A Novel Method for Handwritten Digit Recognition System

NALAIYA THIRAN PROJECT REPORT 2022

Submitted by

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Project Report

ABSTRACT

Handwritten character recognition is one of the practically important issues in pattern recognition applications. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings. To accomplish the recognition task, first, the digits will be segmented into individual digits. Then, a digit recognition module is employed to classify each segmented digit completing the handwritten digit string recognition task. The applications of digit recognition include postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize handwritten digits and which is submitted by users by the way of a scanner, tablet, and other digital devices.

1. INTRODUCTION

1.1 PROJECT OVERVIEW

Handwritten digit recognition is the ability of a computer to recognize the human handwritten digits from different sources like images, papers, touch screens, etc, and classify them into 10 predefined classes (0-9). This has been a topic of boundless research in the field of deep learning. Digit recognition has many applications like number plate recognition, postal mail sorting, bank check processing, etc. In Handwritten digit recognition, we face many challenges because of different styles of writing of different peoples as it is not an Optical character recognition. This research provides a comprehensive comparison between different machine learning and deep learning algorithms for the purpose of handwritten digit recognition. For this, we have used Support Vector Machine, Multilayer Perceptron, and Convolutional Neural Network. The comparison between these algorithms is carried out on the basis of their accuracy, errors, and testing-training time corroborated by plots and charts that have been constructed using matplotlib for visualization.

The accuracy of any model is paramount as more accurate models make better decisions. The models with low accuracy are not suitable for real-world applications. Ex- For an automated bank cheque processing system where the system recognizes the amount and date on the check, high accuracy is very critical. If the system incorrectly recognizes a digit, it can lead to major damage which is not desirable. That’s why an algorithm with high accuracy is required in these real-world applications. Hence, we are providing a comparison of different algorithms based on their accuracy so

that the most accurate algorithm with the least chances of errors can be employed in various applications of handwritten digit recognition.

This paper provides a reasonable understanding of machine learning and deep learning algorithms like SVM, CNN, and MLP for handwritten digit recognition. It furthermore gives you the information about which algorithm is efficient in performing the task of digit recognition. In further sections of this paper, we will be discussing the related work that has been done in this field followed by the methodology and implementation of all the three algorithms for the fairer understanding of them. Next, it presents the conclusion and result bolstered by the work we have done in this paper. Moreover, it will also give you some potential future enhancements that can be done in this field. The last section of this paper contains citations and references used.

1.2 PURPOSE

We describe a method of recognizing handwritten digits by fitting generative models that are built from deformable B-splines with Gaussian "ink generators" spaced along the length of the spline. The splines are adjusted using a novel elastic matching procedure based on the expectation maximization algorithm that maximizes the likelihood of the model generating the data. This approach has many advantages: 1) the system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style; 2) the generative models can perform recognition driven segmentation; 3) the method involves a relatively small number of parameters and hence training is relatively easy and fast; and 4) unlike many other recognition schemes, it does not rely on some form of pre-normalization of input images, but can handle arbitrary scalings, translations and a limited degree of image rotation. We have demonstrated that our method of fitting models to images does not get trapped in poor local minima. The main disadvantage of the method is that it requires much more computation than more standard OCR techniques.

2. LITERATURE SURVEY

2.1 EXISTING PROBLEM

An early notable attempt in the area of character recognition research is by Grimsdale in 1959. The origin of a great deal of research work in the early sixties was based on an approach known as analysis by-synthesis method suggested by Eden in 1968. The great importance of Eden's work was that he formally proved that all handwritten characters are formed by a finite number of schematic features, a point that was implicitly included in previous works. This notion was later used in all methods in syntactic (structural) approaches of character recognition.

1. **K. Gaurav, Bhatia P. K. ,** his paper deals with the various pre-processing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form-based documents and documents containing coloured and complex background and varied intensities. In this, different pre-processing techniques like skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed.

2. **Sandhya Arora** , used four feature extraction techniques namely, intersection, shadow feature, chain code histogram and straight-line fitting features. Shadow features are computed globally for character image while intersection features, chain code histogram features and line fitting features are computed by dividing the character image into different segments. On experimentation with a data set of 4900 samples the overall recognition rate observed was 92.80% for Devanagari characters.

3. **Brakensiek, J. Rottland, A. Kosmala, J. Rigoll**, in their paper a system for off-line cursive handwriting recognition is described which is based on Hidden Markov Models (HMM) using discrete and hybrid modelling techniques. Handwriting recognition experiments using a discrete and two different hybrid approaches, which consist of a discrete and semi-continuous structure, are compared. It is found that the recognition rate performance can be improved of a hybrid modelling technique for HMMs, which depends on a neural vector quantizer (hybrid MMI), compared to discrete and hybrid HMMs, based on tired mixture structure (hybrid - TP),which may be caused by a relatively small data set.

4. **R. Bajaj, L. Dey, S. Chaudhari** , employed three different kinds of features, namely, the density features, moment features and descriptive component features for classification of Devanagari Numerals. They proposed multi classifier connectionist architecture for increasing the recognition reliability and they obtained 89.6% accuracy for handwritten Devanagari numerals.

5. **G. Pirlo and D. Impedovo** in his work on , presented a new class of membership functions, which are called Fuzzy membership functions (FMFs), for zoning-based classification. These FMFs can be easily adapted to the specific characteristics of a classification problem in order to maximize classification performance. In this research, a real coded genetic algorithm is presented to find, in a single optimization procedure, the optimal FMF, together with the optimal zoning described by Voronoi tessellation. The experimental results, which are carried out in the field of handwritten digit and character recognition, indicate that optimal FMF

performs better than other membership functions based on abstract level, ranked-level, and measurement-level weighting models, which can be found in the literature.

6. **Sushree Sangita Patnaik and Anup Kumar Panda** May 2011 , this paper proposes the implementation of particle swarm optimization (PSO) and bacterial foraging optimization (BFO) algorithms which are intended for optimal harmonic compensation by minimizing the undesirable losses occurring inside the APF itself. The efficiency and effectiveness of the implementation of two approaches are compared for two different conditions of supply. The total harmonic distortion (THD) in the source current which is a measure of APF performance is reduced drastically to nearly 1% by employing BFO. The results demonstrate that BFO outperforms the conventional and PSO based approaches by ensuring excellent functionality of APF and quick prevail over harmonics in the source current even under unbalanced supply.

7. **M. Hanmandlu, O.V. Ramana Murthy** have presented in their study the recognition of handwritten Hindi and English numerals by representing them in the form of exponential membership functions which serve as a fuzzy model. The recognition is carried out by modifying the exponential membership functions fitted to the fuzzy sets. These fuzzy sets are derived from features consisting of normalized distances obtained using the Box approach. The membership function is modified by two structural parameters that are estimated by optimizing the entropy subject to the attainment of membership function to unity. The overall recognition rate is found to be 95% for Hindi numerals and 98.4% for English numerals.

8. **Renata F. P. Neves** have proposed SVM based offline handwritten digit recognition. Authors claim that SVM outperforms the multi-layer perceptron classifier. Experiment is carried out on NIST SD19 standard data set. Advantage of MLP is that it is able to segment non-linearly separable classes. However, MLP can easily fall into a region of local minimum, where the training will stop assuming it has achieved an optimal point in the error surface. Another hindrance is defining the best network architecture to solve the problem, considering the number of layers and the amount of perceptron in each hidden layer. Because of these disadvantages, a digit recognizer using the MLP structure may not produce the desired low error rate.

2.2 REFERENCES

1. https://www.tensorflow.org/learn

2. https://www.geeksforgeeks.org/python-tkinter-tutorial/

3.https://medium.com/the-andela-way/applying-machine-learning-to recognize hand written characters- babcd4b8d705

4. https://nanonets.com/blog/handwritten-character-recognition/

5. https://www.geeksforgeeks.org/python-tkinter-tutorial/

6.https://medium.com/the-andela-way/applying-machine-learning-to-recognize hand written characters- babcd4b8d705

7. https://nanonets.com/blog/handwritten-character-recognition/

8. https://www.tensorflow.org/learn

9. R. Alhajj and A. Elnagar, "Multiagents to separating handwritten connected digits," in IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, vol. 35, no. 5, pp. 593-602, Sept. 2005. https://doi.org/10.1109/TSMCA.2005.843389

10.https://towardsdatascience.com/useful-plots-to-diagnose-your-neural-network-521907fa2f45

11. https://towardsdatascience.com/the-best-machine-learning-algorithm-for-handwritten-digitsrecognition-2c6089ad8f09

12.https://www.datacamp.com/community/tutorials/convolutional-neural-networks-python

13.https://www.analyticsvidhya.com/blog/2021/01/building-a-cnn-model-with-95-accuracy/

14. https://www.analyticsvidhya.com/blog/2020/10/what-is-the convolutional-neural-network architecture/

15. https://www.kdnuggets.com/2018/11/top-python-deep-learning libraries.html
16. https://analyticsindiamag.com/7-types-classification-algorithms/
17. https://towardsdatascience.com/image-recognition-with-machin elearning -on-python-imageprocessing-3abe6b158e9a
18. Reference: https://miro.com/app/board/uXjVPNIVgn0=/

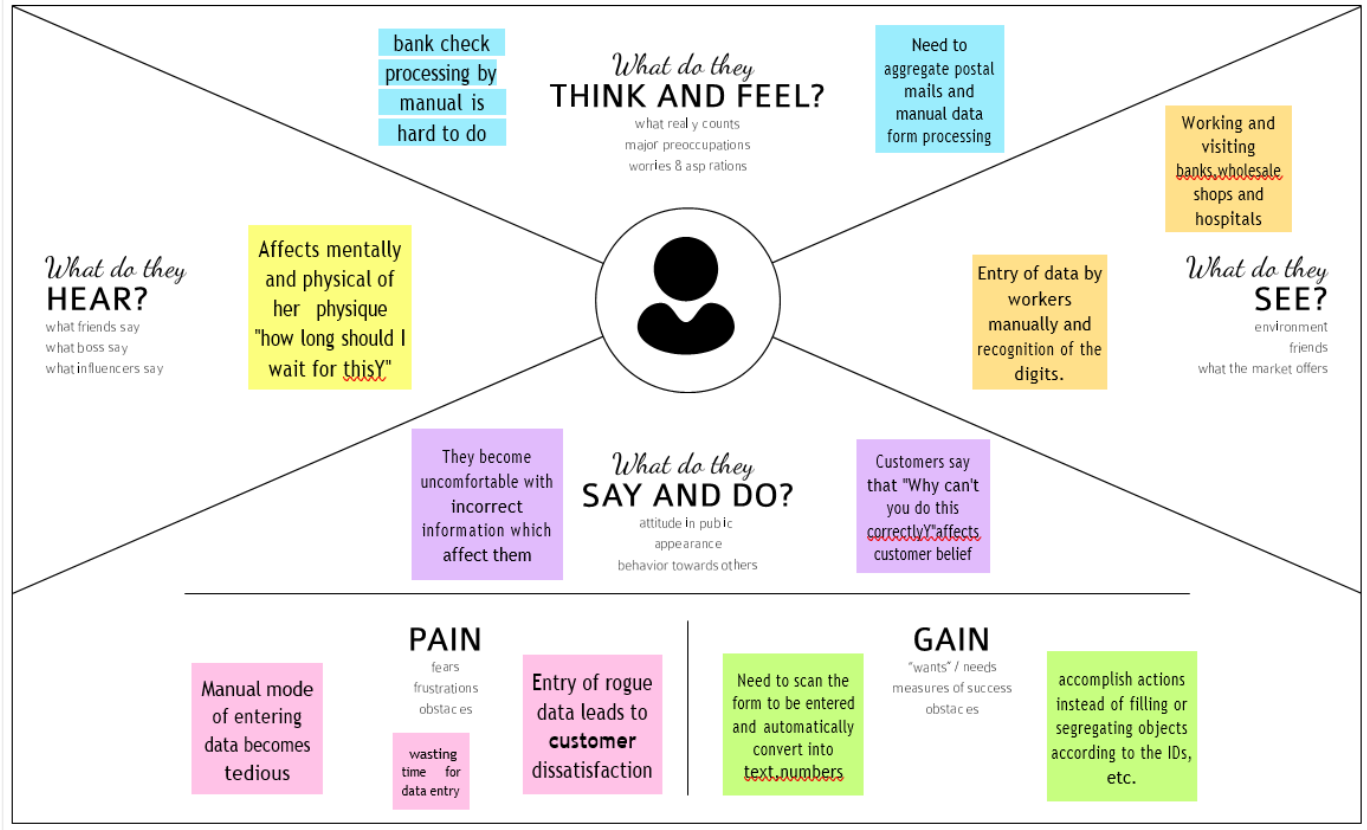
2.3 PROBLEM STATEMENT DEFINITION

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. Though the goal is to create a model which can recognize the digits, it can be extended to letters and an individual's handwriting. The major goal of the proposed system is understanding Convolutional Neural Network, and applying it to the handwritten recognition system.

Problem Statement (PS)	Iam (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Japanese	Recognize the Indian digits	It is difficult	There is no proper source to learn	Frustrated
PS-2	A bank employee	Recognize the digit written on cheque	I can't recognize it	The digits are not written properly	Confused
PS-3	A student	recognize the last date for paying the exam fees which is written on the board	I can't find the correct date	The shapes of the digits are a little bit different.	Sad that I can't recognize the date
PS-4	a placement officer	recognize students' DOB details which have been collected from the students to update the database	I can't able to understand some digits	Some digits are scribbled	Tensed that I can't able to recognize the digits

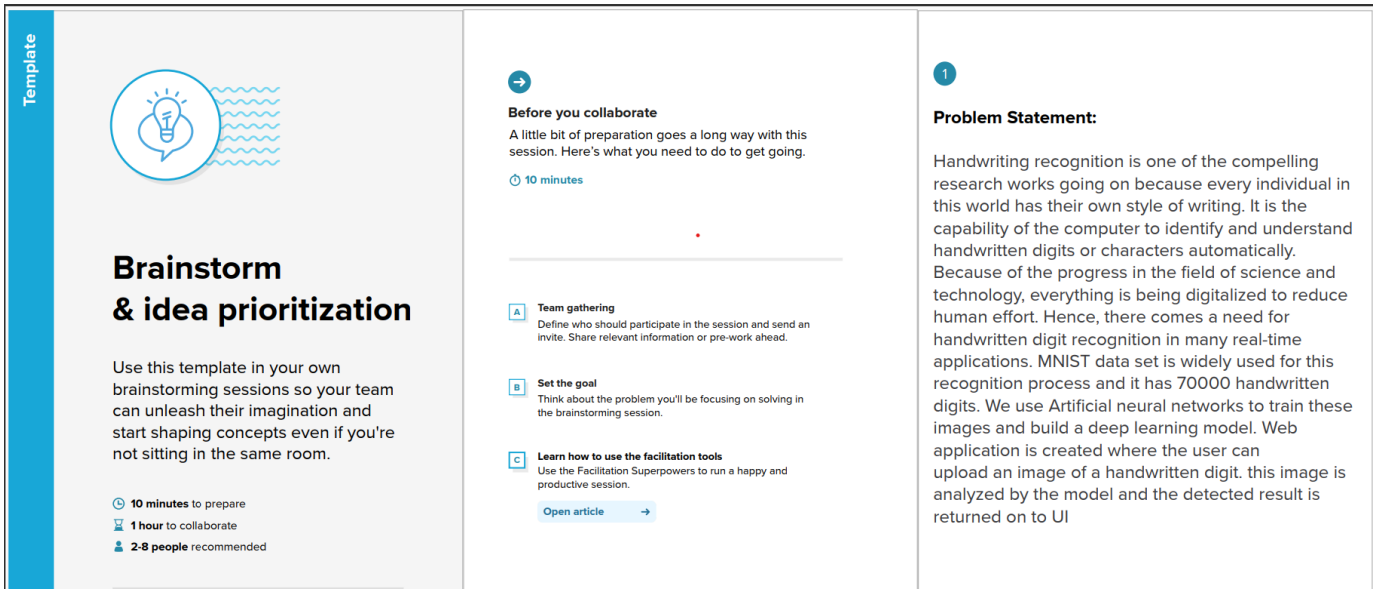
3. IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS

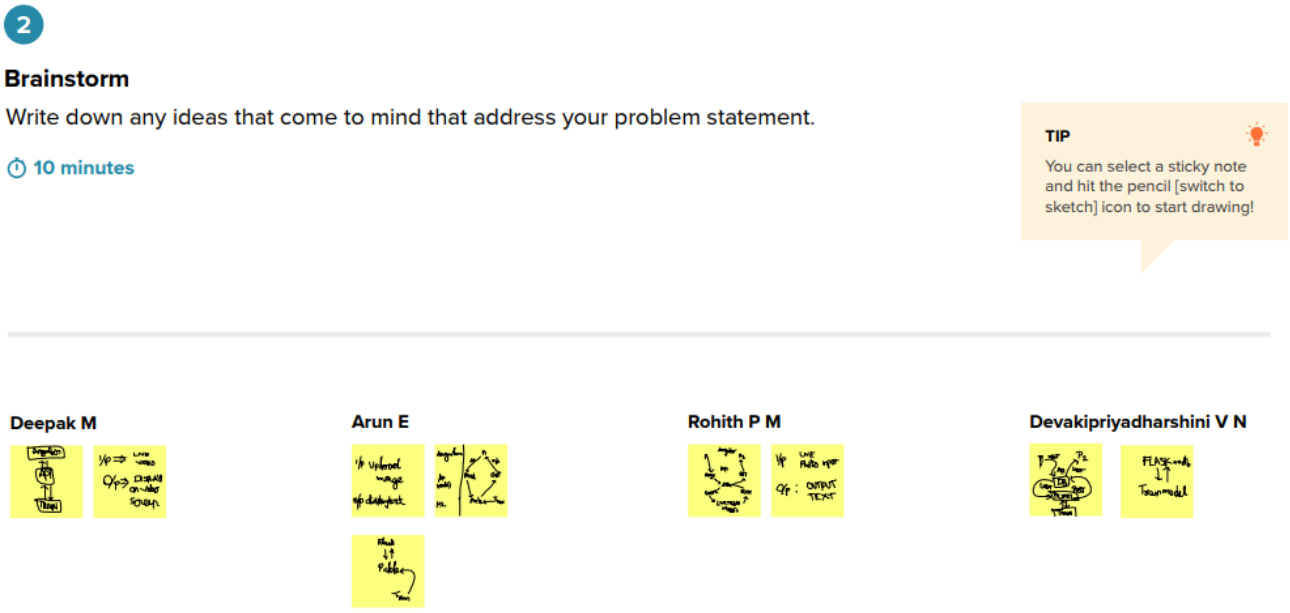


3.2 IDEATION & BRAINSTORMING

Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping



3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

20 minutes

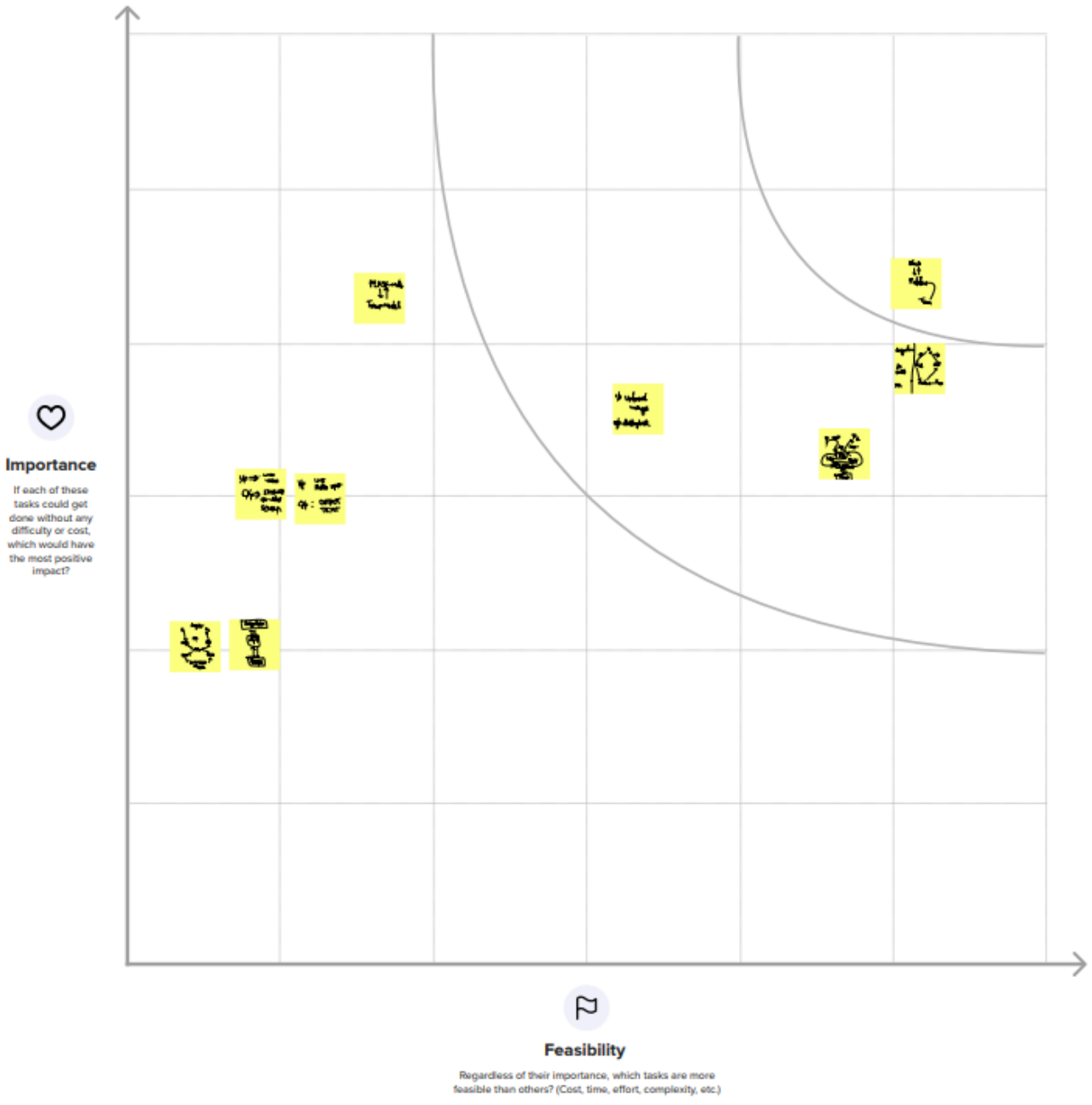
Step-3: Idea Prioritization

4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes



Importance

If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?

Feasibility

Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of the computer to identify and understand handwritten digits or characters automatically. Because of the progress in the field of science and technology, everything is being digitalized to reduce human effort. Hence, there comes a need for handwritten digit recognition in many real-time applications. MNIST data set is widely used for this recognition process and it has 70000 handwritten digits. We use Artificial neural networks to train these images and build a deep learning model. Web application is created where the user can upload an image of a handwritten digit. this image is analyzed by the model and the detected result is returned on to UI.
2.	Idea / Solution description	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 etc.

		Here comes the use of Deep Learning. In the past decade, deep learning has become the hottool for Image Processing, object detection, handwritten digit and character recognition etc. A lot of machine learning tools have been developed like scikit-learn, scipy-image etc. andpybrains, Keras, Theano, Tensorflow by Google, TFLearn etc. for Deep Learning. These tools make the applications robust and therefore more accurate. The Artificial Neural Networks can almost mimic the human brain and are a key ingredient in image processing field. For example, Convolutional Neural Networks with Back Propagation for Image Processing, Deep Mind by Google for creating Art by learning from existing artist styles etc..

3.	Novelty / Uniqueness	The first layer of the architecture is the User layer. User layer will comprise of the people who interacts with the app and for the required results. The next three layers is the frontend architecture of the application. The application will be developed using Bootstrap which is the open source platform for HTML, CSS and JavaScript. The application is deployed in the localhost which is shown on the browser. Through the app, the user will be able to upload pictures of the handwritten digits and convert it into the digitalized form. The one in between the database and view layer is the business layer which is the logical calculations on the basis of the request from the client side. It also has the service interface. The backend layer consists of two datasets: Training Data and Test Data. The MNIST database has been used for that which is already divided into training set of 60,000 examples and test of 10,000 examples.

4.	Social Impact / Customer Satisfaction	As with any work or project taken up in the field of machine learning and image processingwe are not considering our results to be perfect. Machine learning is a constantly evolving field and there is always room for improvement in your methodology; there is always going to be another new approach thatgives better results for the same problem. Theapplication has been tested using three models: Multi-Layer Perceptron (MLP), Convolution Neural Network (CNN). With eachmodel we get a different accuracy of the classifier which shows which one is better.
5.	Business Model (Revenue Model)	The results of training the network is stored in .npz format so that whenever a user tries to recognize the digit, the application does not gointo the training loop again. For classification, we have used logistic classifier, softmax function, one hot encoding, cross entropy and loss minimization using mini batch gradient descent. These are some of the basics of Neural Network which are required to process the output from the network and display in the form the user can understand.

6.	Scalability of the Solution	An implementation of Handwritten Digit Recognition using Deep Learning has been implemented in this paper. Additionally, some of the most widely used Machine Learning algorithms i.e. CNN using Tensorflowhave beentrained and tested on the same data to draw a comparison as to why we require deep learningmethods in critical applications like Handwritten Digit Recognition. In this project, we have shown that using Deep Learning techniques, a very high amount of accuracy can

		be achieved. Using the Convolutional Neural Network with Keras and Theano as backend, Iam able to get an accuracy of 95.72%. Every tool has its own complexity and accuracy. Although, we see that the complexity of the code and the process is bit more as comparedto normal Machine Learning algorithms but looking at the accuracy achieved, it can be saidthat it is worth it. Also, the current implementation is done only using the CPU .Thus we settled on classifying a given handwritten digit image as the required digit using three different algorithms and consequently testing its accuracy. In future weare planning to further explore the topic to recognize people's handwriting.

3.4 PROBLEM SOLUTION FIT

PROBLEM- SOLUTON FIT **Project Title: A NOVEL MODEL FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM** **TEAM ID: PNT2022TMID01476**

Define CS, fit into CC

1. CUSTOMER SEGMENT(S) CS

My customer is a bank manager he trying to Recognize the digits in cheque.

6. CUSTOMER CONSTRAINS: CC

The bank manager recognize the digit but is not clear because of unique style of handwriting.

5. AVAILABLE SOLUTIONS: AS

The bank manager can predict the cheque handwritten digit to complete the transaction.

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

2. JOBS-TO-BE-DONE / PROBLEM: J&P

The cheque hand writing is not clear but the money transaction can not completed

9. PROBLEM ROOT CAUSE: RC

Problem cause is hand written is not clear Hence the transaction is not complete

7. BEHAVIOUR: BE

The customer want to money transaction But the bank manager didn't understand the handwritten and digit hence the transaction is not compete

Focus on J&P, tap into BE, understand RC

Identify strong TR & EM

3. TRIGGERS TR

Problem is hand written is not clear each check take more time the bank manger had irritated

4. EMOTIONS: EM

The cheque handwrittendigit is not understand it take more time the hence bank manager annoyed

10. YOUR SOLUTION SL

Use the MINIST Dataset to recognize handwritten digits convolutional neural network model created using pytorch library to solve the problem

8. CHANNELS of BEHAVIOUR CH

The customer want to money transaction But the bank manager didn't understand the handwritten and digit it's take more time hence the transaction is not compete he had annoyed

Extract online & offline CH of BE

4. REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

4.1.1 System Configuration:

Software requirements**:**

These are the software configurations used:

Operating system: Windows 10.

IDE: Jupyter Notebook.

Python: Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant Whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed, and garbage collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

Jupyter Notebook: Jupyter is a free, open-source, interactive web tool known as a computational notebook, which researchers can use to combine software code, computational output, explanatory text and multimedia resources in a single document. Computational notebooks have been around for decades, but Jupyter in particular has exploded in popularity over the past couple of years. This rapid uptake has been aided by an enthusiastic community of user–developers and a redesigned architecture that allows the notebook.

4.2 NON-FUNCTIONAL REQUIREMENTS

4.2.1 Hardware requirements:

These are the Hardware interfaces used Processor: Intel Pentium 4 or equivalent

RAM: Minimum of 256 MB or higher HDD: 10 GB or higher

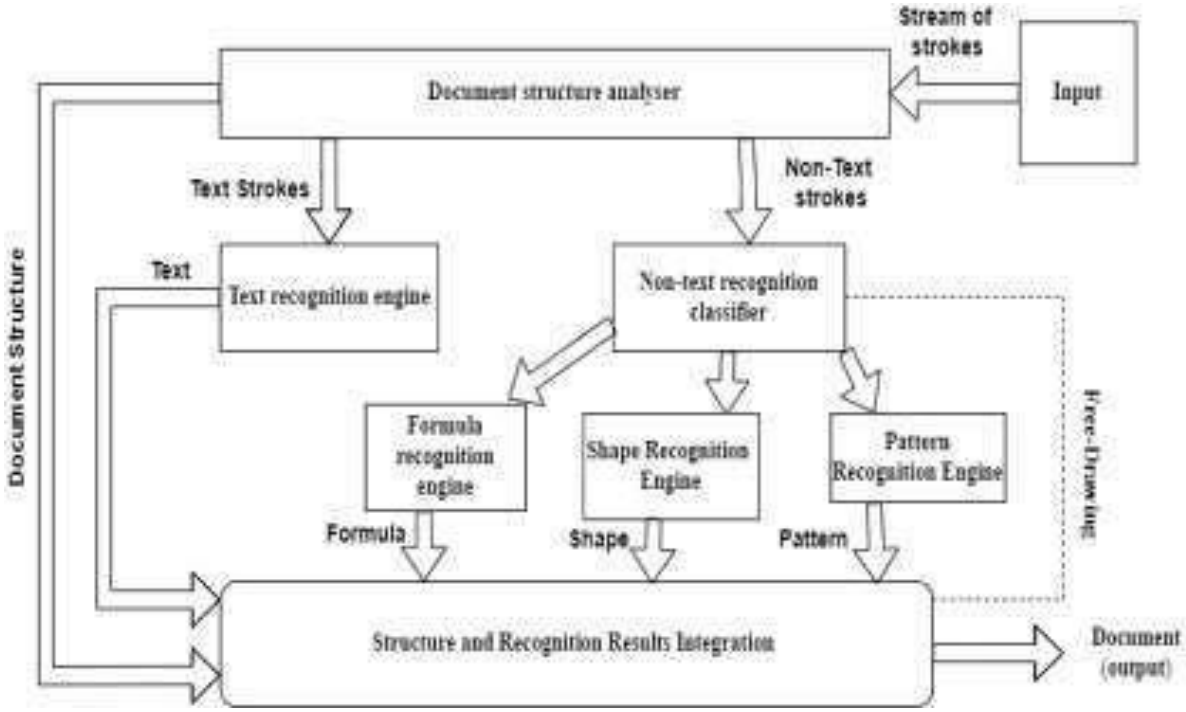
Monitor: 15’ or 17’ colour monitor

Mouse: Scroll or optical mouse

Keyboard: Standard 110 keys keyboard

5. PROJECT DESIGN

5.1 DATA FLOW DIAGRAMS



User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Home	USN-1	As a user, I can view the guide andawareness to use this application.	I can view the awareness to use this application andits limitations.	Low	Sprint-1

		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	I can gain knowledge touse this application by apractical method.	Low	Sprint-1
		USN-3	As a user, I can read the instructions to usethis application.	I can read instructions alsoto use it in a user-friendly method.	Low	Sprint-2
	Recognize	USN-4	As a user, In this prediction page I get tochoose the image.	I can choose the image from our local system andpredict the output.	High	Sprint-2
	Predict	USN-6	As a user, I'm Allowed to upload and choosethe image to be uploaded	I can upload and choose the image from the systemstorage and also in any virtual storage.	Medium	Sprint-3
		USN-7	As a user, I will train and test the input to getthe maximum accuracy of output.	I can able to train and test the application until it gets maximum accuracy of theresult.	High	Sprint-4
		USN-8	As a user, I can access the MNIST data set	I can access the MNISTdata set to produce the accurate result.	Medium	Sprint-3
Customer (Webuser)	Home	USN-9	As a user, I can view the guide to use the webapp.	I can view the awareness of this application and its limitations.	Low	Sprint-1

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criter
Customer (Mobile user)	Home	USN-1	As a user, I can view the guide andawareness to use this application.	I can view the awareness to use application andit limitations.
		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	I can gain knowl touse this applic by apractical met
		USN-3	As a user, I can read the instructions to usethis application.	I can read instruc alsoto use it in a friendly method.
	Recognize	USN-10	As a user, I can use the web applicationvirtually anywhere.	I can use the applicationportal anywhere.
		USN-11	As it is an open source, can use it cost freely.	I can use it witho payment to be pa it toaccess.
		USN-12	As it is a web application, it is installation free	I can use it witho theinstallation of the application o any software.
	Predict	USN-13	As a user, I'm Allowed to upload and choosethe image to be uploaded	I can upload and choose the image the systemstorag also in any virtua storage.

5.2 SOLUTION & TECHNICAL ARCHITECTURE

Solution Architecture :

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of the computer to identify and understand handwritten digits or characters automatically. Because of the progress in the field of science and technology, everything is being digitalized to reduce human effort.

Hence, there comes a need for handwritten digit recognition in many real-time applications. Its goals are to:

- MNIST data set is widely used for this recognition process, and it has 70000 handwritten digits.
- We use Artificial neural networks to train these images and build a deep learning model.
- Web application is created where the user can upload an image of a handwritten digit.
- This image is analysed by the model and the detected result is returned on to UI.

Technical Architecture :

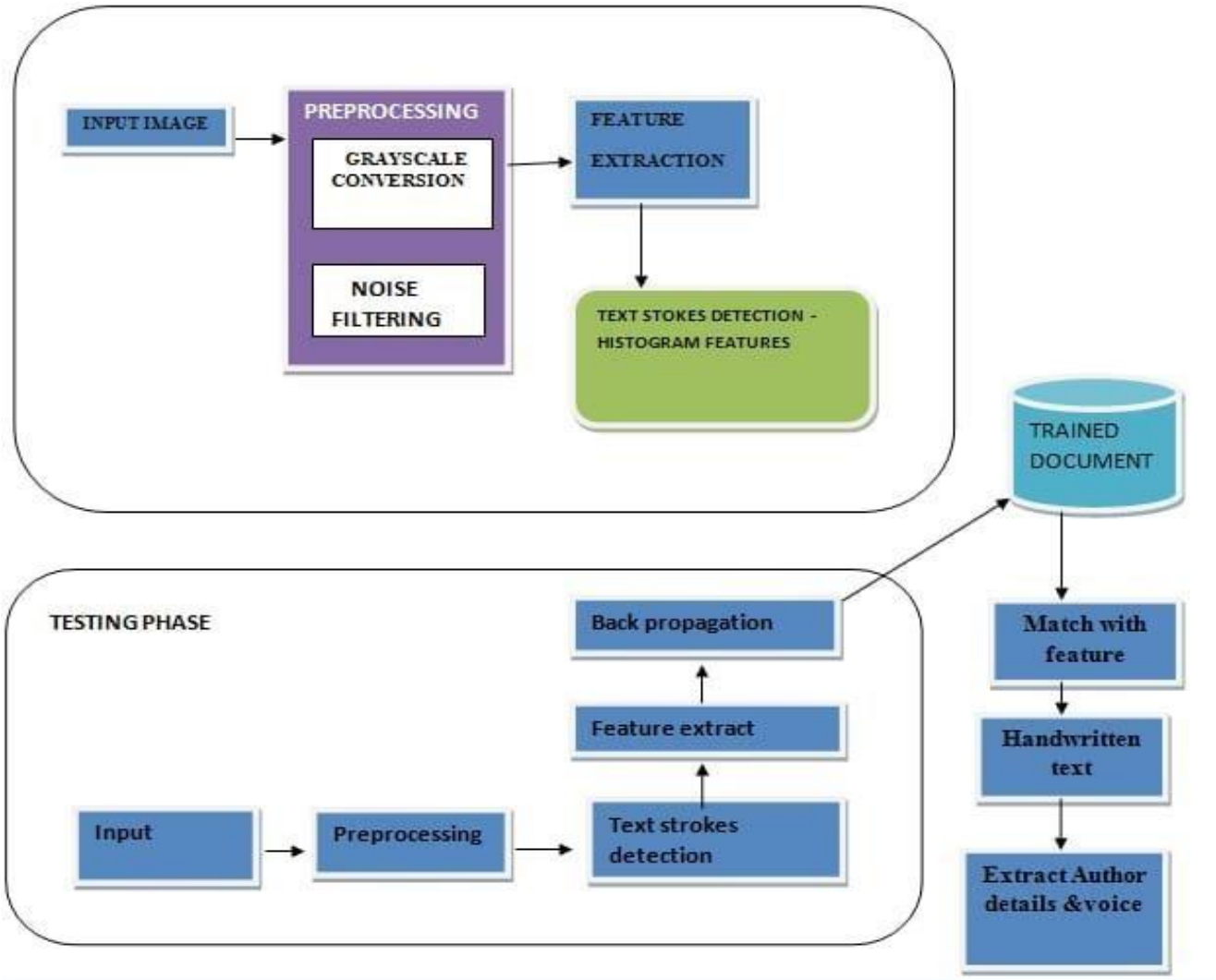


Figure 1: Architecture and data flow of the Handwritten Digit Recognition System.

5.3 USER STORIES

6. PROJECT PLANNING & SCHEDULING

6.1 SPRINT PLANNING & ESTIMATION

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	DEEPAK M ARUN E DEVAKIPRIYADHARSHINI V N ROHITH P M
Sprint-1	Login	USN-2	As a user, I can log into the applicationby entering email & password	1	High	DEEPAK M ARUN E DEVAKIPRIYADHARSHINI V N ROHITH P M
Sprint-2	Upload Image of digital document	USN-3	As a user, I can able to input the imagesof digital documents to the application	2	Medium	DEEPAK M ARUN E DEVAKIPRIYADHARSHINI V N ROHITH P M
Sprint-3	Upload Image of Handwritten document	USN-4	As a user, I can able to input the imagesof the handwritten documents or imagesto the application	2	High	DEEPAK M ARUN E DEVAKIPRIYADHARSHINI V N ROHITH P M
Sprint-4	Recognize digit	USN-5	As a user I can able to get the recognizeddigit as output from the images of digital documents or images	1	Medium	DEEPAK M ARUN E DEVAKIPRIYADHARSHINI V N ROHITH P M

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-4	Recognize digit	USN-6	As a user I can able to get the recognizeddigit as output from the images of handwritten documents or images	2	High	DEEPAK M ARUN E DEVAKIPRIYADHARSH INI V N ROHITH P M

6.2 SPRINT DELIVERY SCHEDULE

Project Tracker, Velocity & Burndown Chart:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	31 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	06 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	13 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) periteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

AV1=sprint duration/velocity=10/6=1.67

AV2=sprint duration/velocity=12/6=2

AV3=sprint duration/velocity=14/6=2.3

AV4=sprint duration/velocity=10/6=1.67

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies suchas Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

SPRINT 1

TASK	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	TOTAL
USN 1	10	2	2	2	2	2	1	10
USN 2	10	2	2	2	2	2	1	10

SPRINT 2

TASK	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	TOTAL
USN 3	15	3	3	3	3	2	1	15

SPRINT 3

TASK	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	TOTAL
USN 4	25	5	5	3	4	5	3	25

SPRINT 4

TASK	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	TOTAL
USN 5	20	4	4	4	4	2	2	20
USN 6	20	4	4	4	2	4	2	20

ACTUAL AND REMAINING

EFFORTS:SPRINT 1

EFFORT	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
ACTUAL EFFORT	20	4	6	3	5	2	0
ESTIMATED EFFORT	20	5	5	5	5	5	0

SPRINT 2

EFFORT	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
ACTUAL EFFORT	15	4	2	5	2	2	0
ESTIMATED EFFORT	15	3	3	3	3	3	0

SPRINT 3

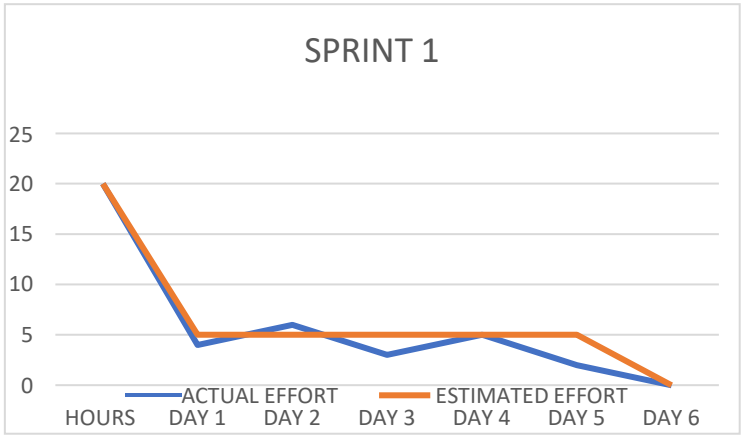
EFFORT	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
ACTUAL EFFORT	25	4	7	6	6	2	0
ESTIMATED EFFORT	25	5	5	5	5	5	0

SPRINT 4

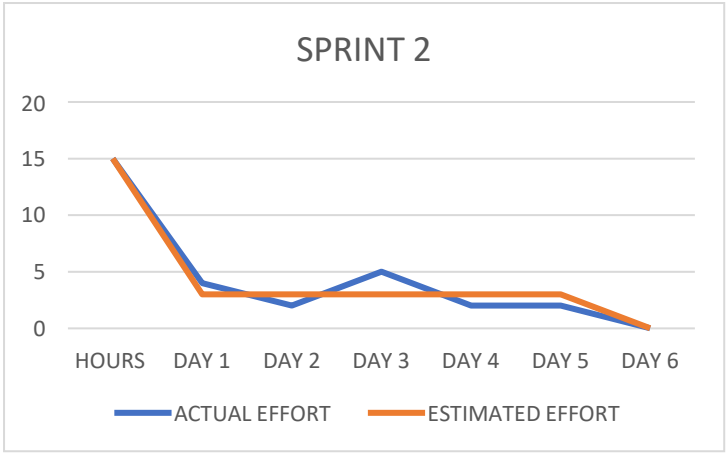
EFFORT	HOURS	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
ACTUAL EFFORT	40	9	7	10	9	5	0
ESTIMATED EFFORT	40	8	8	8	8	8	0

BURNDOWN

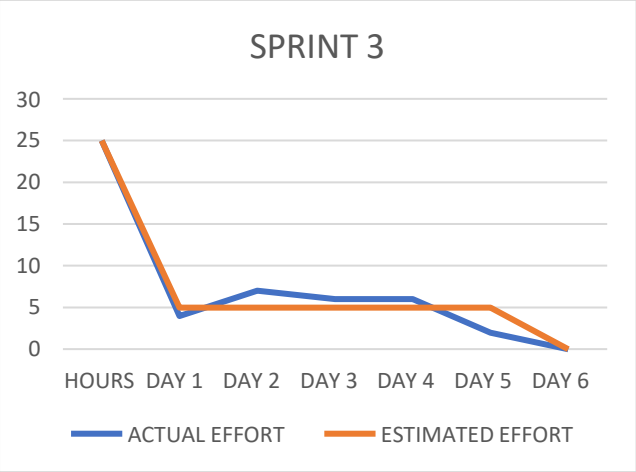
CHART:SPRINT 1



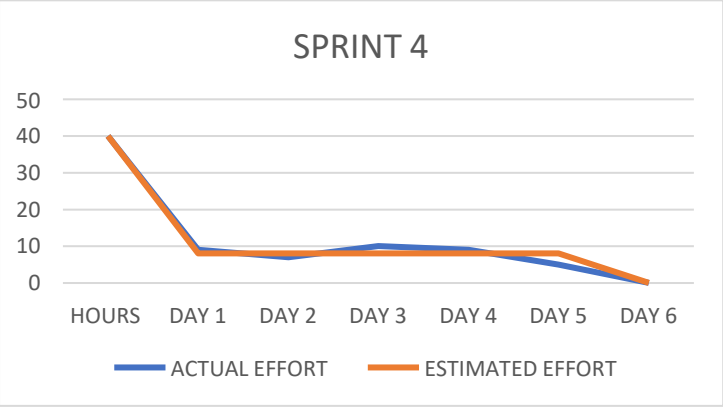
SPRINT 2



SPRINT 3



SPRINT 4



6.3 REPORTS FROM JIRA

Activity Number	Activity Name	Detailed Activity Description	Assigned To	Status / Comments
1.	**Preparation Phase**	Access the resources (courses) in project dashboard Access the guided project workspace Create GitHub account & collaborate with Project Repository in project workspace Set-up the Laptop / Computers based on the prerequisites for each technology track	Deepak M Arun E Devaki Rohith P M	It refers to do the listed activities in the preparation phase and done Prerequisites, Registration, Environment setup
2	**Ideation Phase**	Literature survey on the selected project & Information Gathering Preparation of Empathy Map Canvas to capture the	Deepak M Arun E Devaki Rohith P M	The activities in ideation phase refers to when gathering the idea for project information and picturize in Empathy map, referring the

		user Pains & Gains, Prepare list of problem statements List the ideas by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance		literature survey& brainstormin gthe ideas for thisproject.
3	**Project Design Phase -I**			
3.1	Proposed Solution	Preparation of proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution	Deepak M Arun E Devaki Rohith P M	The solution forthe project is prepared as a standard document structure from Team members
3.2	Problem Solution fit	Preparation of problem solution fit	Deepak M Arun E Devaki Rohith P M	Prepared Problem is analysed and make effective solutions for the proble m
3.3	Solution Architecture	Prepare an architecture for solution	Deepak M Arun E Devaki Rohith P M	Suitable blockdiagram template used to prepare

				Solution architectu re
4	**Project Design Phase -II**			
4.1	Requirement Analysis	Prepare the Functional Requirement and Non-Functional Document	Deepak M Arun E Devaki Rohith P M	Listing o ffunctional a ndnon-functional requirements ofprojects
4.2	Customer Journey	Preparation of customer journey maps to understand the user interactions & experiences with the application (entry to exit)	Deepak M Arun E Devaki Rohith P M	Customer journey ma ps prepared bysuitable template byteam members
4.3	Data Flow Diagrams	Prepare a Data Flow Diagram for Project	Deepak M Arun E Devaki Rohith P M	Use suitabl e data flo w diagram rul esand standards to prepare DFD
4.4	Technology Architecture	Prepare Technology Architecture	Deepak M Arun E Devaki Rohith P M	We created architecture diagram and technologies used for

				this project
5	**Project planning phase**			
5.1	Milestones & Tasks	Prepare Milestone & Activity List	Deepak M Arun E Devaki Rohith P M	When project begins then it isexpected That project related activities must

				be initiated. Inproject planning, seriesof milestones mustbe established.
5.2	Sprint Schedules	Prepare Sprint Delivery Plan	Deepak M Arun E Devaki Rohith P M	In this, Product Backlog, Sprint Schedule for the Project are estimated.
6	**Project Developmen tPhase**			
6.1	Coding & Solutioning	Sprint-1 Delivery: Develop the Code, Test, and push it to GitHub.	Deepak M Arun E Devaki Rohith P M	In this, we aregoing to develop & Submit the developed codeby testing it.
6.2	Acceptance Testing	Sprint-2 Delivery: Develop the Code, Test, and push it to GitHub. Sprint-3 Delivery: Develop the Code, Test, and push it to GitHub.	Deepak M Arun E Devaki Rohith P M	In this, we are going to develop & Submit the developed code by testing it.

7. CODING & SOLUTIONS

7.1 FEATURE 1

HOME PAGE

```
<html>
<head>
    <title>HOME</title>
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <style>
        .topnav {
            overflow: hidden;
            background-color: #333;
        }

        .topnav a {
            float: left;
            color: #f2f2f2;
            text-align: center;
            padding: 14px 16px;
            text-decoration: none;
            font-size: 17px;
        }

        .topnav a:hover {
            background-color: #ddd;
            color: black;
        }

        .topnav a.active {
            background-color: #04AA6D;
            color: #ffffff;
            font-family: Lucida Handwriting;
        }

        body {
            background-color: #eb4559;
        }

        #a {
            color: rgb(255, 255, 255);
            font-size: 60px;
            padding-top: 90px;
            text-align:center;
            font-family: Lucida Handwriting;
        }

        #b {
            position: absolute;
            top: 50%;
            left: 50%;
            transform: translate(-50%,-50%);
        }
        #c {
            position: absolute;
```

```
            top: 65%;
            left: 50%;
            transform: translate(-50%,-50%);
        }
        .upload-box{
            font-size: 16px;
            background: white;
            border-radius: 50px;
            box-shadow: 5px 5px 10px black;
            width: 350px;
            outline: none;
        }
        ::-webkit-file-upload-button{
            color: white;
            background-color: #04AA6D;
            padding:20px;
            border:none;
            border-radius: 50px;
            box-shadow: 1px 0 1px 1px #6b4559;
            outline: none;
        }
        .button{
            color: white;
            background-color: #04AA6D;
            padding:20px;
            border:none;
            border-radius: 50px;
            box-shadow: 1px 0 1px 1px #6b4559;
            outline: none;
        }
    </style>
<body>
    <!--<div class="topnav">
        <a class="active" href="#home">A Novel Method For Handwritten Digit
Recognition</a>
      </div>-->
    <h1 id="a">A Novel Method For Handwritten Digit Recognition</h1>
    <form action="http://127.0.0.1:5000/upload_file" method="POST" enctype =
"multipart/form-data">
    <input id="b" class="upload-box" type="file" name="file" required/><br><br>
    <input id="c" class="button" style="box-shadow: 5px 5px 10px black;"
type="submit" value="RECOGNIZE" />
    </form>
</body>
</head>

</html>
```

OUTPUT:


A Novel Method For Handwritten Digit Recognition
Choose File
No file chosen
RECOGNIZE

7.2 FEATURE 2

RECOGNIZE PAGE

```
<html>

<style>

  .button {
    display: inline-block;
    border-radius: 4px;
    background-color: #eb4559;
    border: none;
    color: #FFFFFF;
    text-align: center;
    font-size: 20px;
    padding: 20px;
    width: 150px;
    transition: all 0.5s;
    cursor: pointer;
    margin: 5px;
    font-family: Lucida Handwriting;
  }

  .button span {
    cursor: pointer;
    display: inline-block;
    position: relative;
    transition: 0.5s;
  }

  .button span:after {
    content: '\00bb';
    position: absolute;
    opacity: 0;
    top: 0;
    right: -20px;
    transition: 0.5s;
  }

  .button:hover span {
    padding-right: 25px;
  }

  .button:hover span:after {
    opacity: 1;
    right: 0;
  }

  .wavies > use{
    animation: waveAround 12s linear infinite;
    &:nth-child(1) { animation-delay:-2s; }
    &:nth-child(2) { animation-delay:-2s; animation-duration:5s }
    &:nth-child(3) { animation-delay:-4s; animation-duration:3s }
```

```
  }

  @keyframes waveAround{
    0% { transform: translate(-90px , 0%) }
    100% { transform: translate(85px , 0%) }
  }

  body {
    height: 100vh;
    background-color: #eb4559;
    display: flex;
    justify-content: flex-end;
    flex-direction: column;
  }
  .inner-header {
    height:40vh;
    width:100%;
    margin: 0;
    padding: 150  0 0;
    color:white;
    font-size: 30px;
    font-family: Lucida Handwriting;
  }
  .flex {

    align-items: center;
    text-align: center;
  }
  form{
    position: absolute;
    top:7%;
    left:94%;
    transform: translate(-50%,-50%);
  }
</style>
<body>
  <form action="http://127.0.0.1:5000/">
    <button class="button" style="vertical-align:middle" ><span>Back
</span></button>
  </form>
  <div class="inner-header flex">
    <h1>The Number Predicted Is</h1>
    <h1 id="a">7</h1>
  </div>
  <svg xmlns="http://www.w3.org/2000/svg"
xmlns:xlink="http://www.w3.org/1999/xlink" viewBox="0 24 150 28"
preserveAspectRatio="none">
    <defs>
       <path id="gentle-wave" d="M-160 44c30 0 58-18 88-18s 58 18 88 18 58-18 88-
18 58 18 88 18 v44h-352z" />
    </defs>
    <g class="wavies">
      <use xlink:href="#gentle-wave" x="50" y="0" fill="#d5d5d5"/>
      <use xlink:href="#gentle-wave" x="50" y="3" fill="#e5e5e5"/>
      <use xlink:href="#gentle-wave" x="50" y="6" fill="white"/>
    </g>
   </svg>
</body>
</html>
```

OUTPUT:


A Novel Method For Handwritten Digit Recognition
Choose File
2.png

8.TESTING

8.1 TEST CASES

This report shows the number of test cases that have passed, failed, and untested.

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	10	0	0	10
Security	1	0	0	1
Outsource Shipping	2	0	0	2
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

8.2 USER ACCEPTANCE TESTING

PURPOSE OF THE DOCUMENT

The purpose of this document is to briefly explain the test coverage and open issues of the Handwritten Digit Recognition project at the time of the release to User Acceptance Testing (UAT).

DEFECT ANALYSIS

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	0	4	2	3	9
Duplicate	0	0	3	0	3
External	0	0	0	1	1
Fixed	0	4	5	4	13
Not Reproduced	0	0	0	0	0
Skipped	0	0	0	1	1
Won't Fix	0	0	0	1	1
Totals	0	8	11	10	26

9. RESULTS

9.1 PERFORMANCE METRICS

After implementing all the three algorithms that are SVM, MLP and CNN we have compared their accuracies and execution time with the help of experimental graphs for perspicuous understanding. We have considered the Training and Testing Accuracy of all the models stated above. After executing all the models, we found that SVM has the highest accuracy on training data while on testing dataset CNN accomplishes the utmost accuracy. Additionally, we have compared the execution time to gain more insight into the working of the algorithms. Generally, the running time of an algorithm depends on the number of operations it has performed. So, we have trained our deep learning model up to 30 epochs and SVM models according to norms to get the apt outcome. SVM took the minimum time for execution while CNN accounts for the maximum running time.

10. ADVANTAGES AND DISADVANTAGES

10.1 ADVANTAGES

1. The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as writing style.

2. The generative models can perform recognition driven segmentation.

3. Handwriting forces your brain to mentally engage with the information, improving both literacy and reading comprehension.

4. Digitalization

5. Data Collection.

10.2 DISADVANTAGES

1. Despite that there are enormous convolutional neural network algorithms proposed for handwritten digit recognition, issues such as recognition accuracy.

2. Get alternative, less likely predictions when available.

3. Anyway Higher processor is required.

4. High cost

5. Time consuming

6. computation time still require for further improvement.

11. CONCLUSION

Our project HANDWRITTEN DIGIT RECOGNITION deals with identifying the digits. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings. In this project, different machine learning methods, which are SVM (Support Vector Machine), ANN (Artificial Neural Networks), and CNN (Convolutional Neural Networks) architectures are used to achieve high performance on the digit string recognition problem.

Recognition of characters and digits is viral in today's digitized world, especially in organizations that deal with handwritten documents that they need to analyse using computer systems. Convolutional Neural Network gets trained from the real-time data and makes the model very simple by reducing the number of variables and gives relevant accuracy. A comparison on different Machine Learning algorithms like Random Forest Classifier, Convolutional Neural Network, Linear Regression, K-Nearest Neighbours, Support vector machine is done, in which the accuracy for CNN is 99.63%. It can be used to convert books, newspapers and handwritten notes into digital text format using machine learning models.

12. FUTURE SCOPE

The proposed system takes 28x28 pixel sized images as input. The same system with further modifications and improvements in the dataset and the model can be used to build Handwritten Character Recognition System which recognizes human handwritten characters and predicts the output. The future development of the applications based on algorithms of deep and machine learning is practically boundless. In the future, we can work on a denser or hybrid algorithm than the current set of algorithms with more manifold data to achieve the solutions to many problems.