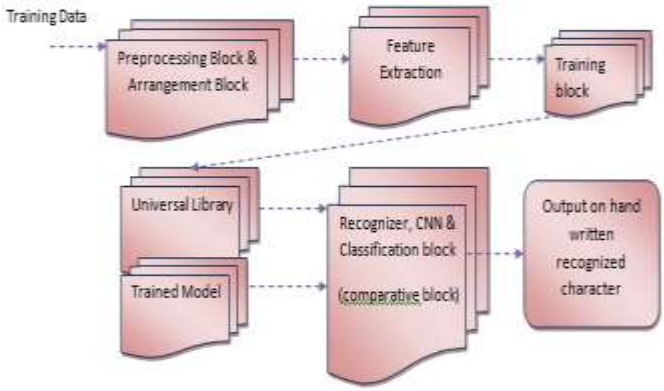

Fig 3.1:Connected blocks of the proposed system

The training block mainly focusing on creating the trained data after the feature extraction. Along with the trained data the test vector set are used to access with universal library block which consists of previous generated vector sets. Such as the trained model and the universal library model are combines the data which comes to feed forward network based on CNN. The classification is done through this block in order to identify the digits extracted from the hand written images.

3.2) MNIST Handwritten Digit Classification Dataset

The MNIST handwritten dataset which consists of 60K in numbers are used to defined the reference network. In this models the dataset or digital images were taken and segregated towards the task on classifying the numbers and the images were undergone to CNN algorithm. The CNN algorithm divide the gray scale images to the smallest blocks, which is known as pixels to perform the analysis on detection. This CNN algorithm will take the images within the pixel range of 28*28 in the gray scale level. This method is mainly taken for its better performance on the error rate, this networks will give the deviation rate of less than 0.6 % and the classifying methods gives more accuracy on predicting numeric's such as 0,1,7 & 9.

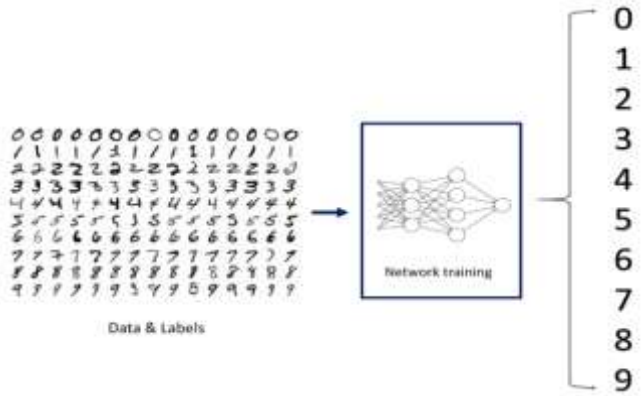

Fig 3.2: MNIST data set to CNN and obtain the digits

After loading the trained data sets from MNIST, that will bring the pictorial representation of letters or digits which posses the principle of natural language processing and it could help in categorizing the letters and digits in order to consume the time of perceive and poser consumption of the networks

3.3) Model Evaluation Methodology

One of crucial task is creating the models, which works on the trained datasets derived from the previous section. After loading the data, the models host to the initiations and develop the internal methodology to solve the problems on image classification and its done using CNN. So the model itself doing the process on training the data and verify the functionality of it, which could leads to the high scale on time to rendering the finalized models. Hence, we can go with the creation of models by concept of equalization and division. Forth method on model detection which consumes times on training and validating is avoided and a model is built from the base, which can be perform the parallel computing and data training and data validation. Each time when the model building is initiated the process of training set is elaborated by the validating them and training with different time slot on the machine cycle. The time taken for the model creation was reduced and due to concurrence on the data set validation, the performance of the model can be checked. The learning curve on the model performance will defines the effectiveness on model with its error tolerant and used to predict the accuracy on the classification of images based on the gray scale or the datasets which trained from the MNIST.

3.4)Working of the System

The working of the system is précised to the four major blocks on operation. In that first block is used to preparing the data set, where the different hand written datasets are obtained from MNIST are feed as basic datasets and followed by building the network. The network is build using convolution neural network where the it follows the 3D representations on data and each pixel is connected with the retroactive field. The tensor flow and keras packages have been used to set up the surroundings on how to be analyzed. Hence the keras which uses large no of hidden layer between input and output, here it uses approximately 512 hidden node which could cultivate the process of had written recognizing Therefore, the next block is acclimated on compiling and testing the model.

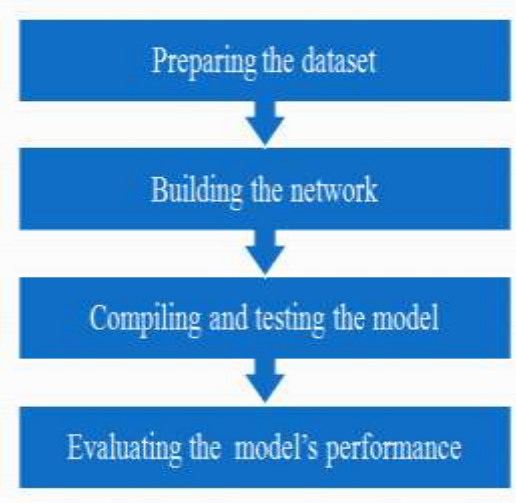

Fig 3.3: Working of the system

The MNIST based dataset are consider for the comparative study. The part of MNIST is taken as base dataset which is extracted as gray scale images. But to identify the hand written the CNN are trained with the dominant colors of image processing ie., RGB. So the network can easily classify their color variations

on varying the aspect ration of an image by changing the width and height which is generated a large data and uses stochastic gradient method which has lower noise on vector set which is shown below.

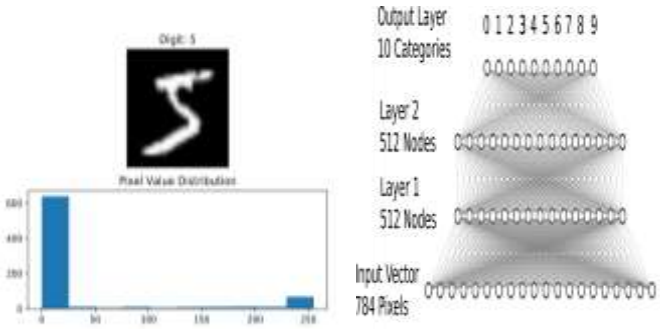

Fig 3.4: Pixel Value Distribution & densely conencted network

The evaluating the model's performance is dealing with cross validation and hold out, which is classified to subsets for training data and test. The training set is used in building the network and the test set are used to validate the performance of the network in associated with feature extraction of a model developed. The processed output sections on the test set vector used to classify the results as over fit, under fit or more matched fit with the training set. These are the operations related to the hold set. The other block is cross validation. The accomplishment on the model is measured from the validation. Among the different sets on validation this work focus the K-fold cross methods which focus the variation between the trained data sets with test data sets. For better performance of the models this mean difference should be less and even it defines the error rate which correlated with the deviation of the sets. This variations are measured from the learning curve of the models which is derived between training and test sets under the validation cycle. Hence this process give the validated value on the CNN & ANN architectures, also its measured that deviation is less compare to the other method five fold cross and its calculated that 20% improvement on validation and 40% improvement in the comparison of above testing methods.

Fig 3.5: Using Keras and Tensor flow Importing dataset

The Kfold method is widely used in CNN which truncated the vector set to K no of folds where all the subsets are equal in size and this is used to measure the most promising metrics of CNN model accuracy, logarithmic loss and F-accuracy under the area of cure of operation .

The metrics used to analyze the CNN classifier is precision, sensitivity F1 score and specificity. These metrics are calculate from finding the four parameters TH, FH,TL & FL.True High (TH): Predicted (+)ve and are actually positive. False High(FH): Predicted (+)ve and are actually negative. True Low (TL): Predicted (-)ve and are actually negative. False Low (FL): Predicted (-)ve and are actually positive.

Precision = TH / (TH + FH) → (3.1)
Sensitivity = TH/ {TH+FL} → (3.2)
Specificity = TL/ {TL+FP} → (3.3)
Accuracy ={TH +TL} / {TH+TL+FH+FL } → (3.4)
F1 Score = 2 * (P * S0 / (P + S) } → (3.5)
Where P →Precision & S→ Sensitivity

Table 3.1: Performance Metrics of CNN

Hex Digit	***Precision***	***Sensitivity***	***Specificity***	***F1 Score***
0	0.97	0.98	0.97	0.97
1	0.97	0.98	0.98	0.97
2	0.98	0.98	0.96	0.98
3	0.97	0.96	0.96	0.96
4	0.94	0.95	0.94	0.94
5	0.95	0.95	0.95	0.95
6	0.97	0.96	0.95	0.96
7	0.97	0.97	0.97	0.97
8	0.97	0.98	0.97	0.97
9	0.98	0.96	0.97	0.96
a	0.92	0.93	0.92	0.92
b	0.97	0.93	0.95	0.94
c	0.94	0.91	0.92	0.92
d	0.95	0.94	0.94	0.94
e	0.96	0.94	0.94	0.94
F	0.97	0.93	0.95	0.94
Mean	**0.96**	**0.95**	**0.95**	**0.95**

3.5)Flow diagram

With reference to understanding on prior sections, the complete flow operation is shown below.

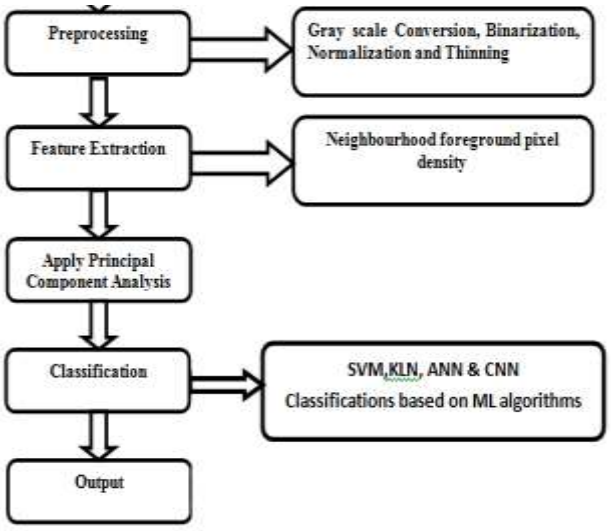

Fig 3.6: Flow of operation

This flow chart describes the steps on image processing. Starting form the pre processing of images and extracting the varying the results as either feed forward or feed back network. Updates the weight according to the to and fro movement of weights through the neurons from the hidden layer to input and output with respect to forward and backward propagation. This CNN has very low back propagation error.

4. RESULTS & DISCUSSIONS

The final accuracy of our model is highly constant and near to 95%. In related to the stability improvement this model developed for the accomplishing the task on hand written recognize it is intended to work under the over time training variations, and also its proven that this models has over come the training delays and the produce lower deviations on the variation of training to the test data sets

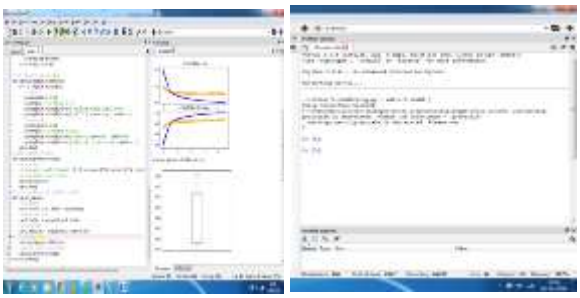

Fig. 4.1. BW- Plot of Accuracy Scores for the Baseline Model Evaluated Using k-Fold Cross-Validation & Prediction of the Handwritten digits

. This section took over 100 epoches for the performance investigation of over time training and error sensitivity. The accuracy and the scale of training sets are inversely related, so for large range of sets the accuracy is deviated by 2 % in the experimental value compare to the initiated value . The pictorial reorientation and plots of variation of parameters it shows that high amount of data and the training set create the notable impact on the training error. The deviation is les and the precision level on testing is 96 % for CNN ,but increasing the efficiency will never give the accuracy of ideal ie., 100%.

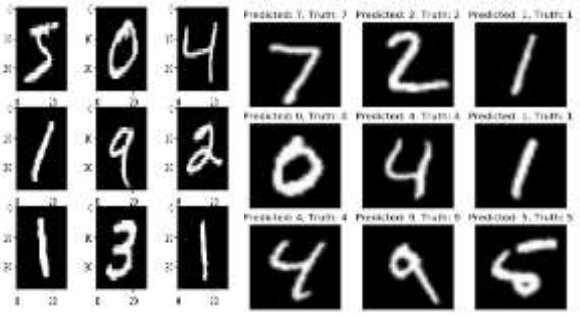

Fig 3.8. Plot of a Subset of Images From the MNIST Dataset and Prediction values

The initiated and experimental accuracy is calculated for the different models which shows the CNN has better accuracy of 96.2% compare to other methods such as KNN,ANN,SVM methods which describes in section II. The process of model creation and parallelism on computation leads to the reduction of power consumption and improves the test data precision percentage. This model will work good for the digital recognize and still is has the problem on recovering the data from the mathematical symbols, pictorial notation and signature variations

Table 4.1 : Precision percentage Vs Methods (Algorithms)

Methods	Initiated accuracy	Experimental precision
ANN	92.1	91.1
CNN	97.5	96.2
SVM	97.1	94.2
KNN	94.1	92.3

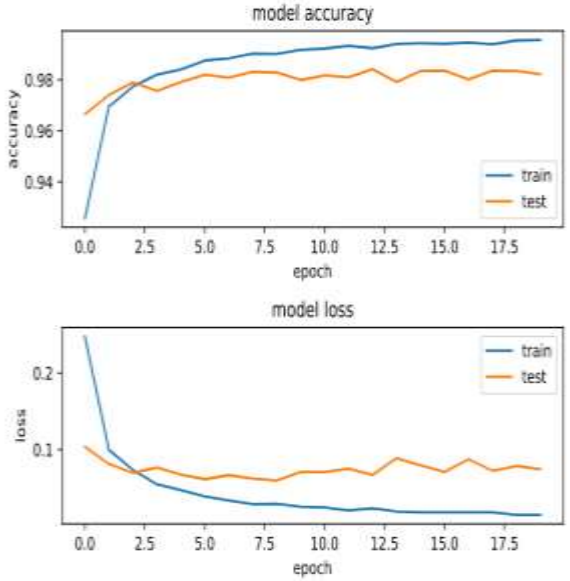

Fig 4.2: Model accuracy and Model Loss of train & test set

The model accuracy and the epoch are generated ant the values are obtained using tensor flow and the simulated values are clearly shown how much the epoch and model accuracy was varying and the another plot shows the level of less could occur on the increment of epoches

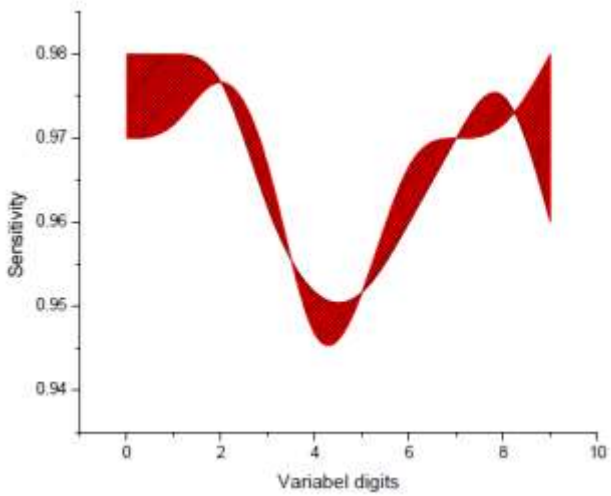

Fig 4.3: Sensitivity Vs identification

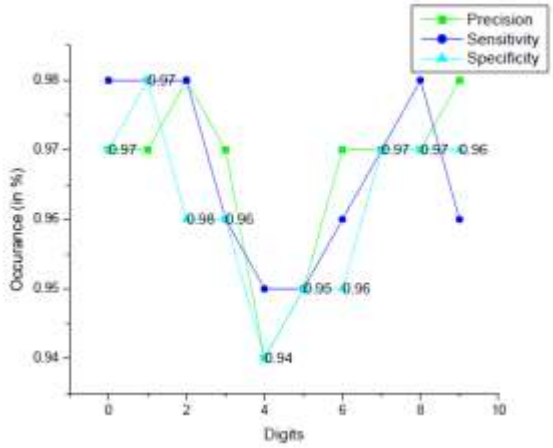

Fig 4.4: Occurrence Metrics Vs identification

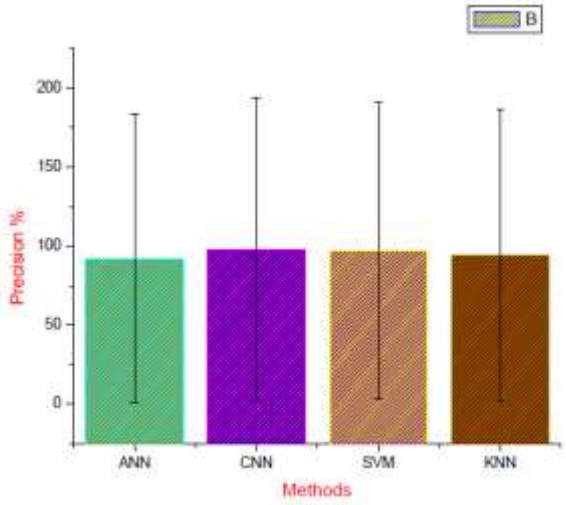

Fig 4.5 : Methods Vs Precsion

The performance metrics of CNN which was found by using the equation 3.1 to 3.5 and the values are tabulated in 1,2 & 3. The table 1 shows the mean accuracy of 96 % and sensitivity, specificity and F1 score as equal mean of 95 %. The corresponding results are used to tabulate the comparative analysis of different methods used in recognize the hand written,. and results shown CNN is having better precision compare to other methodologies the same has been plotted in Fig 13 to 17.

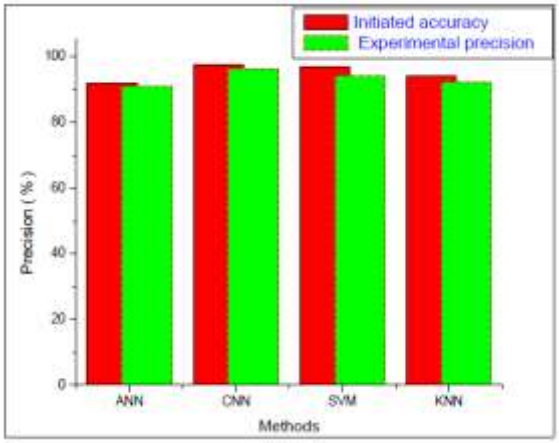

Fig 4.6: Initiated Vs Experimental data of different methods on Precision

Table 4.2 : Precision percentage Vs Methods (Algorithms)

CNN Epoches on variations	Initiated accuracy (CNN)	Experimental precision (CNN)
1	91.1	87.8
3	93.5	90.2
6	97.1	92.2
10	99.1	95.2

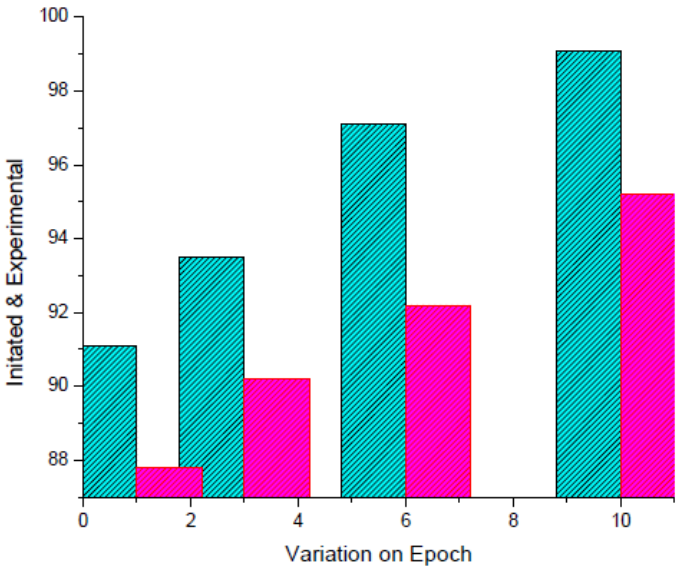

Fig 4.7: Initiated & Experimental Vs Epoch

Since the missing of some picture representation while converting to the CNN we could sense some variation on the results showing the deviation between the trained data and validated test data, henceforth the quality of image could cause the missing of certain pixels which can be avoided by using image compression technique. Based on the deviation (error rate) the Relu based classifications is taken to measure the allowable range of error rate. As the more predication is defined in the models, the data fitting model and data over fitting errors can be reduced, so that the CNN has the high experimental analysis when the epoch were increased.

5. CONCLUSION AND FUTURE PERSPECTIVE

This paper evolves on neural network was developed for handwritten content recognition. Recognition was done by developing a baseline model in which we have to load a data set, prepare pixel data and then design an improved model from where it will make the predictions and thus the handwritten content is recognized. Only character and digit recognition was. The results were shown in the above sections and the level of accuracy predicts up to 96.2%. Further this can be implemented towards the recognize of mathematical symbol and recognition of Arabic and Japanese letter as development of language based model and grammar rules can be implemented. Image recognition of degraded images can

also be implemented. Further to that recognize medical image data and prescription sheets with tablet and on taking an image for recognition and even it can be developed to detecting the vehicle numbers.

REFERENCE

1. Saeed AL-Mansoori "Research article on Intelligent Handwritten Digit Recognition using Artificial Neural Network"
2. S. M. Shamim, Md Badrul Alam Miah, Angona Sarker and Masud Rana "Hand Written Digit Recognition using Machine Learning Algorithms"
3. Chaskar Shubham D "Handwritten Digit Recognition using Artificial Neural Network"
4. Saleh Ali K. Al-Omari, Putra Sumari, Sadik A. Al-Taweel and Anas J.A. Husain-School of Computer Sciences, University Sains Malaysia "Digital Recognition using Neural Network"
5. Berend Jan van der Zwaag "Handwritten Digit Recognition: A Neural Network Demo" - Conference Paper by in October 2001.
6. Dinesh Kumar J R, Ganesh Babu C, Balaji V R "Analysis of Effectiveness of Power on Refined Numerical Models of Floating Point Arithmetic unit for Biomedical Applications" AIP scopus indexed proceedings of international conference on advances in materials processing and characterization. ICAMPC 2019
7. J R Dinesh Kumar et al "Performance investigation multiplier for computing and control allplications", JRDCS,2019.
8. Juan Manuel Alonso-Weber,M. Paz Sesmero, German Gutierrez, Agapito Ledezma, Araceli Sanchis "Handwritten Digit Recognition with Pattern Transformations and Neural Network Averaging".
9. Mishra Shailendra, Jagtap Viragkumar "Efficient Recognition of Handwritten Digits using ANN".
10. Saeed AL-Mansoori "Intelligent Handwritten Digit Recognition using Artificial Neural Network".
11. Saleh Ali K. Al-Omari, Putra Sumari, Sadik A. Al-Taweel and Anas J.A. Husain-School of Computer Sciences, University Sains Malaysia "Digital Recognition using Neural Network" .
12. Dinesh Kumar J.R, Ganesh Babu. C, Karthi S.P, Soundari. D.V , Priyadharsini. K "A Novel System Design for Intravenous Infusion System Monitoring for Betterment of Health Monitoring System using ML- AI" IJRTEE, 2649-2655, 2020
13. S. M. Shamim, Md Badrul Alam Miah, Angona Sarker and Masud Rana "Handwritten Digit Recognition using Machine Learning Algorithms" .
14. Ulrich H.-G.Kreßel, The Impact of the Learning–Set Size in Handwritten–Digit Recognition.
15. Malar, A.C.J., Kowsigan, M., Krishnamoorthy, N., Karthick S, Prabhu E, Venkatachalam K, "Multi constraints applied energy efficient routing technique based on ant colony optimization used for disaster resilient location detection in mobile ad-hoc network" Journal of Ambient Intelligence and Humanized Computing (2020). https://doi.org/10.1007/s12652-020-01767-9
16. V.R. Balaji, Maheswaran S, M. Rajesh Babu, M. Kowsigan, Prabhu E., Venkatachalam K, "Combining statistical models using modified spectral subtraction method for embedded system," Microprocessors and Microsystems, Volume 73, 2020,