BANGLA HAND WRITTEN NUMERAL DIGIT RECOGNITION USING DEEP LEARNING.

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project/internship titled **"Bangla Hand Written Numeral Digit Recognition Using Deep Learning"**, submitted by Yeachir Arafat, Shakaut Kader, Al Amin Rhyad, ID No: 161-15-7459, 161-15-6933, 161-15-7094 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 07 December 2019.

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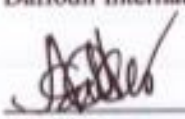

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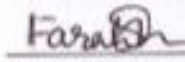

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We hereby declare that, this project has been done by us under the supervision of **Mr. Majidur Rahman, Lecturer, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

As per the present scenario of Bangladesh, it can be stated that most Multi-National Companies (MNCs) or other sectors primarily use analogue etiquettes or hand-written forms. Moreover, the information being inscribed in those forms has to be re-input by a person inside the digital machine for further purpose. On the other hand, the existing hand-written models are using the erstwhile deep-learning algorithm which can hardly be labeled as compatible to the newer requirements. Although they serve the generic necessities regarding primal digit recognition, they are unlikely to provide the companies with significant accuracy in complex situations. This supposedly occurs due the lack of versatile training dataset in this kind of software. This paper investigates the prospects of an alternative solution namely the Convolution Neutral Network (CNN) as the proposed hypothesis. This probable mechanism may ensure an accuracy more than 96% compared to the former counterparts, particularly in regards with the most challenging and noisy cases. Using deep neutral network like the propounded CNN solution may fuse the gaps vis-á-vis the question of efficiency on the digital platform. From all around Bangladesh, approximately 72000+ specimens for training dataset have been collected along with 1700+ for the test dataset which can be depicted to have more accuracy than all other existing forms of solutions. Among the 14000+ specimens being used, there are ample amounts of noisy dataset included as well which can ensure the paramount accuracy in the least expected contexts. In this paper, a comparative analysis will also be presented explaining how the proposed model does have the best precision tactics in contrary with the other options. The objective is to provide a worthwhile courseware for the industrial, marketing and other interacting platform where quantitative and qualitative information require a distinct degree of accuracy.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Recognition of handwritten numerals and characters has a huge interest in computer vision research. The interest developed because of its various applications. This recognition of handwritten numerals and character can use in different fields like- optical character recognition (OCR), number pate recognition, license plate recognition, automatic passport read and so on. Recent progress in machine learning due to the bloom of beep neural network. Showing promising result by harnessing the power of big data. Now character and numeral defecation also be greatly benefited from deep learning. Many people proposed and introduce their work to develop the feature for handwritten Bangla numeral recognition system.

The main motive of machine learning is to sense remember, learn and recognition like a human being. Deep learning is method is one of the best methods of machine learning. With the definition of perception, the idea of deep learning method issued, since 1950s. From those days the deep learning algorithms have been improved, the resemblance of the architecture to the biological neural networks has been increased. In handwritten text recognition a complete document processing system should include. Beside this most of the existing systems have been privatized towards the application. The success of deep neural network in handwritten digit recognition motivated us to use them also to decide vertical cuts for segmentation of digit strings by training the regions between the digits.

1.2 Motivation

We know there is a number plate available in every car. While working with this concept we saw the number plates are not only in English but also available in Bengali in our country. In other developed countries there are many project on this concept. But they all worked on their own language. In Bangladesh we didn't see much workable project on number plate detection. So get interested to work on number plate detection concept.

1.3 Problem Definition

At the first time our main target was number plate detection. But while started working we face some difficulties for detecting number plate. Because in our country most of our number plates are in Bengali. Then we thought we should work with Bangla digit recognition. For this we start to work with Bangla number recognition. And another problem is 1st time we are working with deep neural network but after some days we realize it's not given us better result what we exactly needed. That's why we are working with VGG19 for this project.

1.4 Research Question

To doing this project we didn't face any question. Most of the people are facing question for collecting data set. But our data is a ready dataset we collect it from NamtaDB.

1.5 Research Methodology

At first we collect data from NamtaDB and then after preprocessing we applied these data in code. To get input we have done image preprocessing to convert them in gray scale. We have tried many approaches and most of the approaches are CNN based. At last we got output using VGG19 network. The result we got using VGG network, which is trained more than a one million images. So using this we got it our final output. And we got most accurate output while using VGG19 which is above 99%.

1.6 Research Objective

In Bangladesh digit recognition is not use enough to identify vehicle number plate and research is not sufficiently done yet. That's why we are interest to work using with machine learning. We want to build a model to identify vehicles number plate

1.7 Report Layout

This segment traces the parts of each step that we utilized in our report in short.

1. Chapter -1: Introduction
2. Chapter -2: Background
3. Chapter -3: Research Methodology
4. Chapter -4: Result & Observation
5. Chapter -5: Conclusion & Future Work
6. Chapter -6: References

CHAPTER 2

BACKGROUND

2.1 Related Works

In present advancement in AI because of the sprout of profound neural system demonstrating promising outcome by outfitting the intensity of huge information. Character and numeral discovery like Bengali numeral and character acknowledgment can likewise be significantly profited by profound learning.

Subhadip Basu proposed Dempster-Shafer (DS) is a technique which is the combination of classification choices obtained from 2 Multi-Layer Perceptron (MLP) primarily based classifiers for optical character recognition (OCR) of written Bangla digits exploitation 2 totally different feature sets. Using this technique they get 95.1% result which was great. [1]

Aldo Md Shopon was proposed Recognition Using Auto encoder and Deep Convolutional Neural Network. This paper presents the use of unsupervised pre-training using auto encoder with deep ConvNet in order to recognize handwritten Bangla digits, **0 - 9.** The datasets that are used in this paper are CMATERDB and dataset published by the Indian Statistical Institute (ISI) [2]

There's many way for a good result like Hierarchical Bayesian Network Using these network get its gives 87.5% accuracy in tested on untrained images and hand-drawn digit [3]

In very recent time one of author using Deep Convolutional Neural. Which is very much similar our project. Using these gives very promising result it's almost 96%. [4]

A novel pattern classification approach kernel and Bayesian discriminant based classifier. Solving the matrix inverse substituted by a small threshold. Using this it is promising in practical applications. [5]

From Cheng-Lin Liu∗, Kazuki Nakashima research paper we can found that,they use the CENPAMI digit database ,which was the CEDAR digit database . The two database were written

by totally different and show different styles the CENPARMI database has been very widely tested and achieved high accuracies. [6]

Yuchum Lee research paper we can found that, the database was contains 30,600 training and 5060 testing patterns. The results reported represent the best performances. [7]

Hiroshi Sako, Hiromichi Fujisawa research paper we saw that they use NIST database. From their they found height classification accuracy. [8]

Tasnuva Hassan's research paper they proposed method on Handwritten Bangla Numeral database CMATERdb.The test content 1000 randomly character selected image -100 test images per digit. For this they achieves height accuracy for character recognition. [9]

B. Boser, J. S. Denker research paper they use Zip-code database. The recognition is entirely performed by a multi-layer network. The method has 1 % error rate and about a 9% reject rate on zip code digits provided. [10]

2.2 Bangladesh Perspective

Number recognition system can be used in different sectors of our government and non-government activities. Through the system we can scan any kind of number. In Passport or NID office when we go with a problem we see officials input our id's manually. Sometimes it causes dangerous problem by giving wrong input of id. Manually inputting number of id also causes waste of time. So if we can take input using number recognition system it can save our times as well as wrong inputs. Through the Number Plate recognition system, we can get any car information also. If we can use this in our office activities, it will be useful for everyone. Number recognition system can be used in any sector of work. We can use it in digital banking, Passport office and NID office. It will save our time. If we can implement Number recognition system successfully each and every people will be benefited through the system.

CHAPTER 3
RESEARCH METHODOLOGY

3.1. Introduction

In this project our Dataset was quite heavy. For this reason, we are self-contained also to have relax for our project accuracy. Approximately 72,000+ specimens are for training dataset and 30,000+ specimens are for test dataset. Overall above 1,10,000+ specimens is existing on our dataset. This heavy amount of dataset actually a mental strength for us.

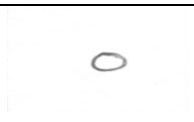
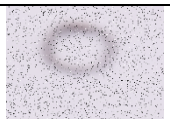
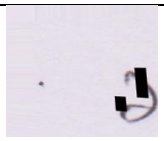
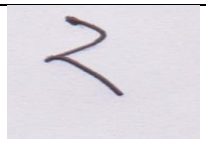
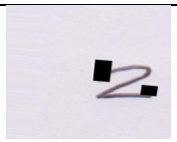
3.2. Working Procedure of Project

About to our project, we try to find out the specific single digit which one input in our program. Our project should able to specified all the numeral digit. To complete the task of ours we don't have to panic with the data set. We feel so lucky for that. Our expected dataset was already prepared in NamtaDB. In this dataset 0-9 all digits are there with various augmented situations. There are 4 kind of variety in dataset like Boxed noise added with digits, Blur effect added with digit images, some of are totally Clean images and most important was Salt paper noise. With this noise our dataset also implemented. We can say our dataset was totally self-contained. Which was really helpful for get proper accuracy in Machine Learning projects.

In our project we firstly defined a model that concrete with the training and test data set. And that model does our desire work. That model consists with 3 stage of part. 1St is Preprocessing the Data. 2nd is Segmentation Data. Last and 3rd is Classification Respectively our required.

TABLE 1

INTRODUCTION OF TRAIN DATA AND TEST DATA

Bengali	English Equivalent	Train Data	Test Data	
০	0			
১	1			
২	2			
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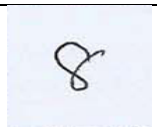
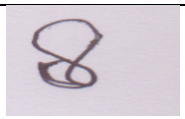
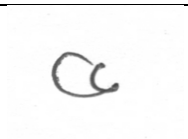
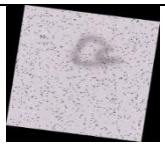
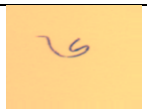
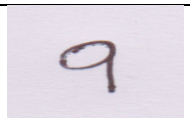
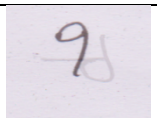
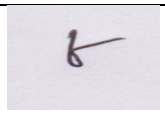
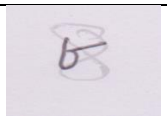
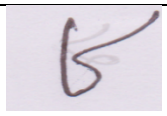
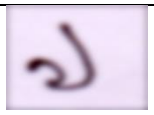
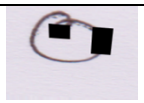
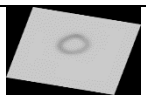
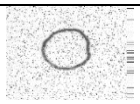
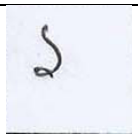
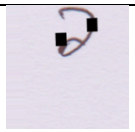
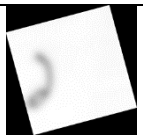
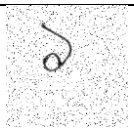
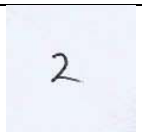
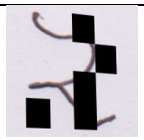
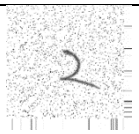
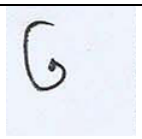
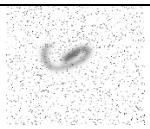
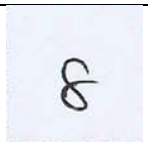
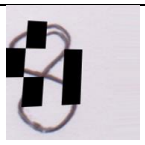
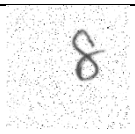
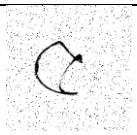
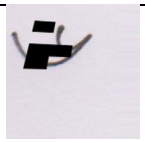
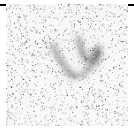
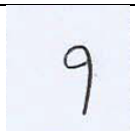
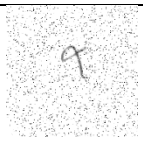
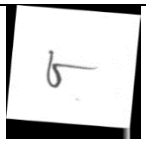
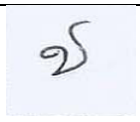
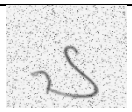
৪	4			
৫	5			
৬	6			
৭	7			
৮	8			
৯	9			

TABLE 2

INTRODUCTION TO VARITY KIND OF DATASET

Bengali	English Equivalent	Clean	Boxed	Blur	Salt Pepper noise
০	0				
১	1				
২	2				
৩	3				
৪	4				
৫	5				
৬	6				
৭	7				
৮	8				
৯	9				

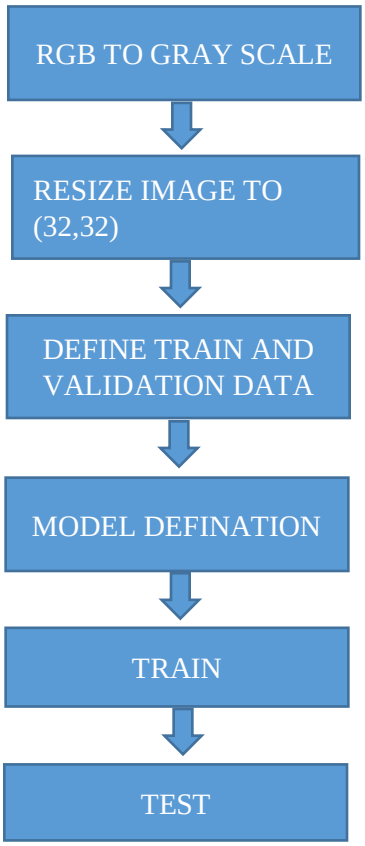


Figure A1. Working Procedure of our project.

Convolutional Neural Network:

Convolutional Neural Network(CNN) an Artificial Intelligence unit calculation or algorithm, for regulated learning, to dissect information. It's about to deep dive of Artificial Neural Network. Intended to perceive visual patterns straightforwardly from pixel images with negligible preprocessing. It recognizes the corners of the object. The CNN figures out how to do this all alone. There is no exceptional guidance for the CNN to concentrate on progressively complex articles in more profound layers. That is exactly how it ordinarily works out when you feed training data into a CNN. Most generally applied to breaking down visual symbolism. CNN is the most powerful innovation field of computer vision. The concealed layers of a CNN as a rule incorporate convolutional layers, pooling layers, completely associated layers, and standardization layers.

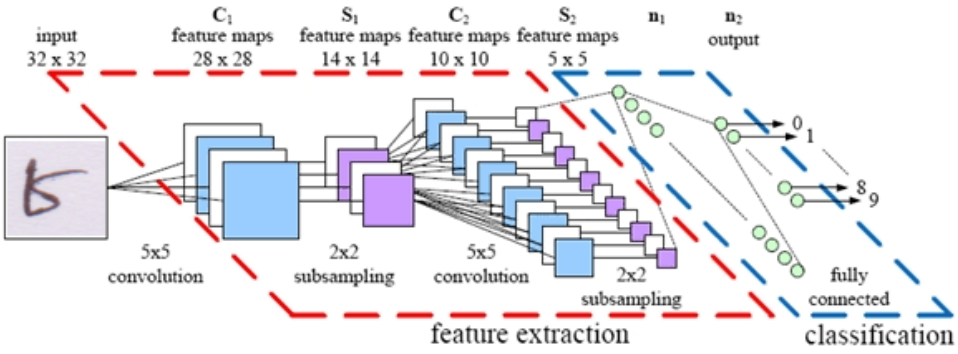


Figure B2. Convolutional Neural Network.

CHAPTER 4

Experimental Results and Discussion

4.1. Experimental Results

At an early age of our project after selecting our dataset we decided to use many type of models on CNN, like Lenet-5, AlexNet, ZFNet, GoogleNet/Inseption, VGG, REG etc etc. We actually already tried almost all of the models of CNN can handle. But we kept moving to changing model one to one. Because of that's the only reason by what we can understand which model exist with best accuracy above all models. And which model actually perfect for our project. We also used for Deep CNN. That model also helped us to get a better accuracy for our project. But we didn't stop here, we kept trying to get an overall best accuracy for this project.

After all, we get the last two models whose accuracy is really good for us and for our project accuracy. And also sufficient from all side for any machine learning project. Those are Lenet-5 and VGG19.

4.2. Descriptive Analysis

Let's a deep dive about those selected model for our project. First go though from Lenet-5.

Lenet-5:

Lenet-5 was invented in 1998. This model was too old. This model is too popular still now for hand written number recognition. This model works with 7 Convolutional layers and 32'*32' size of images. Also with gray scale. For this gray scale and low image size at preprocessing data was light on this model. It's have about 60 Thousand parameters. Lenet-5 also deals with high regulation images, for this deal this model needs to add more layers in operations. This was quite time consuming also.

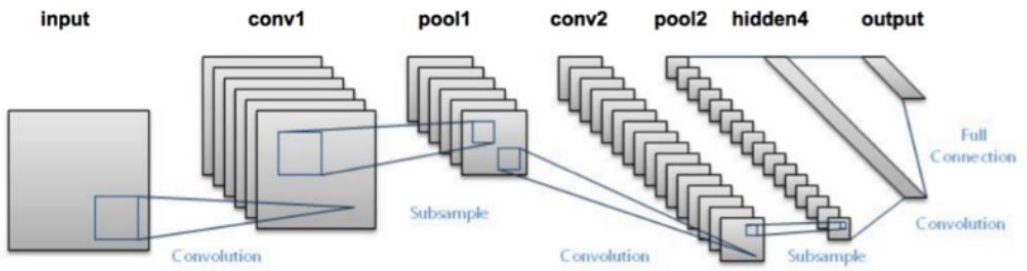


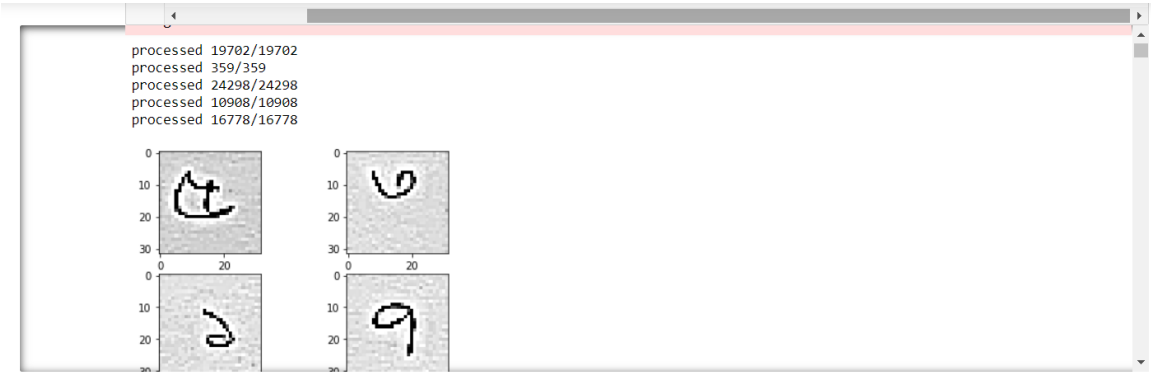
Figure C3. Lenet-5 (1998).

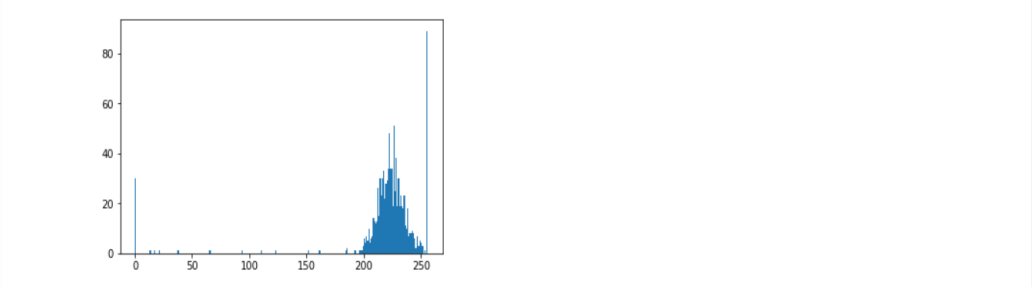
Ok then let's talk about implementation Lenet-5 in our project. Here some screen shots of training Period.

We used Epoch 30 times for last few training. Before that we used to 50,80,100 times also. But now we are able to get accuracy above 98% using this model with 30 Epoch only. We were actually worried about how much our data loss would be. And this model ended our anxiety about value loss. This model took the most lower value loss.

```
Train on 57636 samples, validate on 14409 samples
Epoch 1/30
57636/57636 [==============================] - 828s 14ms/step - loss: 0.7116 - acc: 0.7519 - val_loss: 0.2463 - val_acc: 0.92
75
Epoch 2/30
57636/57636 [==============================] - 765s 13ms/step - loss: 0.1500 - acc: 0.9573 - val_loss: 0.1492 - val_acc: 0.95
97
Epoch 3/30
57636/57636 [==============================] - 765s 13ms/step - loss: 0.1050 - acc: 0.9715 - val_loss: 0.1900 - val_acc: 0.94
79
Epoch 4/30
57636/57636 [==============================] - 762s 13ms/step - loss: 0.0764 - acc: 0.9776 - val_loss: 0.1234 - val_acc: 0.96
72
Epoch 5/30
57636/57636 [==============================] - 764s 13ms/step - loss: 0.0710 - acc: 0.9804 - val_loss: 0.1146 - val_acc: 0.96
57
Epoch 6/30
57636/57636 [==============================] - 762s 13ms/step - loss: 0.0551 - acc: 0.9844 - val_loss: 0.0821 - val_acc: 0.97
```

Here is the value loss and accuracy of Lenet-5 model.





This is our expected result of training respected Lenet-5 model.

Lenet-5 prediction label.

VGG19:

VGG model have a unique 'Uniform Architecture'. For this uniqueness VGG can consist with 16 convolutional layers. This model combined with AlexNet and similar many models and many filters. It's have about 138 Million parameters for executing. Now-a-days this model is the most preferred model for its accuracy.

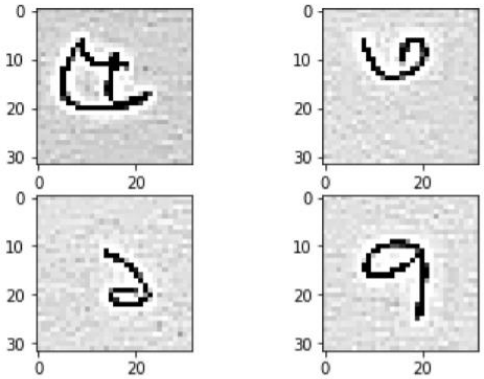
After implementing this model, we got an unbelievable result. It's contain almost 100% prediction level. We astonished about this training. After that result we motivate to write a paper for comparison with existing paper.

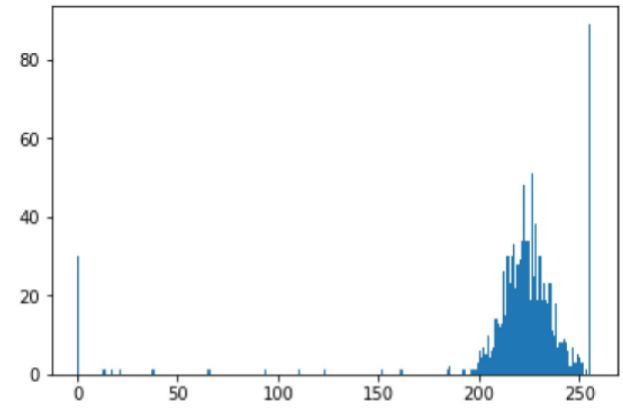
Figure D4. VGG16 Model.

```
Train on 57636 samples, validate on 14409 samples
Epoch 1/30
57636/57636 [==============================] - 824s 14ms/step - loss: 0.5126
- acc: 0.8254 - val_loss: 0.1271 - val_acc: 0.9629
Epoch 2/30
57636/57636 [==============================] - 814s 14ms/step - loss: 0.1158
- acc: 0.9690 - val_loss: 0.1653 - val_acc: 0.9536
Epoch 3/30
57636/57636 [==============================] - 832s 14ms/step - loss: 0.0888
- acc: 0.9771 - val_loss: 0.0785 - val_acc: 0.9788
Epoch 4/30
57636/57636 [==============================] - 854s 15ms/step - loss: 0.0697
- acc: 0.9812 - val_loss: 0.0814 - val_acc: 0.9799
Epoch 5/30
57636/57636 [==============================] - 849s 15ms/step - loss: 0.0627
- acc: 0.9830 - val_loss: 0.0831 - val_acc: 0.9808
Epoch 6/30
```

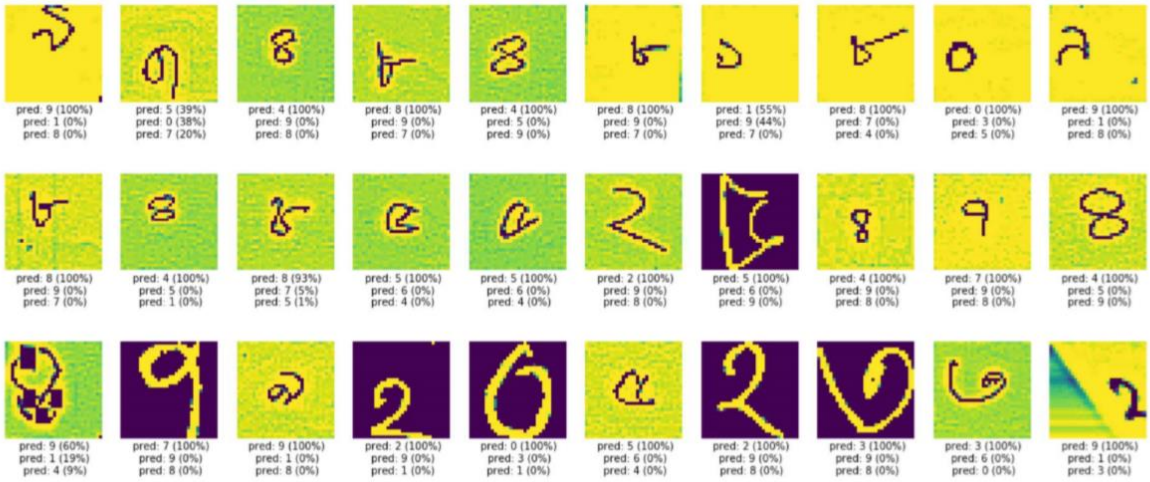
in this screen shot of training the model.

```
processed 19702/19702
processed 359/359
processed 24298/24298
processed 10908/10908
processed 16778/16778
```





Load Dataset from directory.



Our model(VGG19) prediction label.

CHAPTER 5
CONCLUSION AND FUTURE WORK

This project helped us to get a deep dive with this hand written number recognition. Our main motive is about this project are, 1. Detect vehicle bangla number plates, 2. Read the road sign for upcoming future invention self-driving car, 3. A reader for NID number, Passport Number, Birth certificates. Which one can read/scan moreover 1000+ documents in a minute. We are motivated from these ideas.

But all of this are consist of not a single number it's consist of a string. There's consist of loss of number. In this project we just working with single digit recognition, in future we will work with string. So how it'll be works in future? Most of the time people fill up the form with hand written then someone entry this number on the data server. Our plan is just scan number from the paper and it's automatically take these number. In future this project will help us. If govt. takes this project, it'll be a good result for every people.

We researched about bangla vehicle number plate recognition at early age of this project. That time we faced a major problem. That was, bangla number plates are consists with 2 line. Bangla number plates are not like other countries number plate. Outside of Bangladesh all countries consist their number plate with a single line of text. That's why they all can use a similar solution for single line text. This is why we are taking time to prepared ourselves more over for this project.

We also interested to do street sign detect for future self-driving car. For self-driving car it's too important thing to detect the turn, speed breaker, in-front of school, etc. If we done this work, then we will be pleased.

The recognition results reported in this paper show what accuracy the current feature extraction and classification techniques can achieve in handwritten digit recognition. In this paper used different machine learning algorithm for recognition. Handwritten digit recognition using CNN networks. The reported results provide useful insights for selecting right implementation options in developing recognition systems.

CHAPTER 6
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