Hand Written Bangla And English Digit Recognition.

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1. Introduction:

Handwriting recognition is the ability of a machine to receive and interpret handwritten input from multiple sources like paper documents, photographs, touch screen devices etc. Recognition of handwritten and machine characters is an emerging area of research and finds extensive applications in banks, offices and industries. In this project, We developed a machine learning program which is able to recognize human's handwritten English digits (0 to 9) and Bangla digits (০ to ৯) from pictures. The learning algorithm we used is "Artificial neural network" ANN, which is a computational model inspired by animals' central nervous systems. The input pictures should be processed to only black-white color with a fixed number of pixels. The predict function will be able to output the prediction of any pictures of handwritten digit based on weight vectors of the neural network. We will obtain the weight vectors by training the neural network with a set of pictures (training set) of handwritten digit.

Before computers existed, all the information was stored in written form, which is very inefficient form of storage as the paper information cannot be stored for a long time and can get lost or destroyed. On the contrary, information on a computer is stored safely for a long time, and multiple copies of same information can be made quickly. Thus after inventing the computers lot of money was wasted in manual labor for converting this paper information into digital information. Instead, machine learning can be used to identify and convert this paper information into digital information without human intervention or manual labor. Our project is just an introduction to this approach.

Handwritten digit recognition is already widely used in the automatic process in banks , postal offices and some of the existing systems. But it is still a challenging project for us to process all the data as we are working with both English and Bangla digits.

The handwritten digits are not always of the same size, width, orientation and justified to margins as they differ from writing of person to person, so the general problem would be while classifying the digits due to the similarity between digits such as 1 and 7, 5 and 6, 3 and 8, ৫ and ৬ etc. This problem is faced more when many people write a single digit with a variety of different handwritings. Lastly, the uniqueness and variety in the handwriting of different individuals also influence the formation and appearance of the digits.

2. Related Works :

There are few works available on Bangla digit recognition who reaches remarkable result in Bangla Handwritten digit recognition. “Handwritten numeral databases of Indian scripts and multistage recognition” works on mixed numerals [1]. The main feature of their model includes matra (the upper part of the character), vertical line and double vertical line and for the MLF classifier, the feature is constructed from the stroke feature of the characters.
“Automatic Recognition of Unconstrained Off-Line Bangla Handwritten Numerals” [2] is concluded with some good research work. The proposed method mentioned, used to extract features from a concept called water reservoir. It was implemented and continued further use in postal automation sector.
Another work is “Handwritten Bangla Digit Recognition Using Deep Learning”[3]. Where a CNN model was used, that achieves 98.78% accuracy on CMATERDB 3.1.1 datasets.
In this paper we proposed system that able to efficiently recognize the offline handwritten digits with a higher accuracy than previous works done. This system is capable of recognizing English , Bangla digits at a time.

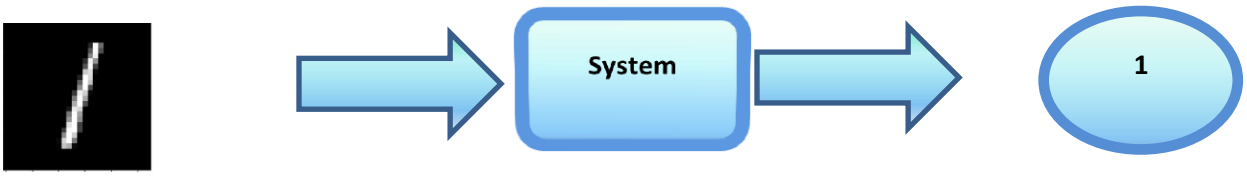
3. Project Objective :

3.1.

This application is useful for recognizing all digits(English , Bangla) given as in input image. Once input image of digit is given to proposed system, then it will recognize input digit which is given in image. Recognition and classification of digits are done by Artificial Neural Network .The main aim of this project is to effectively recognize a particular digit of type format using the Artificial Neural Network approach.

Fig 3.1: Task flow chart.

3.2:



Sample Input **Sample Output**

Fig 3.2: Sample Input & Output.

4 Methodologies / Model:

4.1 preprocessing: Each image is resized to 28 x 28 pixels, as required. Intensity normalization is performed on every Image, which results in images having pixel values in the range -0.5 to 0.5. This normalization of pixel intensities make the network easier to train.

4.2 Feature Extraction: Each 28 x 28 image is flatten into 28*28=784 dimensional vector. This vector represents the normalized intensity values. This vector is taken as feature to pass into the Neural Network.

4.3 Model: Model consist of 3 layers . 1st layer has 784 neurons with relu as activation. 2nd and 3rd each of the layer has 64 neurons and relu function for activation. output layer has 20 neurons and softmax function for activation. Also has 1 input layer . Output layer will produce probability of each class.

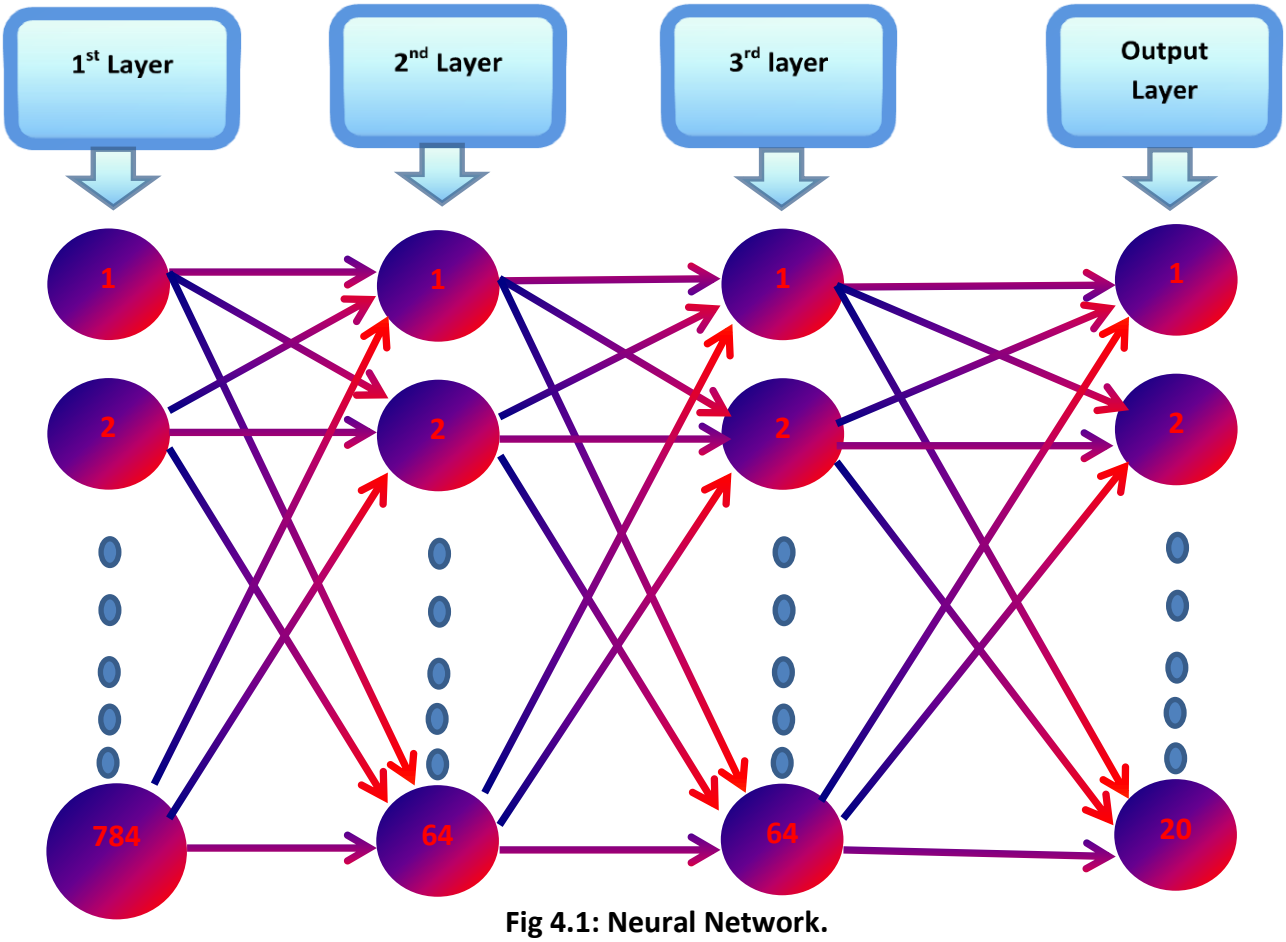


Fig 4.1: Neural Network.

5. Experiments:

5.1.1.Dataset: Dataset of English digit is taken from MNIST dataset and we took only around 2000 samples per class ,and Bangla digits are downloaded from internet. Dataset contains Image of digits .

Dataset has total 19748 images of Bangla digit and 20000 images of English digit .We converted both dataset's 28 × 28-pixel image into a 784 + (1 label) D matrix and store all the image pixels into a CSV file to reduce hard disk read and fast computation. Also, perform a normalization to reduce the effect of illumination differences.

Table 5.1

Class	Total Image	Class	Total Image
0	2000	০	1982
1	2000	১	1982
2	2000	২	1953
3	2000	৩	1975
4	2000	৪	1980
5	2000	৫	1968
6	2000	৬	1981
7	2000	৭	1958
8	2000	৮	1984
9	2000	৯	1967

5.1.2 Samples: Here left side image represent Bangla digit ১ with class label and left side image represent English digit 1 with class label

Fig 5.1: Sample Image With Class Label.

5.1.3 Train / Valid / Test split: The Dataset has total 39748 images. First we have divide the dataset and allocated 80 percent data for training and 20 percent data for testing . Again we divide the testing data and allocate 50 percent for testing and 50 percent for validation. So, 31798 images are used for training, 3975 images are used for Validation and 3975 images are used for testing.

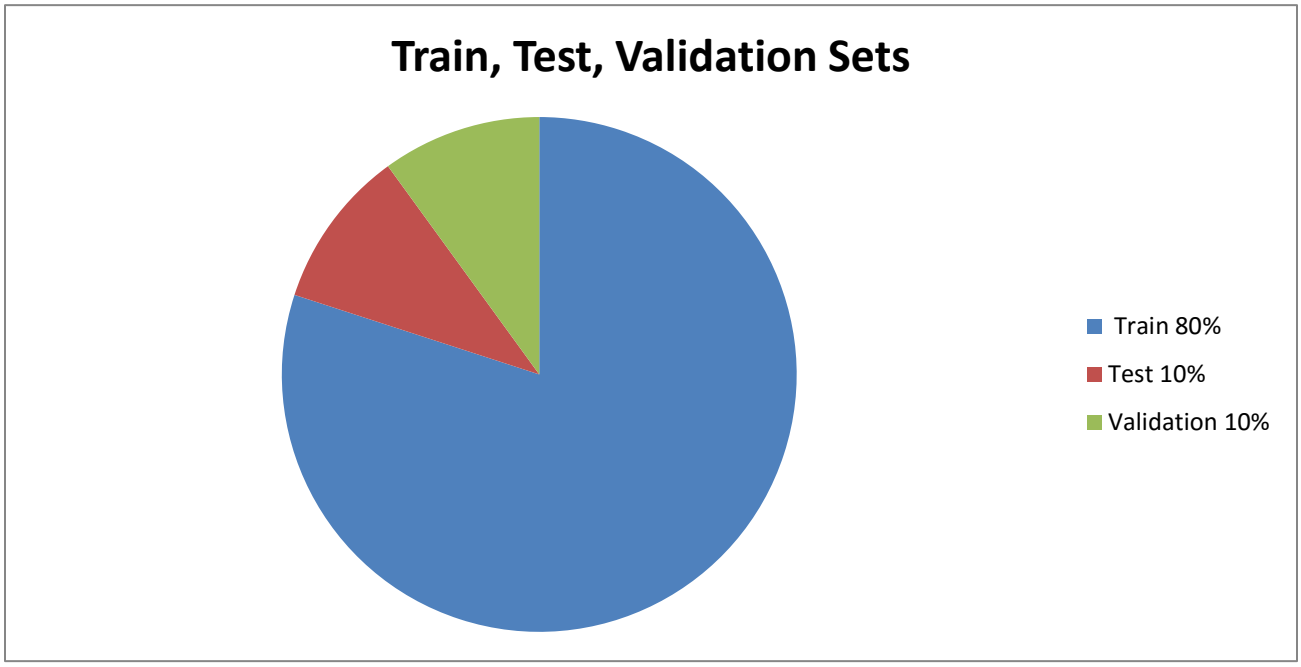


Fig 5.2: Train,Test Validation Split.

5.2 Evaluation Metric : Evaluating machine learning models or algorithms is essential for any project. There are many different types of evaluation metrics available to test a model. These include classification accuracy, logarithmic loss, confusion matrix, and others. A confusion matrix gives us a matrix as output and describes the complete performance of the model. Precision ,recall for each of the class and confusion matrix is given below . In confusion matrix x axis represents predicted value and y axis represents true value

Table 5.2

Class	Precision	Recall	Class	Precision	Recall
0	0.97	0.98	০	0.98	0.92
1	0.97	0.98	১	0.90	0.86
2	0.99	0.97	২	0.94	0.96
3	0.97	0.92	৩	0.93	0.91
4	0.97	0.96	৪	0.88	0.91
5	0.96	0.96	৫	0.89	0.93
6	0.95	0.96	৬	0.91	0.88
7	0.99	0.96	৭	0.96	0.98
8	0.92	0.94	৮	0.90	0.95
9	0.92	0.95	৯	0.85	0.84

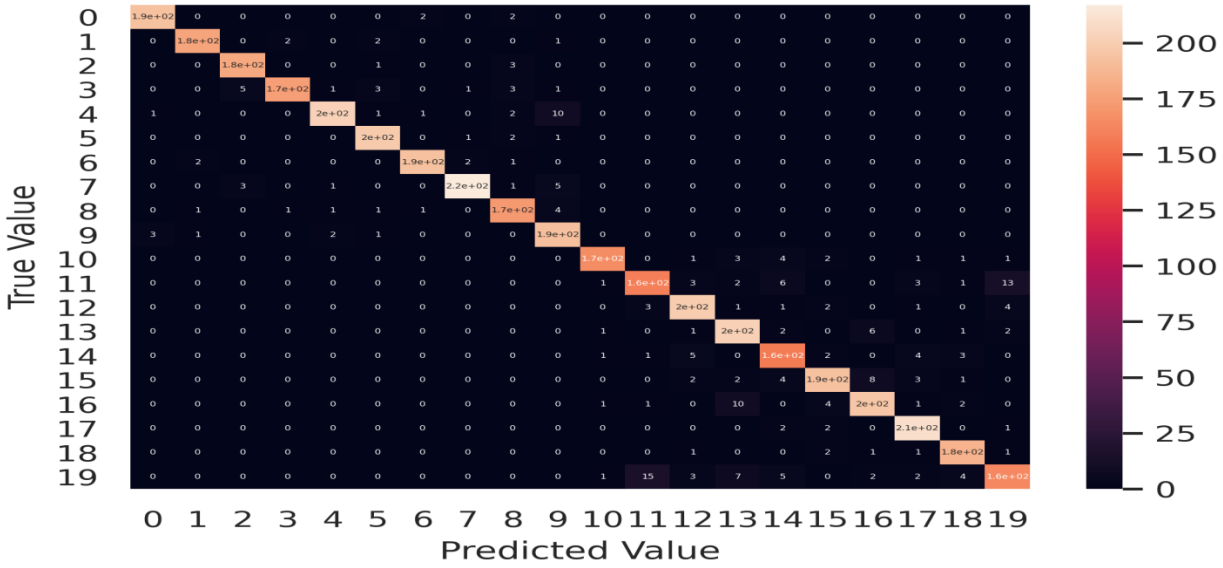


Fig: 5.3 :Confusion Matrix.

5.3 Result: We start with model having 2 hidden layer ,1 output layer and batch size=100 for which we get 96.82 percent training accuracy at epoch 50 ,91.80 percent validation accuracy and 91.37 percent test accuracy.

Then we start tuning hyper parameters . We can see from the table 5.3 that in 1-3 no cases as we increases the batch size training accuracy increases but validation and test accuracy decreases .

Then we take model having 3 hidden layers and 1 output layers .We can see from the table 5.3 that un 4-9 no cases as we decreases the batch size training accuracy , validation accuracy and also the test accuracy increases .

For both of the model we can see epoch 50 give highest training accuracy. We get highest test accuracy 93.61 percent in case 9 where batch size=20 and model having 3 hidden layers .

Table 5.3

Case	Hidden Layer + Output Layer	Batch Size	Training Accuracy						Validation Accuracy	Test Accuracy
			Epoch	%	Epoch	%	Epoch	%	%	%
1	3	100	1	30.20	25	93.58	50	96.82	91.80	91.37
2	3	200	1	97.14	25	98.27	50	99.04	93.33	92.72
3	3	500	1	99.17	25	99.41	50	99.56	93.58	92.65
4	4	500	1	24.09	25	92.39	50	95.23	85.96	85.55
5	4	200	1	90.44	25	96.71	50	97.97	92.23	91.79
6	4	100	1	94.85	25	98.30	50	99.25	92.91	92.75
7	4	50	1	98.31	25	99.50	50	99.64	92.96	92.80
8	4	40	1	99.55	25	99.80	50	99.60	94.14	93.20
9	4	20	1	99.11	25	99.57	50	99.69	94.62	93.61

6. Conclusion :

In this project, we used Artificial Neural Network (CNN) for English and Bangla handwritten digit recognition which shows a good performance to recognize most of the input digits. We had chosen ANN because ANN eliminates the need for manual feature extraction, so we did not need to identify features used to classify images. We had achieved 93.61% accuracy which was a good result for large and unbiased dataset comparing other Numeral sets. For our project purpose, Keras (which uses TensorFlow backend) library was used with ANN which was a recent development in the pattern recognition field.
In future, with more resources and bigger ANN architecture, we may achieve a better result and improve the state of the art for English and Bangla handwritten basic characters, digits, and all other compound characters recognition. After further development of this project we are willing to integrate it with a kids learning mobile app.

REFERENCES:

[1]. Bhattacharya, U., Chaudhuri, B.: Handwritten numeral databases of indian scripts and multistage recognition of mixed numerals. IEEE Trans. Pattern Anal. Mach. Intell. 31, 444–457 (2009). https://doi.org/10.1109/TPAMI.2008.88.

[2]. Pal,U.,Chaudhuri,B.:AutomaticRecognitionofUnconstrainedOff-LineBanglaHandwritten Numerals 1948, 371–378 (2000). https://doi.org/10.1007/3-540-40063-x_49 .

[3]. Alom, Md.Z., Sidike, P., Tarek, M.T., Asari, V.: Handwritten Bangla Digit Recognition using Deep Learning (2017).