"Handwritten Digit Recognition"

A Project Report Submitted to
Gujarat Technological University in Fulfillment of the Requirements for the Degree of
Bachelor of Engineering
In
Information Technology

B. E., Semester VIII

By

Group ID: 119471

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Department of Information Technology
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COLLEGE CERTIFICATE

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This is to certify that the project entitled “Handwritten Digit Recognition” has been carried out by MANTRA JOSHI (170110116017), KASHYAP PATEL (170110116039) and DEEP PATEL (170114116001) under my guidance in partial fulfillment for the degree of Bachelor of Engineering in Information Technology (8th Semester) of Gujarat Technological University, Ahmedabad during the academic year 2020-21.

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Business Model Canvas (Report)	**Completed**
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Periodic Progress Reports (PPR)	**Completed**
Business Model Canvas (Image)	**Completed**
Business Model Canvas (Report)	**Completed**
Patent Drafting Exercise (PDE)	**Completed**
Final Plagiarism Report	**Completed**
Final Project Report	**Completed**

Name of Student : Patel Deep Manojkumar Name of Guide : Mrs.Patel Miral Pritesh

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ABSTRACT

The handwritten digit recognition is the power of computers to recognize human handwritten digits. For machine it is a hard task because handwritten digits are not perfect and can be made with thousands of different ways. The solution is handwritten digit recognition to the problem which uses the image of a digit and recognizes the digit present in the image. The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network. It is easy for humans to identify the digits but machines cannot. It is mandatory to train our machines so that it can be identified by machine as well. Our main goal is to create a model that can easily recognize the digits, it can be extended to letters and to the individual's handwriting. For this project first thing is understanding Convolutional Neural Network and applying it to the handwritten recognition system.

Before Computers Existed All the information was stored in Written form. This is very Inefficient form of Storing data as the paper Information cannot be stored for very long time and can get lost or be destroyed in some or the other way. As we know that Information on computer can be stored for long time and multiple copies of same information can be made easily. Before the computers were invented, money was wasted in manually converting this paper information into digital form of information. Machine learning and deep learning can be used to identify and convert this paper information into digital format without human intervention or manual labour. This project is just an introduction to this approach.

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A Project Report

Submitted By

Mantra Joshi	Enrollment No.170110116017
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In fulfilment for the award of the degree

Of

BACHELOR OF ENGINEERING

In **Information Technology**

Semester 8th (4th year)

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Department of Information Technology

G H Patel College of Engineering & Technology

Vallabh Vidyanagar, Gujarat

GUJARAT TECHNOLOGICAL UNIVERSITY

AHMEDABAD

April 2021

CHAPTER: 1

INTRODUCTION

1.1 Introduction

Handwritten digit recognition is the ability of a computer system to recognize the handwritten inputs like digits, characters etc. from a wide variety of sources like emails, papers, images, letters.

A lot of classification techniques using Machine Learning have been developed and used for this like K-Nearest Neighbors, Convolution neural network, SVM Classifier, Random Forest Classifier.

For example, if a person goes to deposit the cheque in bank so this can help system to read and recognize the check number and do further task easily. the accuracy in these applications is very critical as the cheque number should be accurate without any error or else there will be many problems in transaction.

Deep learning has become the hot tool for Image Processing, object detection, handwritten digit and character recognition.

1.2 Purpose, Scope and Objective

In earlier times Computers used to store all the information in written forms. As we know that it is inefficient form of Storing data as the paper Information cannot be stored for very long time and can get lost or be destroyed in some or the other way

As we know that Information on system can be stored for long time and multiple copies of same information can be copied easily. Thus, after Invention of the computers, money was wasted converting the handwritten information into digital format.
Machine learning and deep learning can be used to identify and convert the handwritten paper information into digital format without human intervention or manual labour.

Objective is to implement handwritten digit recognition with the help of machine learning algorithms. Our main focus is to implement with Convolution neural network algorithm in order to achieve more accurate output.

Future scope is to extend the model to work on nist dataset
Further we can try to increase the accuracy by implementing more number of hidden layers and/or epochs and detect custom hand written digits
one more thing that can be done is to use cnn with more layers to get better accuracy.

CHAPTER: 2

LITRATURE SURVEY

Title	Author	Publication	Methodology	Conclusion/Result
Image classification using deep learning	Harshali Mane K L University	IEEE	Used AlexNet architecture with convolutional neural networks for this purpose.	From the experiments, it is observed that the images are classified correctly even for the portion of the test images and shows the effectiveness ofdeep learning algorithm.
Class Attendance Portal (CAP) using Face recognition	Rahul Ray , Faisal Khan , Harsh Sharma , Gaurav Kumar	IJRASET	- Importing Libraries and splitting the Dataset: Convolution Neural Network: Building CNN -Training the Network Testing	The online automatic Classroom Attendance monitoring portal helps in increasing the accuracy and high processing speed ultimately achieve the high- precision real-time attendance
High-Speed Tracking with Kernelized Correlation Filters	João F. Henriques, Ruii Casairo, Pedro Mertins, and Jorge Batista	IEEE	-Diagonalize filter with the WDiscrete Fourier Transform. -For linear regression our formulation equivalent to a correlation filter.	Demonstrated analytically model natural image translations, under some conditions the resulting data and kernel matrices become circulant.
How transferable Are features in deep neural networks?	Jason Yosinski, Jeff Clune, YoshuaBengio, and Hod Lipson	IEEE	-Datasets: Random A/B splits -Used Convolutional neural network and layers -Random Weights	We have demonstrated a method for quantifying the transferability of features from each layer of a neural network, which reveals their generality or specificity.
Recognition of Handwritten Digit using Convolutional Neural Network in Python.	FathmaSiddiqe, ShadmanSakib, Md.AbuBakSiddique	IEEE	MNIST Dataset Convolutional neural network and its layers.	The accuracy curves are generated for the six cases for the different parameter using CNN MNIST digit dataset. The six cases perform differently because of the various combinations of hidden layers.
Extraction Method of Handwritten Digit Recognition Tested on the MNIST Database	El Kessab, Daoui, B. Bouikhale, M. Fakir and K. Moro	IJAST	-Acquisition of image -- Pretreatment of image- Pre-processing an important process for recognition digit. -CNN layers	In this work, the neural network is proposed for the classification of the standard base MNIST isolated digit. The recognition rate is 80.00% with a Test database containing 60,000. The method of extraction shows

Handwritten Digit Recognition Using Deep Learning	Anuj Dutt, AashiDutt	IJAR CET	Reading the MNIST Dataset Phase1 - Input MNIST Data1 Phase2 – Building Network Architecture Phase 3 –Fully Connected Layer	An implementation of Handwritten Digit Recognition using Deep Learning has been implemented in this paper. Additionally, most widely used Machine Learning algorithms i.e. RFC, KNN.
Designing of Digits Recognition Technique Using Neural Network	Santosh Deshpande, Mukul Kulkarni	IEEE	Handwritten digits image acquisition. Preprocessing & Extraction Digit classification- Learning through Supervised, Learning through Unsupervised Digit recognition- Multilayer Perceptron MLP – This is feed forward ANN. It consists of minimum 3 layers.	Handwritten digit recognition is important part of pattern recognition. The HDR is challenging because of different writing styles and forms. Some of the different methods like supervise and unsupervised learning are discussed.
Scalable Nearest Neighbor Algorithms for High Dimensional Data	Marius Muja & David G. Lowe	IEEE	Hashing Based Nearest Neighbor Techniques & randomized k-d forest algorithm	We found to work best at fast approximate search in high dimension spaces: the randomized k-d trees and a newly introduced algorithm, the priority search k-means tree.
Densely Connected Convolutional Networks	Laurens van der Maaten & Kiliian Q. Weinbirger	IEEE	Neural Network ,Resnets(Residual Networks), L layer network Dataset- CIFAR-10,CIFAR-100	A new convolutional network architecture is introduced, which we refer to as Dense Convolutional Network. The direct connection between any two layers with the same feature-map size is introduced.

CHAPTER: 3

DESIGN ENGINEERING CANVAS

3.1 AEIOU canvas:

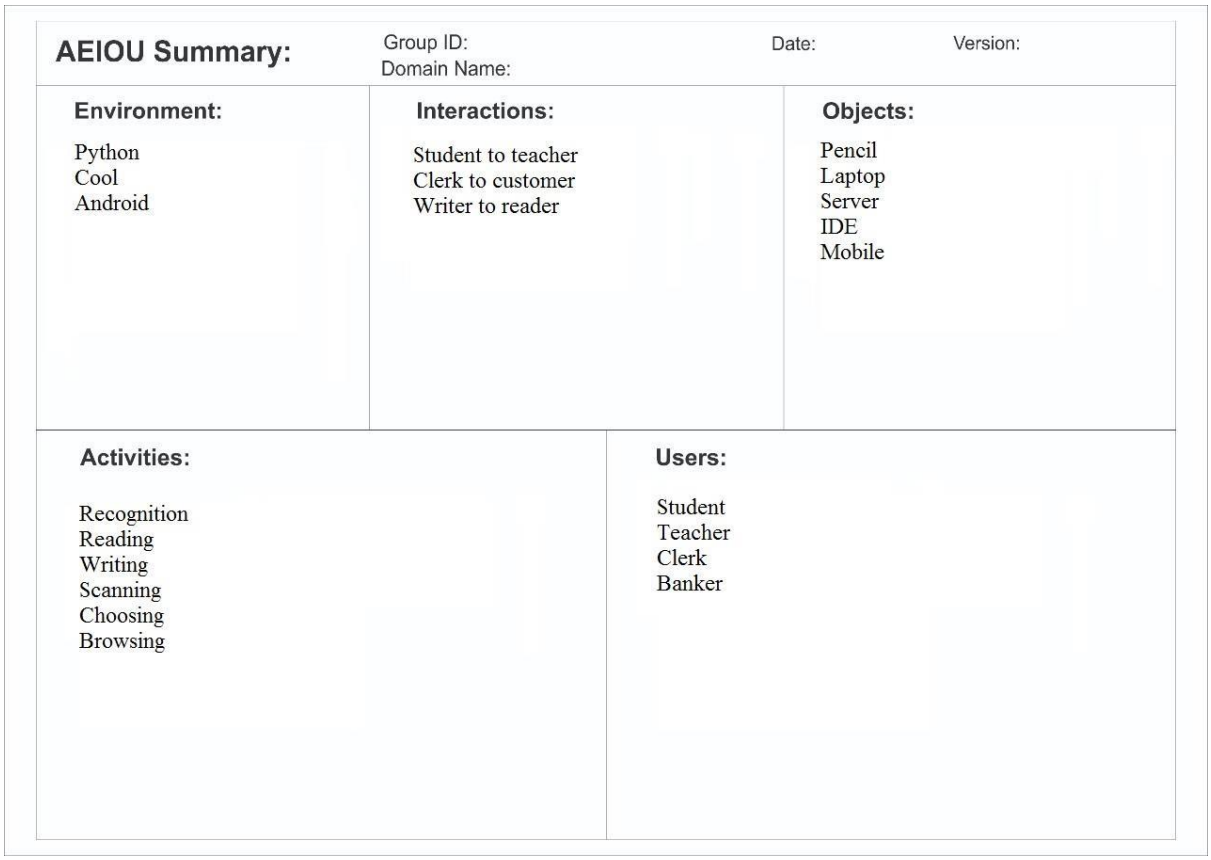


Figure 3.1 AEIOU Summary

The above canvas is an AEIOU Summary about the Activities, Environment, Interactions, Objects and Users. Based on the observations done we were able to draft this summary which includes the situations and the major/minor factors that are responsible for the inactions.

3.2 Product Development Canvas:

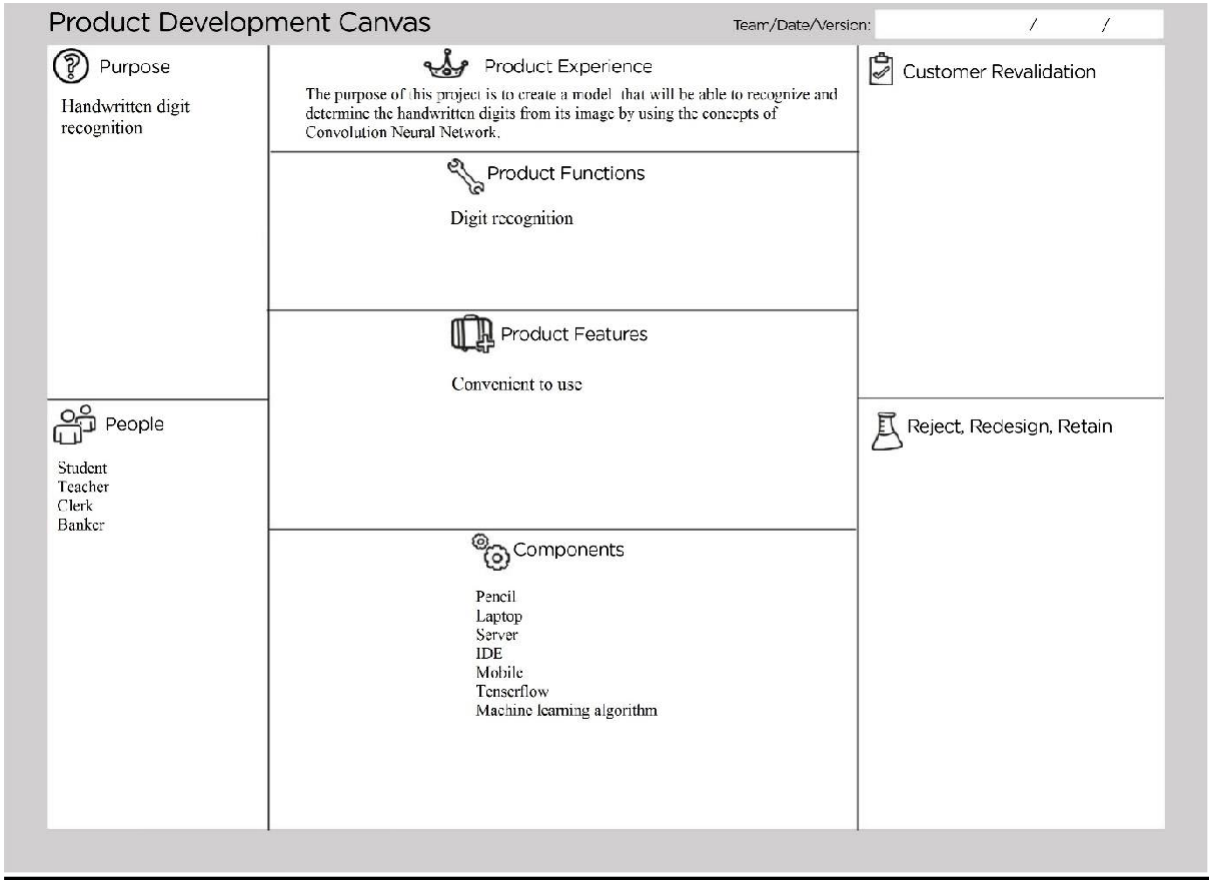


Figure 3.2 Product Development Canvas

Based on the observation in the previous AEIOU summary a particular Ideation can be derived which results into the Ideation Canvas above. This canvas shows the initial idea about the formation of the product and shows that how a particular product should be designed. The factors that will be affecting the development of the product are also included in this canvas.

3.3 Empathy Mapping:

Design For **Design By**

Date **Version**

USER	STAKEHOLDERS
Student Teacher Clerk Banker	Administrative office School

ACTIVITIES

Recognition
Reading
Writing
Scanning
Choosing
Browsing

STORY BOARDING

HAPPY	Each and every institute or school takes exam to evalate the students. Each student is given unique enroll no. and this enroll no. can be scanned and write marks diectly to database.
HAPPY	For selling shares, we need demate account that consist of online details about shares. Coverting that paper information into machine form is tidious task. Here, handwritten digit recongnition can be usefull.
SAD	Computers, laptops are common nowadays, but in ealy life, not everyone could afford it. All details used to be stored in paper form which contains unnecessary documents. This project will overcome that drawback as all documents would be recoverd.
SAD	Bank emloyees need to convert some paper information to machine. This work is ovehead in many other areas/sectors. This project can ovecome that stressful work.

Figure 3.3 Empathy Mapping Canvas

The above canvas shows the empathy part included behind the creation of the project. The canvas includes some short stories that depict the actual case scenarios of the use and need of the product. The scenarios are best show cased using two happy and two sad stories.

3.4 Ideation Canvas

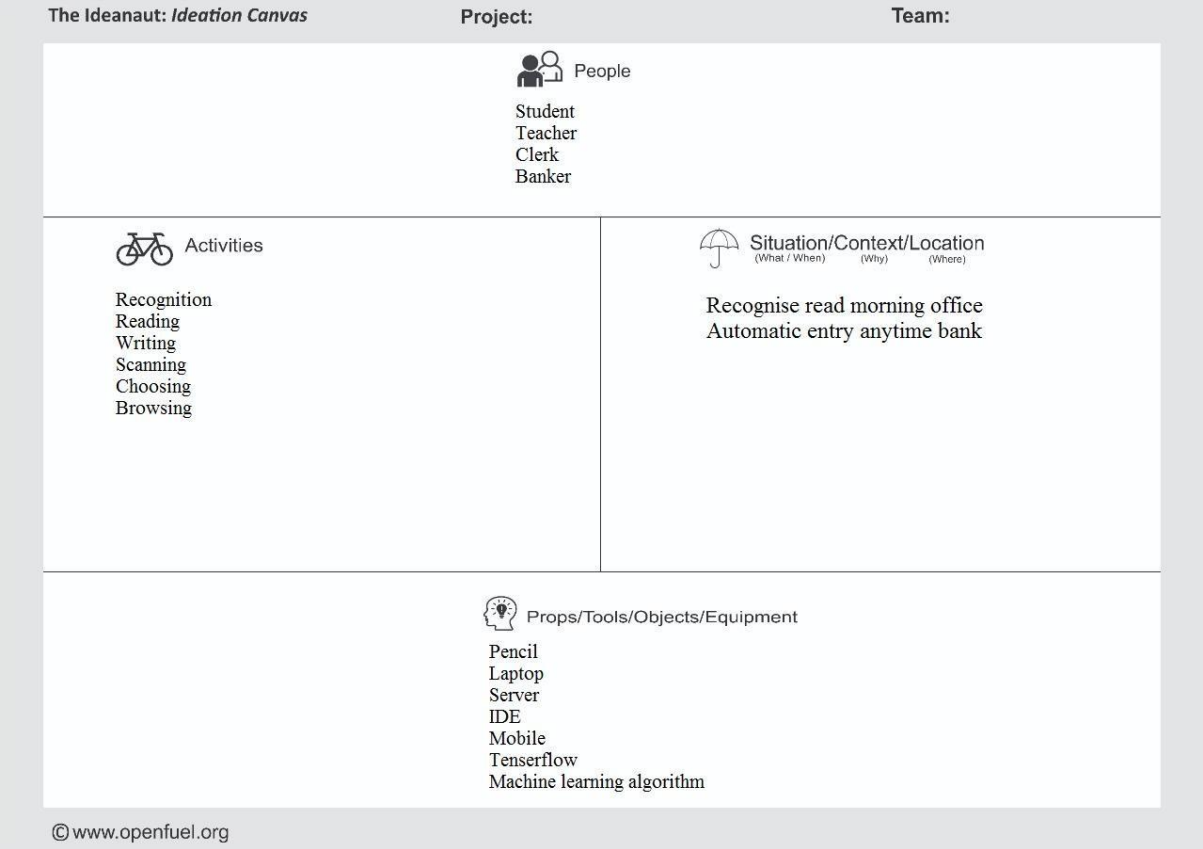


Figure 3.4 Ideation Canvas

After understanding the ideal stage of the product and going through the empathy part of the product it is time to design the final product definition, users, features, functions and components. This canvas will let us know exactly the amount of efforts and the clear idea that is to be put into this project. After that, the Customer revalidation part shows us how true we were in idealizing and creating a solution for the user. After that according to the Validations it is up to us that we reject, redesign and retain the function and features according to the feedback from the customer.

3.5 Business Model Canvas

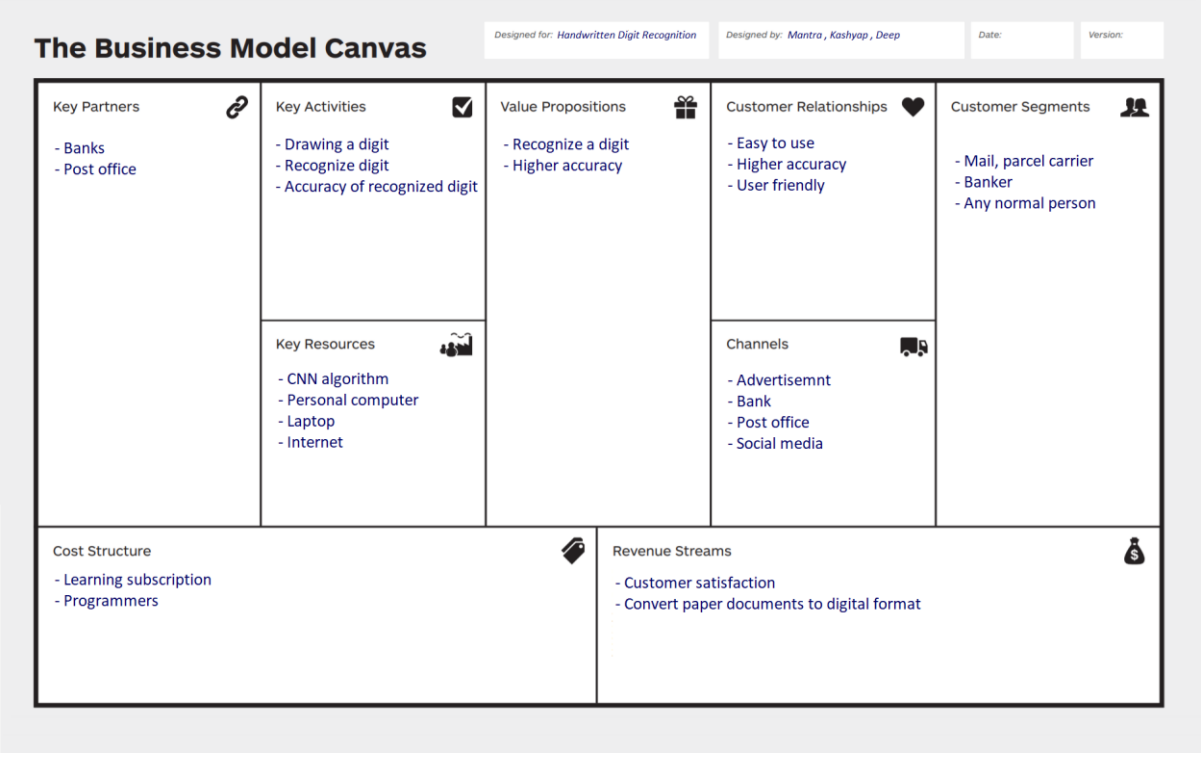


Figure 3.5 Business Model Canvas

Thus, business model canvas can be used to visualize such customer expectations and market problems. This exercise will increase the market strategy and implementation of technology. This will make them more effective in market.

This exercise brings discussions on viability and cost effectiveness into picture with their impact. This exercise will enable us to have knowledge on the steps required to ensure that a solution they develop via project should have a user who can afford it with desired needs. This exercise helps us to understand the true value of the proposed solution.

Business Model Canvas is used to validate the market significance of products and services which will be of technology nature in this case. Technology projects are often solutions or processes that solve a technical problem. However, the market implementation of such solutions also require that the problem solution is designed to overcome not just the technical barriers but also market and business-related barriers of costs, customer reach and collaborations and those that pertain to the practical nature of limited initial capacities within the team.

CHAPTER:4

Architecture & Flow Diagram

4.1 Flow Diagram:

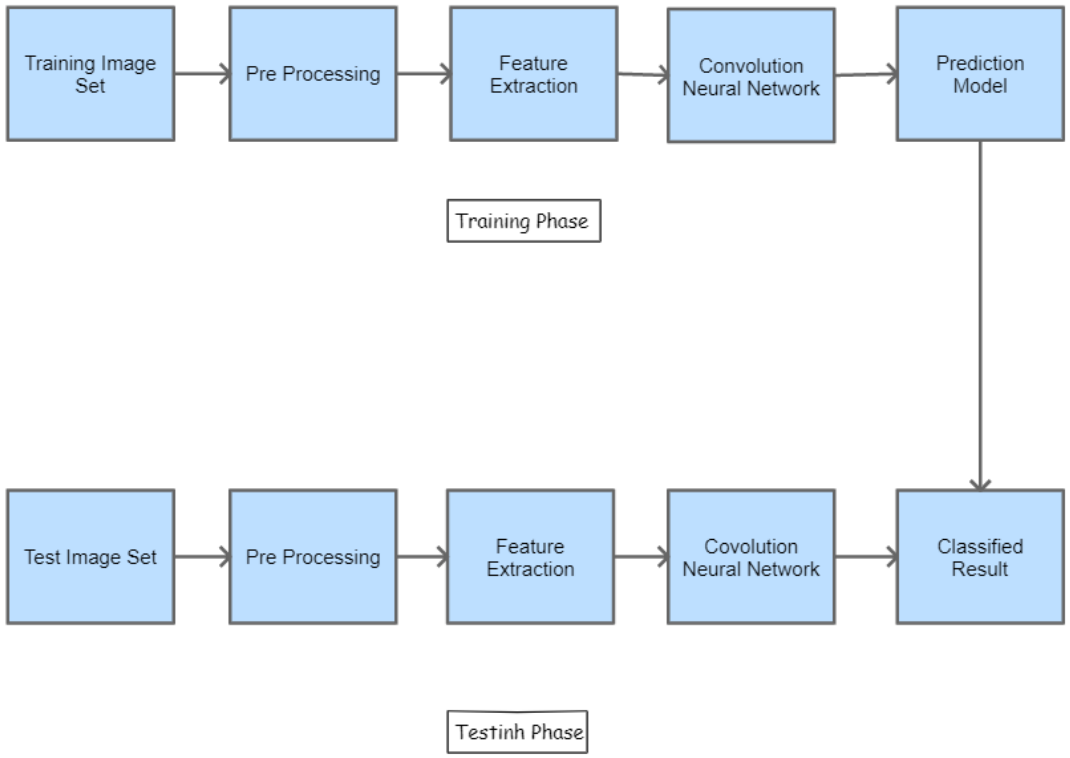


Figure 4.1 Flow Diagram

It consists of two phases, first one is training phase and second one is testing phase. Training phase is used to train the digits in that preprocessing of digit is done at first after that feature extraction takes place and then finally goes to CNN model where the digit recognition takes place and stored in a dataset. Second phase is the testing phase where the test image is given as input and then preprocessing of digit and feature extraction takes place and then finally goes to CNN model where it goes through several layers and finally we get the recognized digit as the output.

4.2 System Architecture:

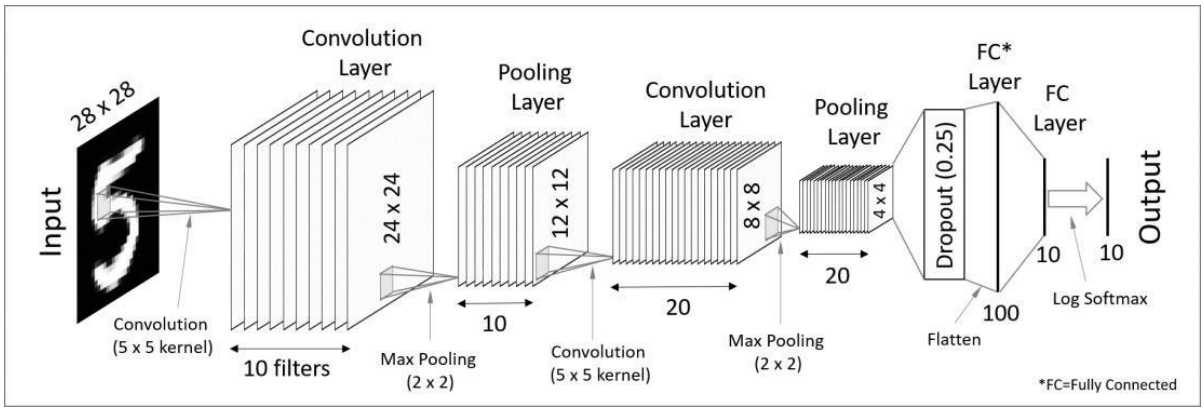


Figure 4.2 System Architecture

Layers of Convolutional neural network:

- Input provided is raw pixel value
- Convolutional layer - Neuron layer result are translated by Input layers. There it is required to specify the filter that is to be used. The filter is of 5*5 window which slides over input data to get maximum intensity pixels.
- Rectified linear unit [ReLU] layer: activation function is provided on the data taken as an image. ReLU function prevent the values of pInputixels form changing in the case of back propagation,.
- Pooling layer: Performs aIn pooling layer down-sampling operation are performed in volume along the dimensions (width, height).
- Full connected layer: focuse is on score class, and the input digits is found with a maximum score.

As we go deeper and deeper in the layers, the complexity is increased a lot. But it might worth going as accuracy will also increase.

4.3 Dataset:

Dataset: MNIST data for handwritten digits is used as a database.
Modified National Institute of Standards and Technology (MNIST) is a large set of computer vision dataset.

- Extensively used for training and testing different systems.
- It was created from the two special datasets of National Institute of Standards and Technology (NIST).
- Holds binary images of handwritten digits.
- The training set contains handwritten digits from around 200-250 people.
- MNIST is often regarded as the first data sets among other data sets to prove the functioning of neural networks.

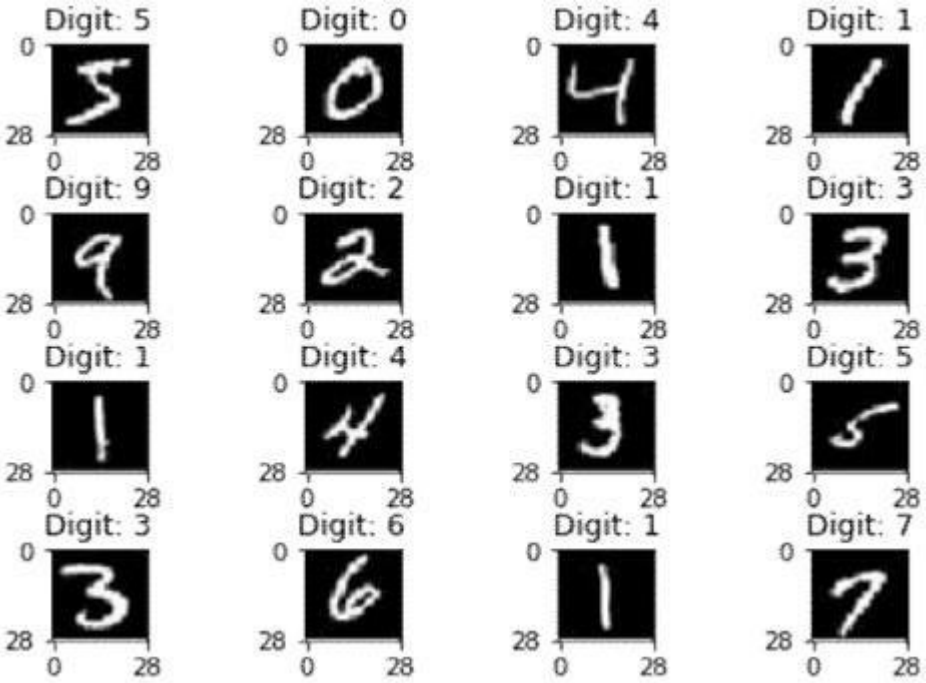


Fig 4.3 Handwritten Digits

- The database contains 60,000 images used for training.
- Few images can be used for cross-validation purposes.
- All the digits are grayscale and positioned in a fixed size.
- The intensity lies at the centre of the image with 28×28 pixels.
- Since all the images are 28×28 pixels, it forms an array which can be flattened into 28*28=784 dimensional vector.

Keras library and the Tkinter library for building GUI.

4.4 CNN (Convolutional Neural Network)

- CNN has become famous among the recent times. CNN is part of an in-depth feed networks that can perform many tasks at a much better time and accurate than other classifiers, in a variety of image and video recognition systems, a complementation system and natural language processing.

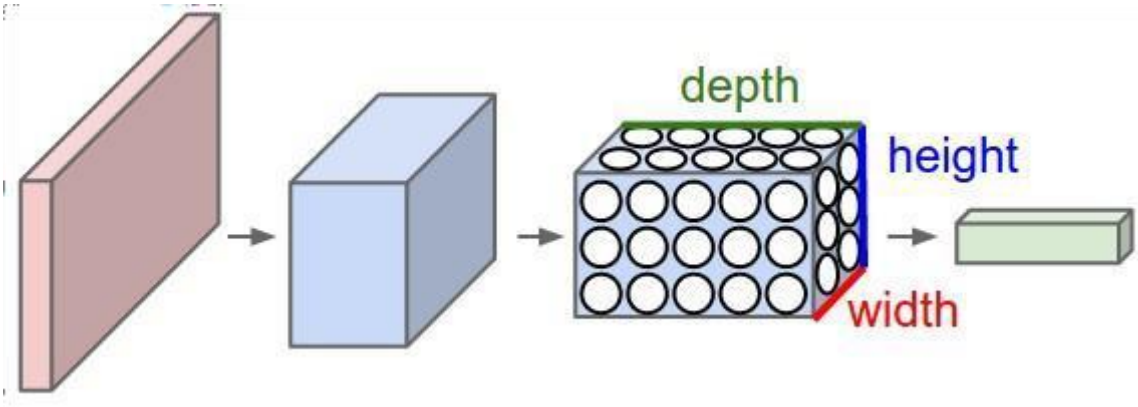


Fig 4.4 Convolution Network

Arrangements of neurons in CNN

The use of neural nets in the automated tagging algorithms by Facebook, google search images for Amazon with their product recommendations has spreaded the CNN widely. Pinterest for their home-based feeds and Instagram for search infrastructure. Image classification or object recognition creates problem for conveying an image as a parameter and guessing whether the situation satisfies or not (cat or not, dot or not), or the chances or most satisfactory state of the image. We can quickly see patterns, creations from previous knowledge and knowledge.

Fig 4.5Difference what we see vs what system see

Inputs and output

When a computer or program takes a picture, pixel price list is seen immediately. Suppose 480 * 480 * 3 where 480 * 480 size, 3 means RGB values. Each of these numbers is given a value of 0 to 255 as the pixel power at that time. The important point is that, the computer program predicts and makes the assumption as an outline of what the image might mean or a certain category (say 0.90 for class 1, 0.96 for class 2, 0.4 for section 3) based on taking a picture as an input.

Algorithm

To identify the steps to create a predictable system, we can define a strategy as -
Divide the image into smaller image tiles - Like sliding windows, we can pass the navigation window over the whole large image and each effect is saved differently, as part of a larger image as a small image style.

Feeding each small tile into a small network of neural size - we rarely start the parameters at the same values and if not, then we mark that tile as interesting.
Save results from each subtitle to new list - we don't like to misinterpret the original file index. So we put the results in a grid of the same layout as the actual image.
Sample reduction - reducing the size of the same new members, sample reduction is used for multiple combinations.

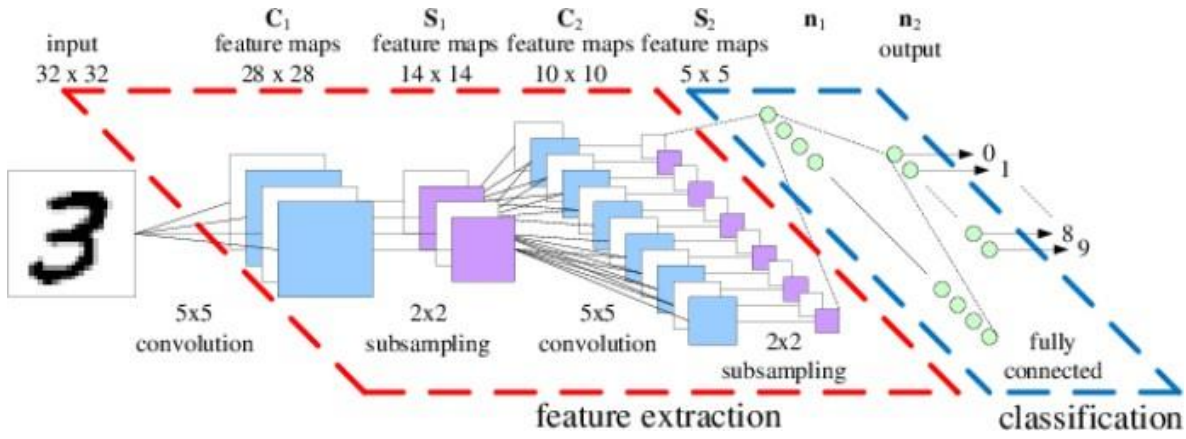


Fig 4.6CNN model

4.5 Design

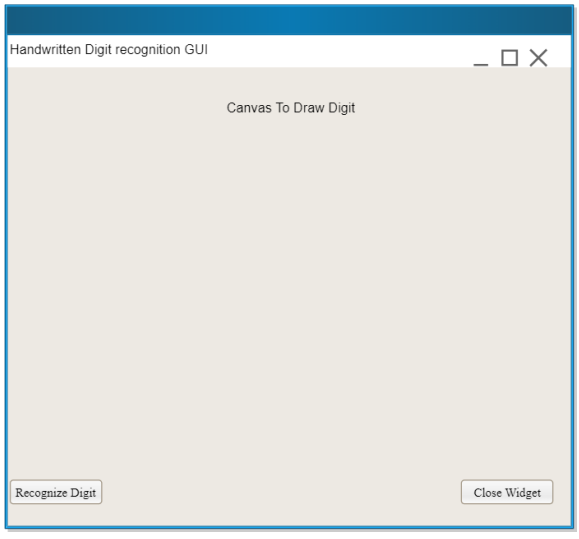


Fig 4.7 Home Page Design

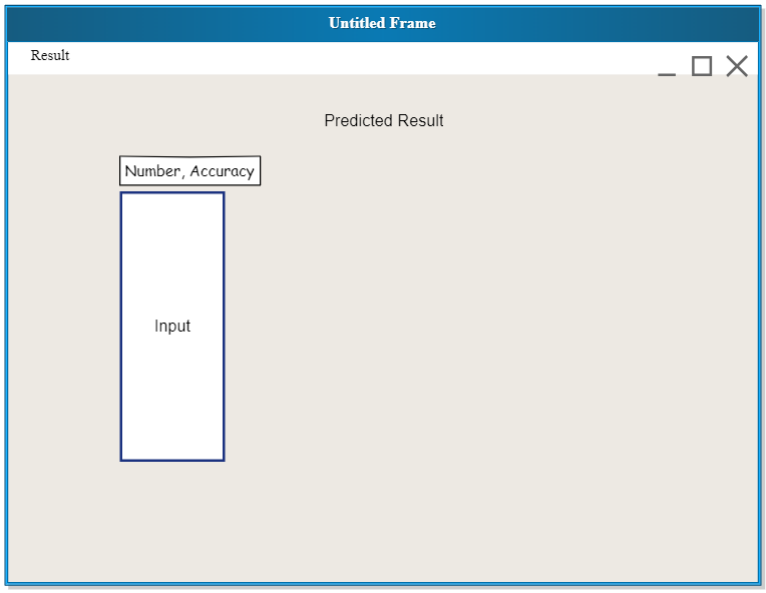
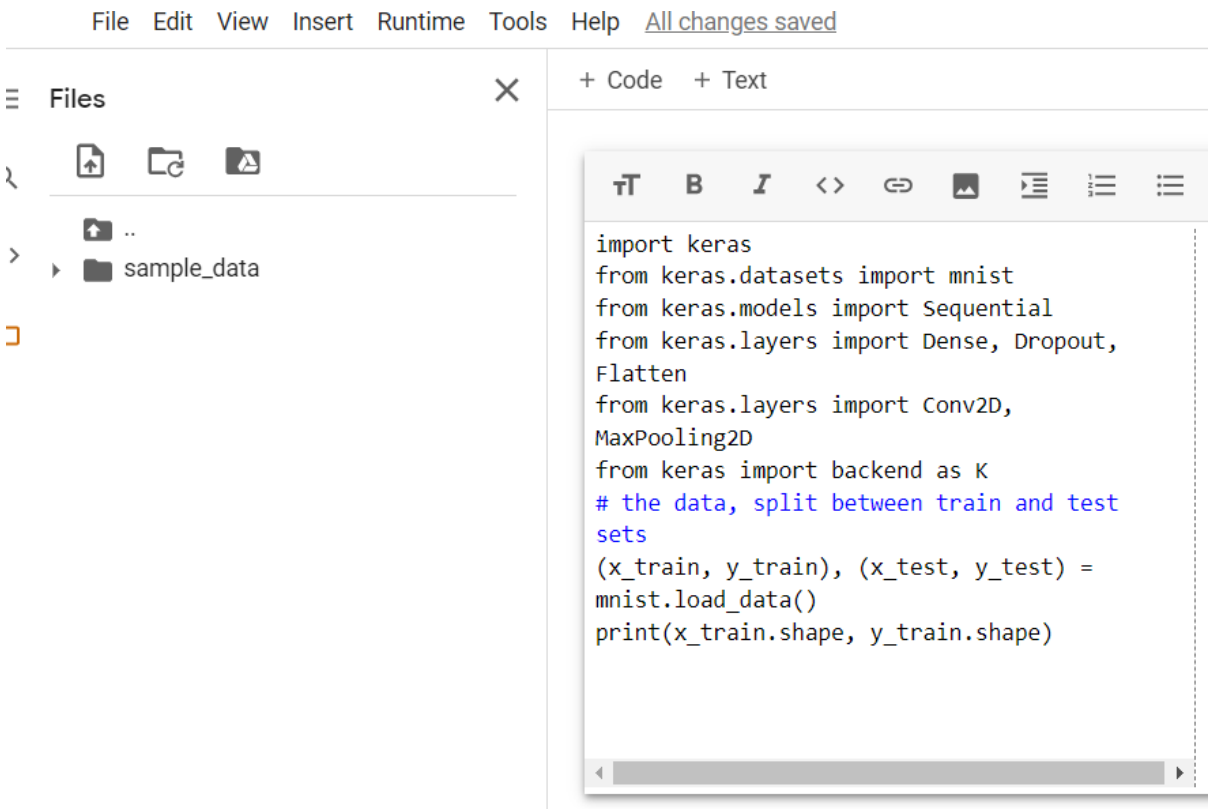


Fig4.8 UI/UX Design

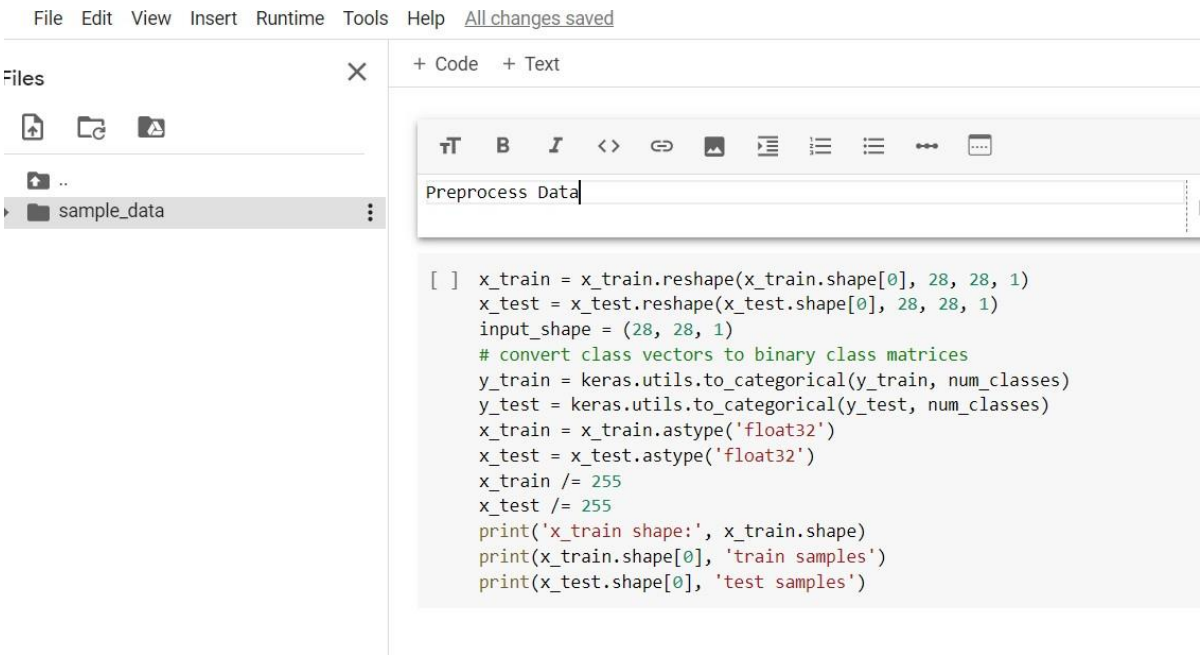
CHAPTER:5

Implementation

Datasets



Data Preprocessing



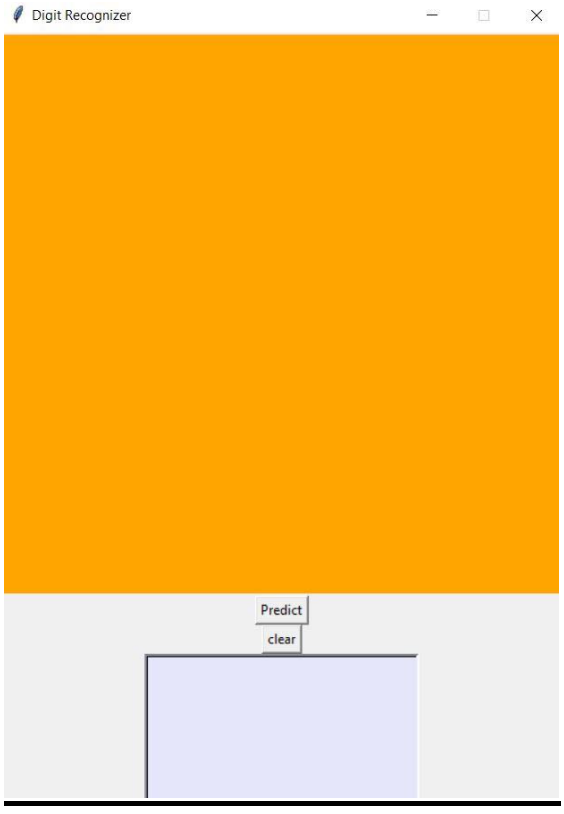
Building CNN model

```
batch_size = 128                                                    #cnn model creation
num_classes = 10
epochs = 10

model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),activation='relu',input_shape=input_shape))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss=keras.losses.categorical_crossentropy,optimizer=keras.optimizers.Adadelta(),metrics=['accuracy'])
```

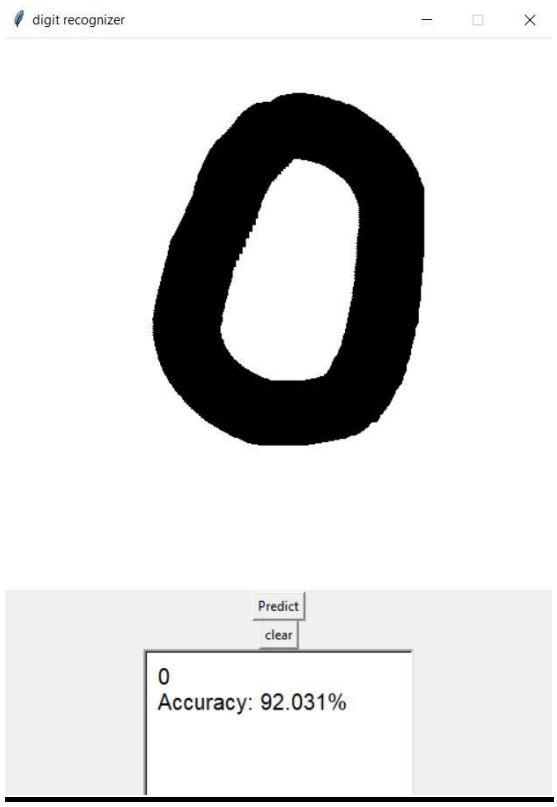
Training & Evaluation of model

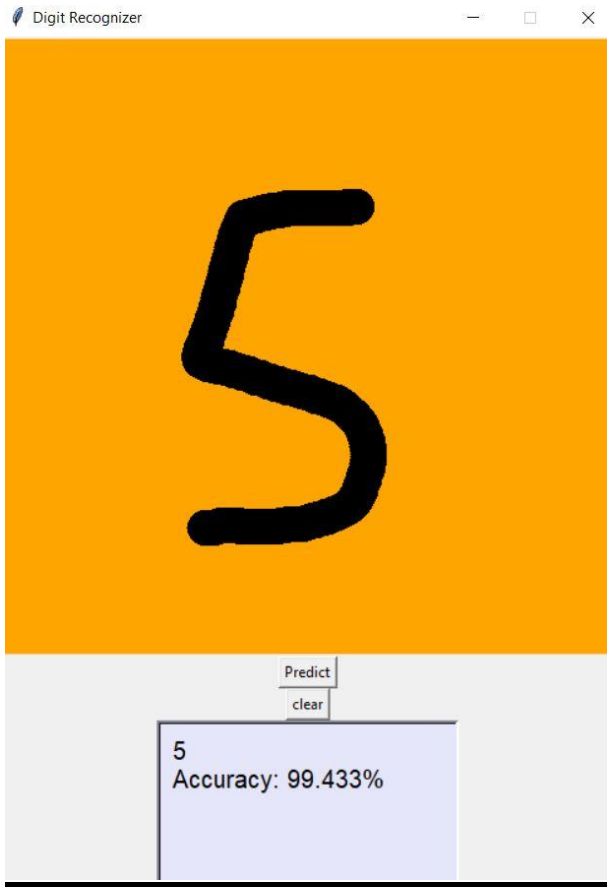
```
hist = model.fit(x_train, y_train,batch_size=batch_size,epochs=epochs,verbose=1,validation_data=(x_test, y_test))
print("The model has successfully trained")

model.save('mnist.h5')
print("Saving the model as mnist.h5")

score = model.evaluate(x_test, y_test, verbose=0)                   #evaluate model
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

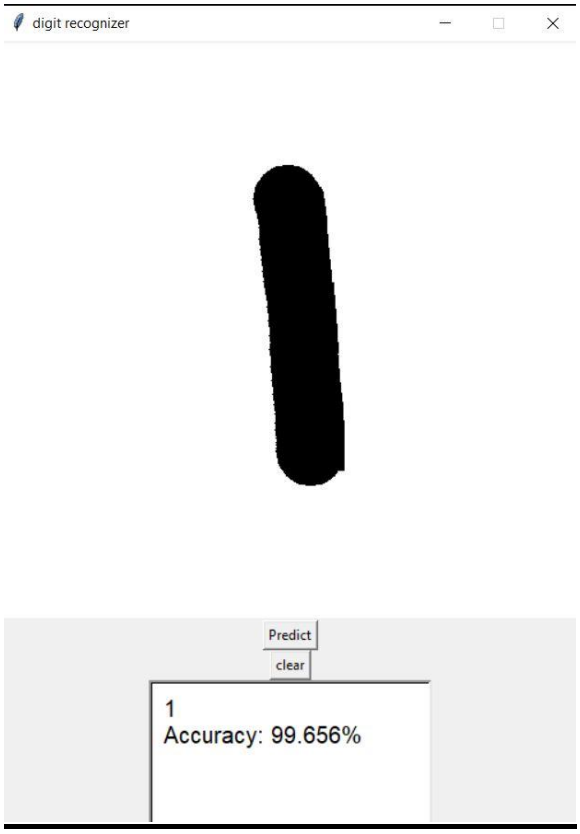
GUI



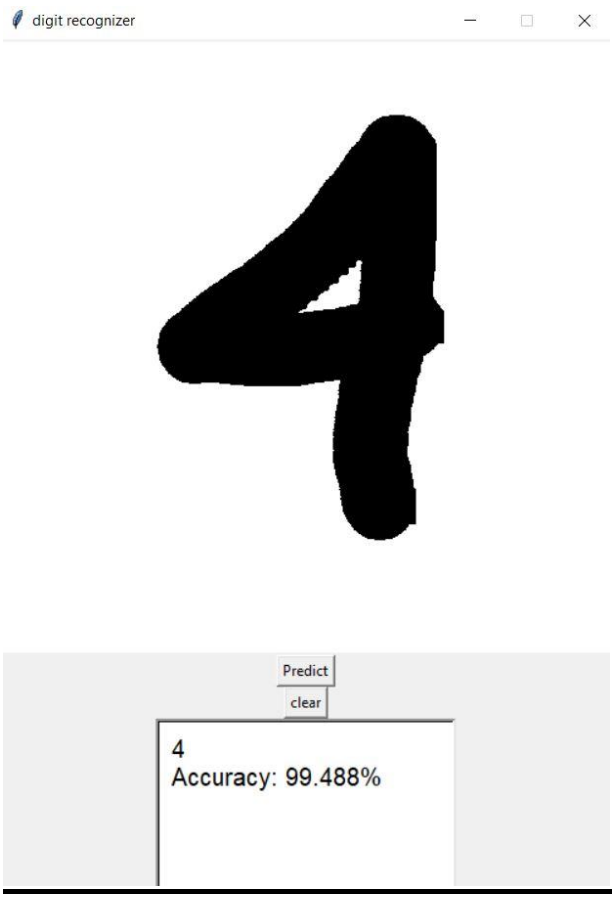
Recognize a digit






digit recognizer
Predict
clear
1
Accuracy: 99.656%

Digit Recognizer
Predict
clear
9
Accuracy: 98.672%


digit recognizer
Predict
clear
4
Accuracy: 99.488%

Digit Recognizer
Predict
clear
6
Accuracy: 94.166%

CHAPTER:6

SUMMARY & FUTURE SCOPE

6.1 Future scope:

- To extend the model to work on nist dataset
- Further we can try to increase the accuracy by implementing more number of hidden layers and/or epochs and detect custom hand written digits
- one more thing that can be done is to use cnn with more layers to get better accuracy

6.2 Tools and technologies Required

- Basic knowledge of working of Deep learning Technology
- CNN Algorithm
- Tensorflow
- scikitlearn
- Python

6.3 Summary

- There are numerous ways in which humans can represent digits, so if our implementation is successful it would be easy to understand handwritten digits by computer.

- Further we can create a system which can recognize alphabets & numbers both that could be easy to understand human handwriting as well, that’s our main moto.

REFERENCES & BIBLIOGRAPHY

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- https://www.tensorflow.org/tutorials/quickstart/beginner
- http://www.iro.umontreal.ca/~pift6266/H10/notes/deepintro.html
- https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

CHAPTER: 8

APPENDIX

9.1 Periodic Progress Reports (PPR)

- **Periodic Progress Report - 1 (PPR-1)**

PPR Details

Periodic Progess Report : First PPR

Project : Handwritten digit recognition

Status : Submitted

1. What Progress you have made in the Project ?

We are done with data preprocessing of MNIST dataset.

2. What challenge you have faced ?

Challenge is to convert mnist dataset from 2 dimension to 3 dimension before we proceed to next step.

3. What support you need ?

No support needed

4. Which literature you have referred ?

Online tutorial for data preprocessing

Document : Download

- **Periodic Progress Report - 2 (PPR-2)**

PPR Details

Periodic Progess Report : Second PPR

Project : Handwritten digit recognition

Status : Submitted

1. What Progress you have made in the Project ?

Next task was to implement CNN model and we are done with the building of model

2. What challenge you have faced ?

The challenge was to implement several layers in CNN model to achieve higher accuracy

3. What support you need ?

To implement we need to collect information about layers and learn keras library

4. Which literature you have referred ?

Linkedin online tutorial

Document : Download

- **Periodic Progress Report - 3 (PPR-3)**

PPR Details

Periodic Progess Report : Third PPR

Project : Handwritten digit recognition

Status : Submitted

1. What Progress you have made in the Project ?

We are done with the training and evaluation of CNN model

2. What challenge you have faced ?

Challenge here was to train the model and evaluate it

3. What support you need ?

No support required

4. Which literature you have referred ?

Online tutorial

Document : Download

- **Periodic Progress Report - 4 (PPR-4)**

PPR Details

Periodic Progess Report : Forth PPR

Project : Handwritten digit recognition

Status : Submitted

1. What Progress you have made in the Project ?

Atlast comes implementation of GUI and we have successfully completed the task of building a GUI

2. What challenge you have faced ?

To implement we have to learn tkinter library

3. What support you need ?

To explore about gui we need to watch tkinter tutorials

4. Which literature you have referred ?

Online tutorial on tkinter

Document : Download

9.3 Business Model Canvas (BMC) Report

Handwritten Digit Recognition

Introduction:

Handwritten digit recognition is the ability of a computer system to recognize the handwritten inputs like digits, characters etc. from a wide variety of sources like emails, papers, images, letters. Objective is to implement handwritten digit recognition with the help of machine learning algorithms. Our main focus is to implement with Convolution neural network algorithm in order to achieve more accurate output.

Customer Segment:

- mail,parcel carrier
- banker
- any noormal person

Value Proposition:

- recognize a digit
- higher accuracy

Customer Relationship:

- easy to use
- higher accuracy
- user friendly

Channels:

- advertisemnt
- bank
- post office
- social media

Key Activities:

- drawing a digit
- recognize digit
- accuracy of recognized digit

Key Resources:

- CNN algorithm
- Personal computer
- laptop
- internet

Key Partnership:

- banks
- post office

Cost Structure:

- learning subscription
- programmers

Revenue Stream:

- customer satisfaction
- convert paper documents to digital format

Conclusion:

There are numerous ways in which humans can represent digits, so if our implementation is successful it would be easy to understand handwritten digits by computers.

College : G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR
Department : Information Technology
Discipline : BE
Semester : Semester 8
Project Name : Handwritten digit recognition
Team ID : 119471

Form 1 – APPLICATION FOR GRANT OF PATENT

Applicants :

Sr. No	Name	Nationality	Address	Mobile No.	Email Id
1	Joshi Mantrakumar Dharmeshkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	7990824629	mantra.joshi25@gmail.com
2	Patel Kashyapkumar Dipakkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9426563480	kashyappatel104@gmail.com
3	Patel Deep Manojkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9106680589	deeppatel00175@gmail.com

Inventors :

Sr. No	Name	Nationality	Address	Mobile No.	Email Id
1	Joshi Mantrakumar Dharmeshkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR ,	7990824629	mantra.joshi25@gmail.com

			Gujarat Technologycal University.		
2	Patel Kashyapkumar Dipakkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9426563480	kashyappatel104@gmail.com
3	Patel Deep Manojkumar	Indian	Information Technology , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9106680589	deeppatel00175@gmail.com

I/We, the applicant(s) hereby declare(s) that:

Following are the attachments with the applications :

Form 2 - PROVISIONAL/COMPLETE SPECIFICATION

1 . Title of the project/invention :

Handwritten digit recognition

2. Preamble to the description :

Provisional

3. Description

a) Field of Project / Invention / Application :

IT Deep Learning project

b) Prior Art / Background of the Project / Invention :

Before Computers Existed All the information was stored in Written form. This is very Inefficient form of Storing data as the paper Information cannot be stored for very long time and can get lost or be destroyed in some or the other way. As we know that Information on computer can be stored for long time and multiple copies of same information can be made easily.

c) Summary of the Project / Invention :

There are numerous ways in which humans can represent digits, so if our implementation is successful it would be easy to understand handwritten digits by humans.

d) Objects of Project / Invention :

Recognize zip codes on mail for postal mail sorting by Mail carrier in post office
Numeric entry in tax form etc
Used by bankers to recognize cheque number, amount and account number

e) Drawings :

f) Description of Project / Invention : (full detail of project) :

Handwritten digit recognition consists of two phases, first one is training phase and second one is testing phase. Training
phase is used to train the digits in that preprocessing of digit is done at first after that feature extraction takes place and then finally goes to CNN model where the digit recognition takes place and stored in a dataset. Second phase is the testing phase where the test image is given as input and then preprocessing of digit and feature extraction takes place and then finally goes to CNN model where it goes through several layers and finally we get the recognized digit as the output.

g) Examples :

h) Claims (Not required for Provisional Application) / Unique Features of Project

High accuracy in recognizing digits
Show accuracy in percentage

4. Claims

5. Date and signature

6. Abstract of the project / invention :

The handwritten digit recognition is the power of computers to recognize human handwritten digits. For machine it is a hard task because handwritten digits are not perfect and can be made with thousands of different ways. The solution is handwritten digit recognition to the problem which uses the image of a digit and recognizes the digit present in the image. The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network.

Form 3 – STATEMENT AND UNDERTAKING UNDER SECTION 8

Name of the applicant(s) :	I/We, Joshi Mantrakumar Dharmeshkumar ,Patel Kashyapkumar Dipakkumar ,Patel Deep Manojkumar Hereby declare :
Name,Address and Nationality of the joint applicant :	(i) that I/We have not made any application for the same/substantially the same victim invention outside India. (ii) that the rights in the application(s) has/have been assigned to

Name of the Country	Date of Application	Application Number	Status of the Application	Date of Publication	Date of Grant
N/A	N/A	N/A	N/A	N/A	N/A

(iii)That I/We undertake that upto the date of grant of the patent by the Controller, I/We would keep him informed in writing the details regarding corresponding applications for patents filed outside India within three months from the date of filing of such application.

Dated this 11 day of May 2021

To be signed by the applicant or his authorised registered patent agent : Signature.....

Name of the Natural Person who has signed :	Joshi Mantrakumar Dharmeshkumar ,Patel Kashyapkumar Dipakkumar ,Patel Deep Manojkumar

To,
The Controller of Patents,
The Patent Office,
At Mumbai

Plagiarism Checker X Originality Report

Similarity Found: 24%

Date: Thursday, April 22, 2021
Statistics: 773 words Plagiarized / 3235 Total words
Remarks: Medium Plagiarism Detected - Your Document needs Selective Improvement.
---

1 " Handwritten Digit Recognition " A Project Report Submitted to Gujarat Technological University in Fulfillment of the Requirements for the Degree of Bachelor of Engineering In Information Technology B. E., Semester – VII By Group ID:100085 Mantra Joshi Kashyap Patel Deep Patel Enrollment No. 170110116017 Enrollment No. 170110116039 Enrollment No. 170114116001 Faculty Guide Prof.

Miral Patel [Assistant Professor (IT)] Academic Year 2020-21 Department of Information Technology G H Patel College of Engineering & Technology Vallabh Vidyanagar, Anand 2 Acknowledgment We would like to express our gratitude and appreciation to all those who gave us the incentive to work on this project. A special thanks to our project guide, Prof. Miral Patel, whose presence, stimulating suggestions and encouragement, helped us to coordinate our project.

Hereby, we would also like to acknowledge with much reverence the crucial role of our department, who were supportive and provided us with all the possible assistance as and when required. Moreover, we are thankful to the Head of the Department (Information Technology), Dr.Nikhil Gondaliya, who has given his unmatched guidance in achieving the goal as well as his motivation to maintain our project's progress in track.

Last but not the least, the involvement of the panels during every single presentation helped us vivify our vision for this project, their straight-forwardness and concise comments aided our ambition in making of this project. 3 COLLEGE CERTIFICATE Date: Ts io ceiha t projctnttld " Handwritten Digit Recognition "s ben cad out MANTRA JOSHI (170110116017), KASHYAP PATEL (170110116039) and DEEP PATEL (170114116001) under my guidance in partial fulfillment for the degree of Bachelor of Engineering in

Information Technology (7th Semester) of Gujarat Technological University, Ahmedabad during the academic year 2020-21. Internal Guide Head of Department Prof. Bhargesh Patel Dr.

Nikhil Gondaliya Assistant Professor (IT) Head & Professor (IT) Seal of Institute 4 Undertaking of Originality of Work We hereby certify that we are the sole authors of this IDP/UDP project report and that neither any part of this IDP/UDP project report nor the whole of the IDP/UDP project report has been submitted for a degree by other student(s) to any other University or Institution.

We certify that, to the best of our knowledge, the current IDP/UDP project report does not infringe an'scopght violanpropy ghts that y as, techniques, quotations or any other material from the work of other people included in our IDP/UDP project report, published or otherwise, are full acknowledged in accordance with the standard referencing practices.

Furthermore, to extent that we have included copyrighted material that surpasses the boundary of fair dealing within the meaning of the Indian Copyright (Amendment) Act 2012, we certify that we have obtained a written permission from the copyright owner(s) to include such material(s) in the current IDP/UDP project report and have included copies of such copyright clearances to our appendix.

We declare that this is a true copy of our report, including any final revisions, as approved by our supervisors. Date: Place: Enrollment No. Name Signature 170110116017 Mantra Joshi 170110116039 Kashyap Patel 170114116001 Deep Patel 5 ABSTRACT The handwritten digit recognition is the power of computers to recognize human handwritten digits. For machine it is a hard task because handwritten digits are not perfect and can be made with thousands of different ways.

The solution is handwritten digit recognition to the problem which uses the image of a digit and recognizes the digit present in the image. The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network. It is easy for humans to identify the digits but machines cannot.

It is mandatory to train our machines so that it can be identified by machine as well. Our main goal is to create a model that can easily recognize the digits, it can be extended to letters and to the handwriting. For this project first thing is understanding Convolutional Neural Network and applying it to the handwritten recognition system.

Before Computers Existed All the information was stored in Written form. This is very Inefficient form of Storing data as the paper Information cannot be stored for very long time and can get lost or be destroyed in some or the other way. As we know that Information on computer can be stored for long time and multiple copies of same information can be made easily.

Before the computers were invented, money was wasted in manually converting this paper information into digital form of information. Machine learning and deep learning can be used to identify and convert this paper information into digital format without human intervention or manual labour. This project is just an introduction to this approach. 6 LISTS OF FIGURES Figure No. Figure Name Page No. 3.1 AEummy …… 4 3.2 Pent Cnvas…… 5 3.3

Empathg Cas…… 6 3.4 Idon C…… 8 4.1 Flow Diaam ……. 9 4.2 Se …. … ……. … 10 4.3 11 4.4 Convolution Network 12 4.5 12 4.6 CNN Model 13 4.7 13 4.8 14 7 TABLE OF CONTENTS Sr Topic Page No. No. 1 1 1 1 2 2 3 Design Engineer 4 4 3.2 Product Development Canvas.. 5 6 8 4 Archite 9 9 10 11 12 13 5 15 6 16 16 16 16 7 Refer 17 8 18 8 " Handwritten Digit Recognition " A Project Report Submitted By Mantra Joshi Kashyap Patel Deep Patel Enrollment No.170110116017 Enrollment No.170110116039 Enrollment No.170114116001 In fulfilment for the award of the degree Of BACHELOR OF ENGINEERING In Information Technology Semester 7th (4th year) Academic Year 2020-21 Department of Information Technology G H Patel College of Engineering & Technology Vallabh Vidyanagar, Gujarat GUJARAT TECHNOLOGICAL UNIVERSITY AHMEDABAD November 2020 1 CHAPTER: 1 INTRODUCTION 1.1 Introduction Handwritten digit recognition is the ability of a computer system to recognize the handwritten inputs like digits, characters etc.

from a wide variety of sources like emails, papers, images, letters. A lot of classification techniques using Machine Learning have been developed and used for this like K-Nearest Neighbors, Convolution neural network, SVM Classifier, Random Forest Classifier.

For example, if a person goes to deposit the cheque in bank so this can help system to read and recognize the check number and do further task easily. the accuracy in these applications is very critical as the cheque number should be accurate without any error or else there will be many problems in transaction. Deep learning has become the hot tool for Image Processing, object detection, handwritten digit and character recognition. 1.2

Purpose, Scope and Objective In earlier times Computers used to store all the

information in written forms. As we know that it is inefficient form of Storing data as the paper Information cannot be stored for very long time and can get lost or be destroyed in some or the other way As we know that Information on system can be stored for long time and multiple copies of same information can be copied easily.

Thus, after Invention of the computers, money was wasted converting the handwritten information into digital format. Machine learning and deep learning can be used to identify and convert the handwritten paper information into digital format without human intervention or manual labour. Objective is to implement handwritten digit recognition with the help of machine learning algorithms.

Our main focus is to implement with Convolution neural network algorithm in order to achieve more accurate output. Future scope is to extend the model to work on nist dataset Further we can try to increase the accuracy by implementing more number of hidden layers and/or epochs and detect custom hand written digits one more thing that can be done is to use cnn with more layers to get better accuracy.

2 CHAPTER: 2 LITRATURE SURVEY Title Author Publication Methodology Conclusion/Result Image classification using deep learning Harshali Mane K L University IEEE Used AlexNet architecture with convolutional neural networks for this purpose. From the experiments, it is observed that the images are classified correctly even for the portion of the test images and shows the effectiveness ofdeep learning algorithm.

Class Attendance Portal (CAP) using Face recognition Rahul Ray , Faisal Khan , Harsh Sharma , Gaurav Kumar IJRASET - Importing Libraries and splitting the Dataset: Convolution Neural Network: Building CNN -Training the Network Testing The online automatic Classroom Attendance monitoring portal helps in increasing the accuracy and high processing speed ultimately achieve the high- precision real-time attendance High-Speed Tracking with Kernelized Correlation Filters João F.

Henriques, Ruii Casairo, Pedro Mertins, and Jorge Batista IEEE -Diagonalize filter with the WDiscrete Fourier Transform. -For linear regression our formulation equivalent to a correlation filter. Demonstrated analytically model natural image translations, under some conditions the resulting data and kernel matrices become circulant.

How transferable Are features in deep neural networks? Jason Yosinski, Jeff Clune, YoshuaBengi o, and Hod Lipson IEEE -Datasets: Random A/B splits -Used Convolutional neural network and layers -Random Weights We have demonstrated a method for quantifying the transferability of features from each layer of a neural network, which reveals their generality or specificity. Recognition of Handwritten Digit using

Convolutional Neural Network in Python. FathmaSiddi qe, ShadmanSak ib, Md.AbuBakS iddique IEEE MNIST Dataset Convolutional neural network and its layers.

The accuracy curves are generated for the six cases for the different parameter using CNN MNIST digit dataset. The six cases perform differently because of the various combinations of hidden layers. Extraction Method of Handwritten Digit Recognition Tested on the MNIST Database El Kessab, Daoui, B. Bouikhale, M. Fakir and K.

Moro IJAST -Acquisition of image -- Pretreatment of image- Pre-processing an important process for recognition digit. -CNN layers In this work, the neural network is proposed for the classification of the standard base MNIST isolated digit. The recognition rate is 80.00% with a Test database containing 60,000.

The method of extraction shows 3 Handwritten Digit Recognition Using Deep Learning Anuj Dutt, AashiDutt IJAR CET Reading the MNIST Dataset Phase1 - Input MNIST Data1 Phase2 – Building Network Architecture Phase 3 – Fully Connected Layer An implementation of Handwritten Digit Recognition using Deep Learning has been implemented in this paper. Additionally, most widely used Machine Learning algorithms i.e. RFC, KNN.

Designing of Digits Recognition Technique Using Neural Network Santosh Deshpande, Mukul Kulkarni IEEE Handwritten digits image acquisition. Preprocessing & Extraction Digit classification- Learning through Supervised, Learning through Unsupervised Digit recognition- Multilayer Perceptron MLP This is feed forward ANN. It consists of minimum 3 layers. Handwritten digit recognition is important part of pattern recognition.

The HDR is challenging because of different writing styles and forms. Some of the different methods like supervise and unsupervised learning are discussed. Scalable Nearest Neighbor Algorithms for High Dimensional Data Marius Muja & David G. Lowe IEEE Hashing Based Nearest Neighbor Techniques & randomized k-d forest algorithm We found to work best at fast approximate search in high dimension spaces: the randomized k-d trees and a newly introduced algorithm, the priority search k-means tree.

Densely Connected Convolutional Networks Laurens van der Maaten & Kiliian Q. Weinbirger IEEE Neural Network ,Resnets(Residual Networks), L layer network Dataset- CIFAR- 10,CIFAR-100 A new convolutional network architecture is introduced, which we refer to as Dense Convolutional Network. The direct connection between any two layers with the same feature-map size is introduced.

4 CHAPTER: 3 DESIGN ENGINEERING CANVAS 3.1 AEIOU canvas: Figure 3.1 AEIOU Summary The above canvas is an AEIOU Summary about the Activities, Environment, Interactions, Objects and Users. Based on the observations done we were able to draft this summary which includes the situations and the major/minor factors that are responsible for the inactions.

5 3.2 Product Development Canvas: Figure 3.2 Product Development Canvas Based on the observation in the previous AEIOU summary a particular Ideation can be derived which results into the Ideation Canvas above. This canvas shows the initial idea about the formation of the product and shows that how a particular product should be designed.

The factors that will be affecting the development of the product are also included in this canvas. 6 3.3 Empathy Mapping: Figure 3.3 Empathy Mapping Canvas 7 The above canvas shows the empathy part included behind the creation of the project. The canvas includes some short stories that depict the actual case scenarios of the use and need of the product.

The scenarios are best show cased using two happy and two sad stories. 8 3.4 Ideation Canvas Figure 3.4 Ideation Canvas After understanding the ideal stage of the product and going through the empathy part of the product it is time to design the final product definition, users, features, functions and components. This canvas will let us know exactly the amount of efforts and the clear idea that is to be put into this project.

After that, the Customer revalidation part shows us how true we were in idealizing and creating a solution for the user. After that according to the Validations it is up to us that we reject, redesign and retain the function and features according to the feedback from the customer. 9 CHAPTER:4 Analysis & Design Methodology 4.1 Flow Diagram: Figure 4.1

Flow Diagram It consists of two phases, first one is training phase and second one is testing phase. Training phase is used to train the digits in that preprocessing of digit is done at first after that feature extraction takes place and then finally goes to CNN model where the digit recognition takes place and stored in a dataset.

Second phase is the testing phase where the test image is given as input and then preprocessing of digit and feature extraction takes place and then finally goes to CNN model where it goes through several layers and finally we get the recognized digit as the output. 10 4.2 System Architecture: Figure 4.2 System Architecture Layers of

Convolutional neural network: • Input provided is raw pixel value • Convolutional layer - Neuron layer result are translated by Input layers. There it is required to specify the filter that is to be used. The filter is of 5*5 window which slides over input data to get maximum intensity pixels.

Rectified linear unit [ReLU] layer: activation function is provided on the data taken as an image. ReLU function prevent the values of pInputixels form changing in the case of back propagation,. Pooling layer: Performs aIn pooling layer down-sampling operation are performed in volume along the dimensions (width, height).

Full connected layer: focuse is on score class, and the input digits is found with a maximum score. As we go deeper and deeper in the layers, the complexity is increased a lot. But it might worth going as accuracy will also increase. 11 4.3 Dataset: Dataset: MNIST data for handwritten digits is used as a database.

Modified National Institute of Standards and Technology (MNIST) is a large set of computer vision dataset. • Extensively used for training and testing different systems. • It was created from the two special datasets of National Institute of Standards and Technology (NIST). • Holds binary images of handwritten digits. • The training set contains handwritten digits from around 200-250 people.

• MNIST is often regarded as the first data sets among other data sets to prove the functioning of neural networks. Fig 4.3 Handwritten Digits • The database contains 60,000 images used for training. • Few images can be used for cross-validation purposes. • All the digits are grayscale and positioned in a fixed size. • The intensity lies at the centre of the image with 28×28 pixels.

• Since all the images are 28×28 pixels, it forms an array which can be flattened into 28*28=784 dimensional vector. Keras library and the Tkinter library for building GUI. 12 4.4 CNN (Convolutional Neural Network) • CNN has become famous among the recent times. CNN is part of an in-depth feed networks that can perform many tasks at a much better time and accurate than other classifiers, in a variety of image and video recognition systems, a complementation system and natural language processing. Fig 4.4

Convolution Network Arrangements of neurons in CNN The use of neural nets in the automated tagging algorithms by Facebook, google search images for Amazon with their product recommendations has spreaded the CNN widely. Pinterest for their home-based feeds and Instagram for search infrastructure. Image classification or object recognition creates problem for conveying an image as a parameter and guessing

whether the situation satisfies or not (cat or not, dot or not), or the chances or most satisfactory state of the image. We can quickly see patterns, creations from previous knowledge and knowledge. Fig 4.5Difference what we see vs what system see Inputs and output When a computer or program takes a picture, pixel price list is seen immediately.

Suppose 480 * 480 * 3 where 480 * 480 size, 3 means RGB values. Each of these numbers is given a value of 0 to 255 as the pixel power at that time. The important point is that, the computer program predicts and makes the assumption as an outline of what the image might mean or a certain category (say 0.90 for class 1, 0.96 for class 2, 0.4 for section 3) based on taking a picture as an input.

13 Algorithm To identify the steps to create a predictable system, we can define a strategy as - Divide the image into smaller image tiles - Like sliding windows, we can pass the navigation window over the whole large image and each effect is saved differently, as part of a larger image as a small image style. Feeding each small tile into a small network of neural size - we rarely start the parameters at the same values and if not, then we mark that tile as interesting.

Save results from each subtitle to new list - we don't like to misinterpret the original file index. So we put the results in a grid of the same layout as the actual image. Sample reduction - reducing the size of the same new members, sample reduction is used for multiple combinations. Fig 4.6CNN model 4.5 Design Fig 4.7

Home Page Design 14 Fig4.8 UI/UX Design 15 CHAPTER:5 Implementation Datasets Data Preprocessing 16 CHAPTER:6 SUMMARY & FUTURE SCOPE 6.1 Future scope: ? To extend the model to work on nist dataset ? Further we can try to increase the accuracy by implementing more number of hidden layers and/or epochs and detect custom hand written digits ? one more thing that can be done is to use cnn with more layers to get better accuracy 6.2

Tools and technologies Required • Basic knowledge of working of Deep learning Technology • CNN Algorithm • Tensorflow • scikitlearn • Git • Python 6.3 Summary • There are numerous ways in which humans can represent digits, so if our implementation is successful it would be easy to understand handwritten digits by humans.

• Further we can create a system which can recognize alphabets & numbers both that could be easy to understand human handwriting as well, that’s our main m 17 REFERENCES & BIBLIOGRAPHY References •

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Periodic Progress Reports (PPR) • Periodic Progress Report - 1 (PPR-1) 19 • Periodic Progress Report - 2 (PPR-2) 20 • Periodic Progress Report - 3 (PPR-3) 21 • Periodic Progress Report - 4 (PPR-4)

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