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A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

submitted by

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CHAPTER 1
INTRODUCTION

PROJECT OVERVIEW

Machine learning and deep learning play an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and in many more areas.

Handwritten Digit Recognition is the ability of computer systems to recognise handwritten digits from various sources, such as images, documents, and so on. This project aims to let users take advantage of machine learning to reduce manual tasks in recognizing digits.

PURPOSE

Digit recognition systems are capable of recognizing the digits from different sources like emails, bank cheque, papers, images, etc. and in different real-world scenarios for online handwriting recognition on computer tablets or system, recognize number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on.

CHAPTER 2
LITERATURE SURVEY

EXISTING PROBLEM

The fundamental problem with handwritten digit recognition is that handwritten digits do not always have the same size, width, orientation, and margins since they vary from person to person. Additionally, there would be issues with identifying the numbers because of similarities between numerals like 1 and 7, 5 and 6, 3 and 8, 2 and 5, 2 and 7, etc. Finally, the individuality and variation of each individual's handwriting influence the structure and appearance of the digits.
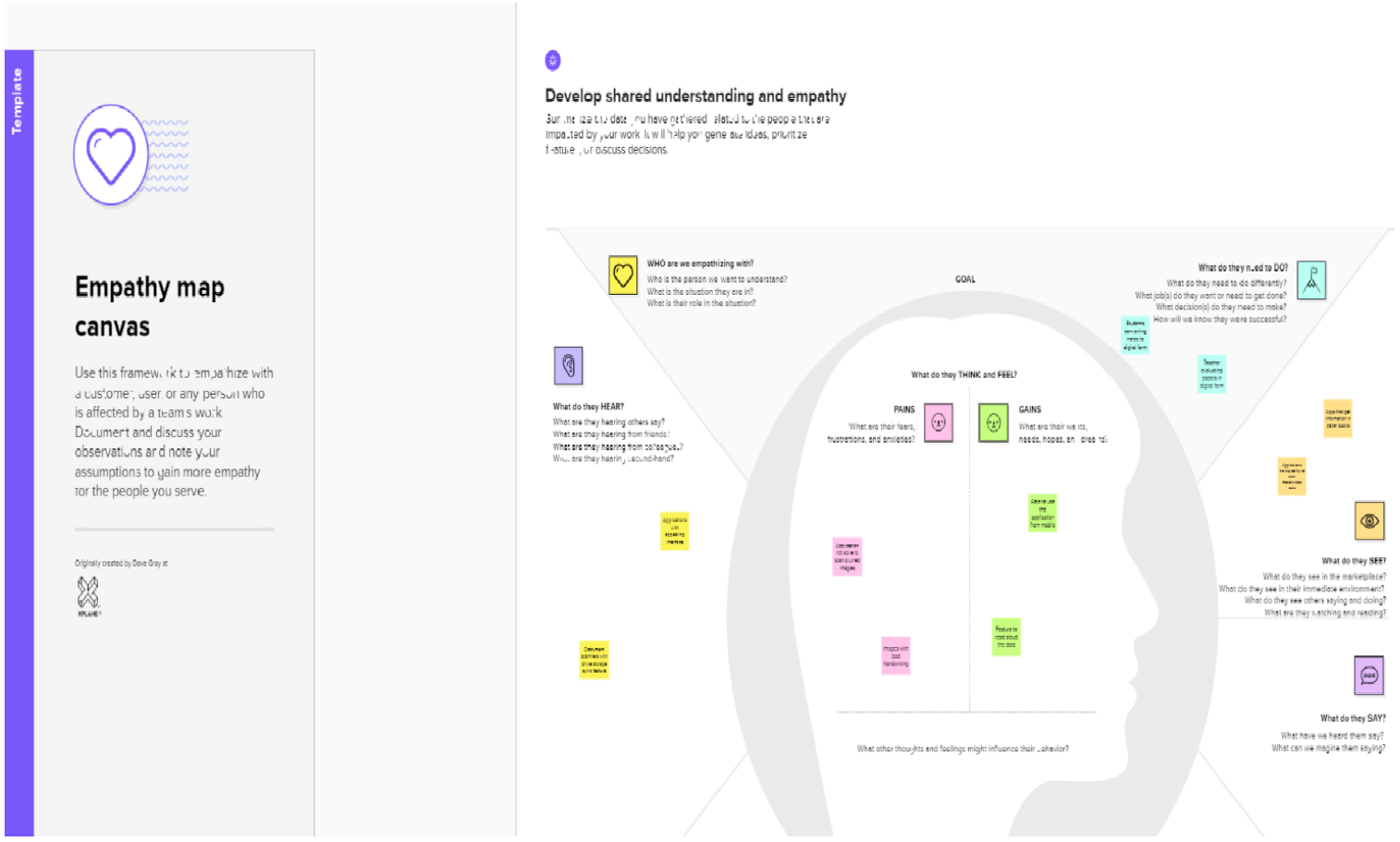
PROBLEM STATEMENT DEFINITION

For years, the traffic department has been combating traffic law violators. These offenders endanger not only their own lives, but also the lives of other individuals. Punishing these offenders is critical to ensuring that others do not become like them. Identification of these offenders is next to impossible because it is impossible for the average individual to write down the license plate of a reckless driver. Therefore, the goal of this project is to help the traffic department identify these offenders and reduce traffic violations as a result.

CHAPTER 3
IDEATION AND PROPOSED SOLUTION

EMPATHY MAP CANVAS

IDEATION & BRAINSTORMING

PROPOSED SOLUTION

S.NO	Parameter	Description
1.	Problem Statement (Problem to be solved)	**Statement**–The handwritten digit recognition is the capability of computer applications to recognize the human handwritten digits. **Description**: It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes.
2.	Idea / Solution description	1. It is the capability of a computer to fete the mortal handwritten integers from different sources like images, papers, touch defenses. 2. It allows users to translate all those signatures and notes into electronic words in a text document format and this data only requires far less physical space than the storage of the physical copies.
3.	Novelty / Uniqueness	Accurately recognize the digits rather than recognizing all the characters like OCR.

4.	Social Impact / Customer Satisfaction	1.Artificial Intelligence developed the app called Handwritten digit Recognizer. 2. It converts the written word into digital approximations and utilizes complex algorithms to identify characters before churning out a digital approximation.
5.	Business Model (Revenue Model)	• This system can be integrated with traffic surveillance cameras to recognize the vehicle's number plates for effective traffic management.
		• Can be integrated with the Postal system to identify and recognize the pin-code details easily.
6.	Scalability of the Solution	• Ability to recognise digits in more noisy environments. • There is no limit in the number of digits it can be recognized.

Problem Solution Fit

Project Title: **A Novel Method for Handwritten Digit Recognition System** Project Design Phase-I – Solution Fit Template

Team ID- **PNT2022TMID49804**

Define CS, fit into CC	1. CUSTOMER SEGMENT(S) **CS**	6. CUSTOMER CONSTRAINTS **CC**	5. AVAILABLE SOLUTIONS	Explore AS, differentiate
	One who wants to extract digits from handwritten text images	Unclear image will not give accurate results.	Traditional systems of handwriting recognition have relied on handcrafted feature and a large amount of prior knowledge.	

Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS **J&P**	9. PROBLEM ROOT CAUSE **RC**	7. BEHAVIOUR **BE**	Focus on J&P, tap into BE, understand RC
	People can struggle to read others' handwriting. The handwritten digits *are* not always of the same size, width, orientation as they differ from writing of person to person, so the general problem would be while classifying the digits.	The issue is that there's a wide range of handwriting – good and bad. This makes it tricky for programmers to provide enough examples of how every character might look.	Customers must try with clear image and neat handwriting to get accuracy in digits	

Identify strong TR & EM	3. TRIGGERS **TR**	10. YOUR SOLUTION	8. CHANNELS of BEHAVIOUR **CH**	Extract online & offline CH of BE
	When there is need for recognition of handwritten digits	It uses Artificial Neural Network to recognize them. Neural Network is used to train and identify written digits. After training and testing, the accuracy rate reached 99%. This accuracy rate is very high.	8.1 ONLINE Extract online channels from behaviour block	
	4. EMOTIONS: BEFORE / AFTER **EM** frustration, exhausted > curious, satisfied		8.2 OFFLINE Extract offline channels from different handwriting styles	

CHAPTER 4

REQUIREMENT ANALYSIS

FUNCTIONAL   REQUIREMENTS

Following are the functional requirements of the proposed solution.

FR No.	Sub Requirement (Story / Sub-Task)
FR-1	Image Data: Handwritten digit recognition alludes to a PC's ability to recognize human transcribed digits from different sources, for example, photos, reports, contact screens, and so on, and classify them into ten laid out orders (0-9). In the realm of deep learning, this has been the subject of endless examinations.
FR-2	Website: Web facilitating makes the code, illustrations, and different things that make up a site open on the web. A server has each site you've at any point visited. The kind of facilitating decides how much space is designated to a site on a server. Shared, devoted, VPS, and affiliate facilitating are the four fundamental assortments.
FR-3	Digit Classifier Model: To prepare a convolutional network to foresee the digit from a picture, utilize the MNIST information base of manually written digits. get the preparation and approval information first.
FR-4	Cloud: The cloud offers a scope of IT administrations, including virtual capacity, organizing, servers, information bases, and applications. In plain English, cloud computing is portrayed as a virtual stage that empowers limitless capacity and admittance to your information over the web.
FR-5	Modified National Institute of Standards and Technology dataset: The abbreviation MNIST stands for the MNIST dataset. It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9.

NON FUNCTIONAL REQUIREMENTS

.

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	One of the extremely critical issues in design acknowledgment applications is the acknowledgment of written by hand characters. Applications for digit acknowledgment incorporate finishing up structures, handling bank checks, and arranging mail.
NFR-2	Security	The framework creates an exhaustive portrayal of the launch boundaries.
NFR-3	Reliability	The examples are utilized by the brain organization to reason rules for perusing written by hand digits consequently. Besides, the organization might more deeply study penmanship and subsequently upgrade its exactness by expanding the amount of preparing examples.

Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognize handwritten numbers. |

NFR-4	**Performance**	The web application is created to provide a smooth user experience and make clients satisfied with the digit recognition service.
NFR-5	**Availability**	The web application will be available for everyone who owns a smart device with internet connection 24/7
NFR-6	**Scalability**	Scalability of the web application depends on the server size and datasets provided to the web application.

CHAPTER 5
PROJECT DESIGN

DATA FLOW DIAGRAM
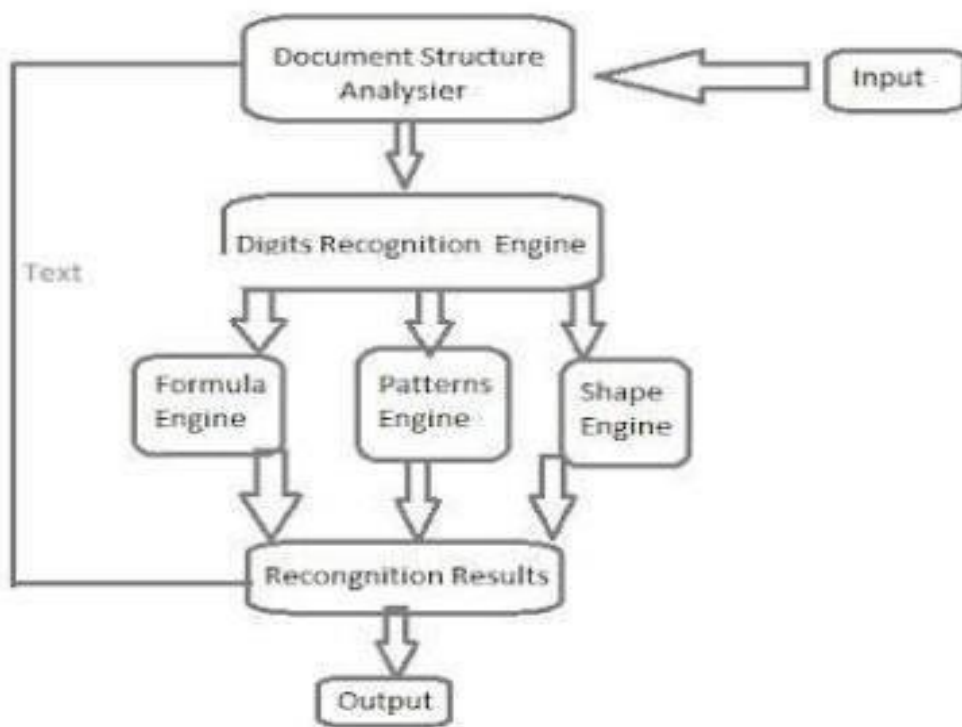
SOLUTION & TECHNICAL ARCHITECTURE

Technical Architecture:
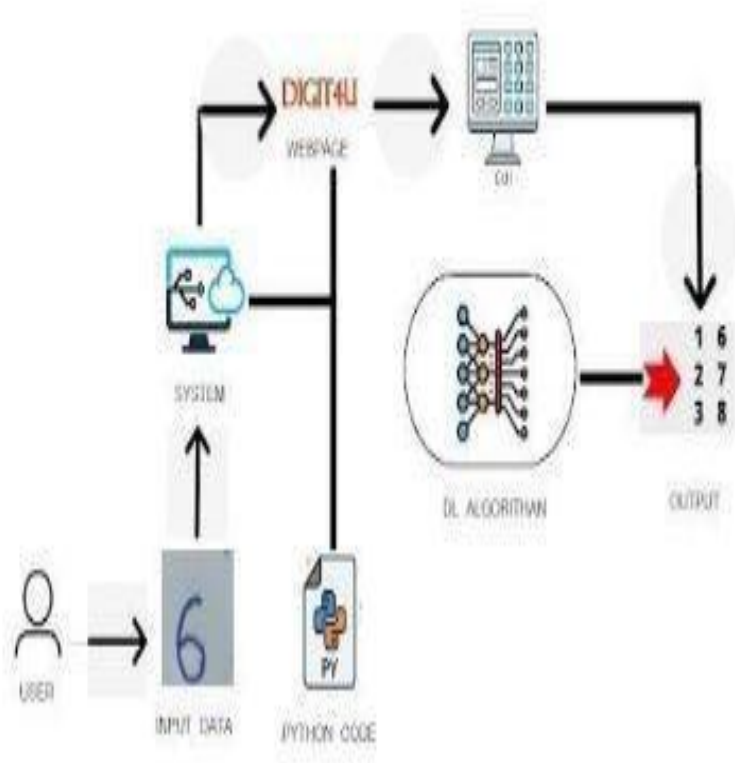
USER STORIES

User Type	Functional Requirements	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
Customer	Accessing the Application	USN-1	As a user, I should be able to access the application from anywhere and use on any devices	User can access the application using the browser on any device	High	Sprint-4
	Uploading Image	USN-2	As a user, I should be able to upload images to predict the digits	User can upload images	High	Sprint-3
	Viewing the Results	USN-3	As a user, I should be able to view the results	The result of the prediction is displayed	High	Sprint-3
	Viewing Other Prediction	USN-4	As a user, I should be able to see other close predictions	The accuracy of other values must be displayed	Medium	Sprint-4
	Usage Instruction	USN-5	As a user, I should have a usage instruction to know how to use the application	The usage instruction is displayed on the home page	Medium	Sprint-4

CHAPTER 6
PROJECT PLANNING AND SCHEDULING

SPRINT PLANNING AND ESTIMATION

SPRINT	USER STORY / TASK	STORY POINTS	PRIORITY	TEAM MEMBERS
Sprint – I	Get the dataset	3	High	Sibilingam.S
	Explore the data	2	High	Petchi Muthu.R
	Data Pre-Processing	3	High	Lokesh.A
	Prepare training and testing data	3	High	Vasanth.B
Sprint – II	Create the model	3	High	Sibilingam.s
	Train the model	3	High	Petchi muthu.R
	Test the model	3	High	Lokesh.A
Sprint – III	Improve the model	2	High	Vasanth.B
	Save the model	3	High	Sibilingam.S
	Build the Home Page	3	High	Petchi muthu.R
	Setup a database to store input images	2	High	Lokesh.A
Sprint – IV	Build the results page	3	High	Sibilingam.s

	Integrate the model with the application	3	High	Petchi muthu.R
	Test the application	3	High	lokesh.A

CHAPTER 7
CODING & SOLUTIONING

```python
1    from flask import Flask, render_template, request
2    from scipy.misc import imsave, imread, imresize
3    import numpy as np
4    import keras.models
5    import re
6    import base64
7
8    import sys
9    import os
10   sys.path.append(os.path.abspath("./model"))
11   from load import *
12
13   app = Flask(__name__)
14   global model, graph
15   model, graph = init()
16
17   @app.route('/')
18   def index():
19       return render_template("index.html")
20
21   @app.route('/predict/', methods=['GET','POST'])
22   def predict():
23       # get data from drawing canvas and save as image
24       parseImage(request.get_data())
25
26       # read parsed image back in 8-bit, black and white mode (L)
27       x = imread('output.png', mode='L')
```

```python
27          x = imread('output.png', mode='L')
28          x = np.invert(x)
29          x = imresize(x,(28,28))
30
31          # reshape image data for use in neural network
32          x = x.reshape(1,28,28,1)
33          with graph.as_default():
34              out = model.predict(x)
35              print(out)
36              print(np.argmax(out, axis=1))
37              response = np.array_str(np.argmax(out, axis=1))
38              return response
39
40      def parseImage(imgData):
41      # parse canvas bytes and save as output.png
42          imgstr = re.search(b'base64,(.*)', imgData).group(1)
43          with open('output.png','wb') as output:
44              output.write(base64.decodebytes(imgstr))
45
46      if __name__ == '__main__':
47          app.debug = True
48          port = int(os.environ.get("PORT", 5000))
49          app.run(host='0.0.0.0', port=port)
```

IBM PROJECT

Handwritten Digit Recognition

The website is designed to predict the handwritten digit.

Select a image: Choose File No file chosen

Predict   Clear

IBM PROJECT

Handwritten Digit Recognition

The website is designed to predict the handwritten digit.

Select a image: Choose File 5.png

Predict   Clear

IBM PROJECT

Handwritten Digit Recognition output

Predicted number:5

CHAPTER 8
ADVANTAGES & DISADVANTAGES

ADVANTAGES

- Reduces manual work
- More accurate than average human
- Capable of handling a lot of data
- Can be used anywhere from any device

DISADVANTAGES

- Cannot handle complex data
- All the data must be in digital format
- Requires a high performance server for faster predictions
- Prone to occasional errors

CHAPTER 9
CONCLUSION

This project demonstrated a web application that uses machine learning to recognise handwritten numbers. Flask, HTML, CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 99.61% recognition rate. The proposed project is scalable and can easily handle a huge number of users. Since it is a web application, it is compatible with any device that can run a browser. This project is extremely useful in real-world scenarios such as recognizing number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on. There is so much room for improvement, which can be implemented in subsequent versions.

CHAPTER 10
FUTURE SCOPE

This project is far from complete and there is a lot of room for improvement. Some of the improvements that can be made to this project are as follows:

- Add support to detect from digits multiple images and save the results
- Add support to detect multiple digits
- Improve model to detect digits from complex images
- Add support to different languages to help users from all over the world

This project has endless potential and can always be enhanced to become better. Implementing this concept in the real world will benefit several industries and reduce the workload on many workers, enhancing overall work efficiency.