DOODLE RECOGNITION

by Karibasappa K.g

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A Mini Project Report

On

DOODLE RECOGNITION

submitted in partial fulfillment of the requirement for the degree of

Bachelor of Engineering

In

Computer Science and Engineering

Submitted By

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CERTIFICATE

This is to certify that Mini Project entitled Doodle Recognition is a bonafide work carried out by the student team Ms. Shrinidhi R H - O1FE20BCS227, Ms. Arya Kinagi -O1FE20BCS058, Ms. Nayana D G - O1FE20BCS235, Ms. Priya M - O1FE20BCS239, in partial fulfillment of completion of fifth semester B. E. in Computer Science and Engineering during the year 2022 – 2023. The project report has been approved as it satisfies the academic requirement with respect to the project work prescribed for the above said programme.

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1.

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ABSTRACT

In our project “Doodle Recognition”, we developed a deep learning model for automatic doodle recognition. Doodles, or simple drawings made with a pen or pencil, are a common form of communication and self-expression. However, the process of manually categorizing and labeling doodles can be time-consuming and error-prone, and also when the name of an object is unknown, to search its name through the specifications could be hard. To address these challenges, we used a convolutional neural network (CNN) and Residual Network (ResNet) to classify doodles into various categories.

We trained and tested our model on a dataset of doodles collected from online sources (Kaggle Website) and found that it achieved an accuracy of CNN being 97.12% and Resnet being 97.46% on the test set. Our model has the potential to significantly reduce the effort required to categorize and label doodles, making it a useful tool for researchers and educators working with doodles.

It can serve as the fundamental model for sketch-based modeling and sketch-based image retrieval.

ACKNOWLEDGEMENTS

The sense of contentment and elation that accompanies the successful completion of our project and its report would be incomplete without mentioning the names of the people who helped us in accomplishing this.

We are indebted to our guide Dr. Karibasappa K G who was nothing but, a constant source of enthusiasm and whose profound guidance, valuable suggestions, and beneficent direction was mainly responsible for us to complete this project.

We take this opportunity to express our deep sense of gratitude and sincere thanks to our Head of the department, Dr. Meena S. M. for her tremendous source of inspiration and help in challenging our effort in the right direction.

Last but not least we like to thank all the course faculty, teaching and non-teaching staff for helping us during the project.

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1. INTRODUCTION

Preamble

Doodle Recognition is a technology that allows a computer to interpret and classify hand-drawn images, also known as doodles. This can be accomplished through the use of machine learning and deep learning algorithms, which enable the computer to analyze and understand the features of a doodle and assign it to a specific category or class. The goal of doodle recognition is to provide a fast and accurate means of identifying and categorizing doodles, and it has a wide range of applications in various fields, including education, entertainment, and communication. In this Project, we will explore the basics of doodle recognition and discuss some of the ways in which it is being used and developed.

1.2 Motivation

Quick, Draw! was where we first learned about doodle recognition. Quick, Draw! is an online game built with machine learning developed by Google Creative Lab and Data Arts Team.

It prompts the player to doodle an image on the screen and the model guesses what the image depicts in a human-to-computer game of Pictionary.

However, it does not have the feature to scan hand drawn doodle images or to draw doodles in air.

Hence, in order to improve the scope for creating doodles, we considered the features, scan a drawn doodle and make a doodle in front of the camera in air.

1.3 Objectives of the project

- Identify and study the methodologies already available in the literature survey, "Doodling with Deep Learning!" by Towards Data Science.
- The above literature has no feature to scan a hand drawn doodle image which is to be added to our model and it has an accuracy of 92.11 % which shall be improved in our model.
- Our application resolves the above issue by providing us with two input options, scan a drawn doodle and make a doodle in front of the camera in air.
- This application can be used to search for names of various objects based on the doodles. It can also be used by the hearing and speech impaired people to convey their needs to those around them.
- This application shall have better scope for creating doodle images as well as better accuracy for the results.

1.4 Literature Survey

1. **Kristine Guo, James WoMa, Eric Xu, "Quick, Draw! Doodle Recognition" Stanford University, 2018.**

   In this paper, a multi-class classifier was built to assign hand-drawn doodles from Google's online game Quick, Draw! into 345 unique categories.

   The main observation is that Quick Draw! dataset contains numerous preprocessed images of various categories that will help in making an efficient model.

   Multiple variations of k-nearest neighbors and a convolutional neural network were implemented and compared which achieved 35% accuracy and 60% accuracy, respectively.

2. **Karan Chauhan, Shrwan Ram, "Image Classification with Deep Learning and Comparison between Different Convolutional Neural Network Structures using TensorFlow and Keras", M.B.M. Engineering College Jodhpur, India, International Journal of Advance Engineering and Research Development(IJAERD), 2018.**

   In this paper, a large number of different images, which contain two types of animals, namely cat and dog are used for image classification.

Four different structures of CNN are compared on CPU systems, with four different combinations of classifiers and activation functions.
For Binary image classification, combination of sigmoid classifier and Relu activation function gives higher classification accuracy than any other combination of classifier and activation function.
The main observation is that the comparison between different neural networks will help in the optimal selection of the neural network that will be used to train the model with the help of TensorFlow and Keras.

3. **E. Boyaci and M. Sert, "Feature-level fusion of deep convolutional neural networks for sketch recognition on smartphones", 2017 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, 2017.**

   In this paper, feature-level fusion is implemented that use deep convolutional neural networks (CNNs) for recognizing hand-free sketches and develops a sketch recognition application for smartphones based on client-server application architecture.

   Results on TU-Berlin hands-free sketch benchmark dataset show that, feature-level fusion scheme achieves a recognition accuracy of 69.175%.
   This outcome is promising when contrasted and the human acknowledgment exactness of 73.1% on the equivalent dataset.
   The main observation is that it helps in understanding various datasets for the implementation of the project.

4. **Wayne Lu, Elizabeth Tran, "Free-hand Sketch Recognition Classification", Stanford University, 2017.**

   In this paper, a publicly available dataset of 20,000 sketches across 250 classes from Eitz et al. is used.

   Convolutional neural network (CNN) is applied in order to improve performance to increase the recognition accuracy on sketches drawn by different people.
   The effects of several hyperparameters on overall performance are analyzed using a residual network (ResNet) approach.
   The main observation is that better understanding of CNN will help in an efficient model creation.

5. **Habibollah Agh Atabay, "Hand Drawn Sketch**

Classification Using Convolutional Neural Networks", Gonbad Kavous University, Iran, 2016.

In this paper, the accuracy of sketch image classification is improved by training a few deep CNNs.

The size of inputs in the currently used architectures of CNNs is greater than 200×200 pixels which has limited the accuracy of classification.

Input is given in the form of tiny images, thus the architecture of CNNs are simplified and thus be trained in a reasonable time, in CPU mode and increase the speed of training.

The main observation is that studying CNN on different datasets will help in analyzing the model thus resulting in better outcomes.

6. **Towards Data Science, Akhilesh Reddy, Vincent Kuo, Kirti Pande, Tiffany Sung, Helena Shi, "Doodling with Deep Learning!"**

Worked to understand the unique structure of doodle data and figured out how to connect with Google Cloud Platform to run the models

Performed data cleaning & preprocessing through shuffling csv files and augmenting images with stroke information and more

Ran reduced dataset of five classes on three simple classifiers on our local system

Implemented Deep learning models from a simple CNN to ResNets and MobileNets

Submitted results to the competition (Kaggle) and created an app.

1.5 Problem Definition

The aim of the proposed work is to design and develop a model to create and classify the doodle images.

2. PROPOSED SYSTEM

A proposed system is a plan or design for a system that is intended to meet a specific set of needs or achieve a specific set of goals.

2.1 Description of Proposed System.

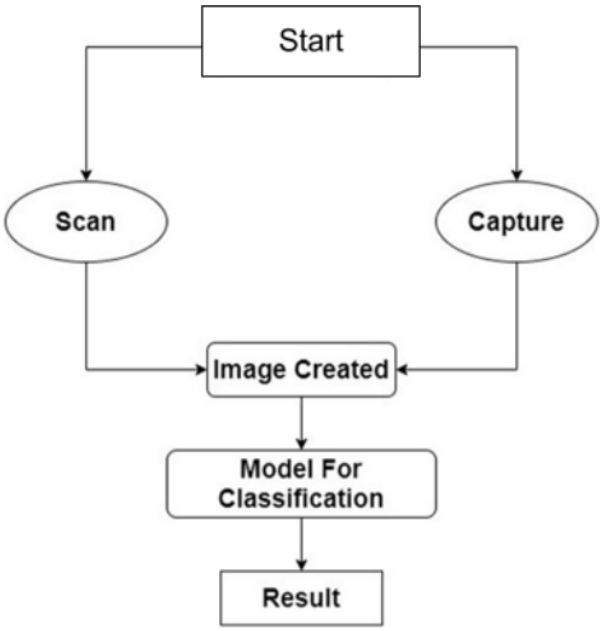

Fig : Flowchart of the proposed system

The above flowchart description -

a) Input model selection

Scan image directly.

Draw a doodle in front of the camera in air.

b) Capture the image

Doodle image is created using any one of the above input modes.

c) Classification of the doodle image

Doodle image is recognized and classified into its respective label.

d) Result

Result is displayed.

2.2 Description of Target Users

● Speech impaired people: They use this application to convey their immediate requirements to those around them so that they can be understood and assisted.

● Normal People: They can use it for various different purposes like to know the name of any unknown object, of which they are familiar only with the object's appearance. They can also use it as a game to pass boredom.

2.3 Advantages/Applications of Proposed System

- Speech impaired people can use Doodle recognition for communicating with each other.
- This application can be used to develop gaming applications to kill boredom.
- This application can also be used for password protection.

2.4 Scope

- The user should be at a specific distance (10-20 cm) from the system to draw the doodle.
- Serious doodling creates a measurable change in our physical and neurological states.
- Then considered application to a social cause that would aid people who are blind, deaf or hard of hearing in effectively expressing their opinions.
- Not just them, regular people may also utilize it to learn the name of an unknown thing.
- For password protection, we can use doodle drawing, which would be more straightforward than other password protection systems.

3. SOFTWARE REQUIREMENT SPECIFICATION

Software Requirement Definition (SRS) is a comprehensive specification and description of the software requirements that must be met for the software system to be developed successfully. In order to completely grasp consumer wants, there must be contact between various customers and the contractor.

3.1 Overview of SRS

- The detailed description of requirements specifications i.e., functional requirements, use case diagrams and nonfunctional requirements.
- Software and Hardware requirements are also discussed.

3.2 Requirement Specifications

Functional requirements are product features or functions that developers must implement to enable users to accomplish their tasks.

3.2.1 Functional Requirements

- The application shall be implemented as a client - server system with a collection of doodle images.
- The user interface to the system shall be an interactive form - based interface.
- Client access to the application shall be provided through a password.
- Authentication of user whenever he/she logs into the system using doodle password protection.

3.2.2 Use case diagrams

The dynamic behavior of a system is represented by a use case diagram. It incorporates use cases, actors, and their interactions to encapsulate the functionality of the system. It simulates the duties, services, and operations needed by a system or application subsystem.

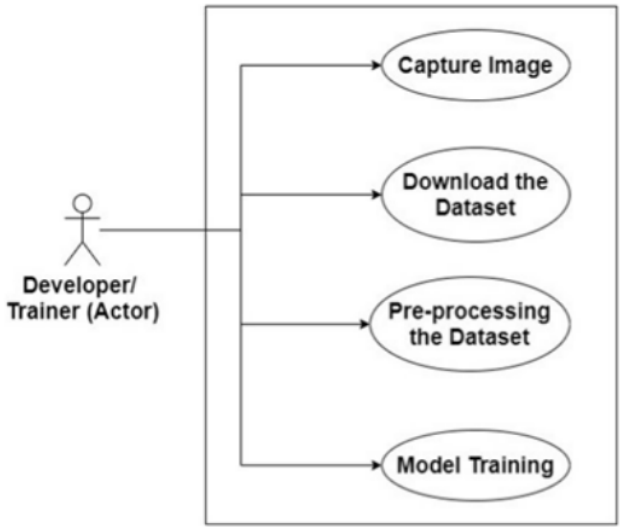

Fig 3.2.2.1 This figure shows the use case diagram for the developer/ trainer.

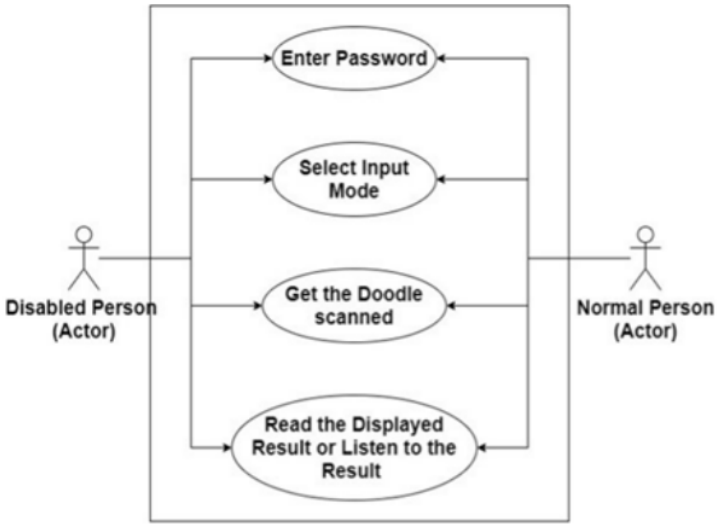

Fig 3.2.2.1 This figure shows the use case diagram for the disabled person.

3.2.3 Use Case descriptions using scenarios, as per Pressman Template

Use Case:	Developer
Primary Actor:	Developer/Trainer
Goal in Context:	To create a target user friendly application for Doodle recognition.
Preconditions:	Complete Knowledge on how the system would work.
Trigger:	An executable code.

Scenario:	o Capture image. o Downloading the dataset. o Pre-processing the dataset o Model Training.
Exceptions:	o Any code errors will be debugged. o Error occurring in Downloading the Dataset must be taken care of with enough memory space.

Use Case:	Disabled People
Primary Actor:	Disabled People(Deaf/Dumb)
Goal in Context:	To use it for communicating with each other
Preconditions:	To have a proper personal computer with all requirements.
Trigger:	Start the application.
Scenario:	o Select input mode. o Get the doodle scanned. o Hear the Result.
Exceptions:	Since Hearing impaired people cannot hear the results, they will be able to read the results on screen.

Use Case:	Normal People
Primary Actor:	Normal People
Goal in Context:	o To know the name of any unknown object, of which they are familiar only with the object's appearance. o To pass boredom
Preconditions:	To have a proper personal computer with all requirements.
Trigger:	Start the application.
Scenario:	o Select the input mode. o Get the Doodle scanned. o Hear the Result.
Exceptions:	o Problem faced while drawing non-continuous doodles, which will be resolved by assigning a keyboard key.

3.2.4 Nonfunctional Requirements

System qualities including security, reliability, performance, maintainability, scalability, and usability are defined by nonfunctional requirements (NFRs). They act as limitations or limits on how the system is designed for the various backlogs.

3.2.4.1 Performance requirements

- The User shall expect the password to be recognised accurately and as fast as possible.
- The User shall expect the application to display the output.

3.2.4.3 Usability

- The Interface should be user friendly to the target users.

3.3 Software and Hardware requirement specifications

The description of what the system should accomplish, the service or services it delivers, and the limitations on its operation make up the software requirements for a system. The hardware requirements are the requirements of the hardware device.

3.3.1 Hardware:

- The system requires a high GPU for computation.
- Fast processing required in many image processing applications.
- Data needs to be processed efficiently.
- Low cost and portable.
- Optimized memory architecture faster memory access.

3.3.2 Software:

- The Interface will be interactive form-based and user friendly.
- The application shall be provided through a password.
- Authentication of users is provided through doodle password protection.
- The application will display and tell out the output/Result loud.

4. SYSTEM DESIGN

The process of creating a system's components, including its architecture, modules, and components, as well as its many interfaces and the data it processes, is known as system design.

4.1 Architecture of the system

- Application will provide us with two options. First, doodles can be created on paper and scanned so that the application can recognize them. Second, it can be obtained by drawing in the air in front of the camera.
- Following the input mode selection, the application will create the doodle image and classify the doodle.
- The result will be displayed.

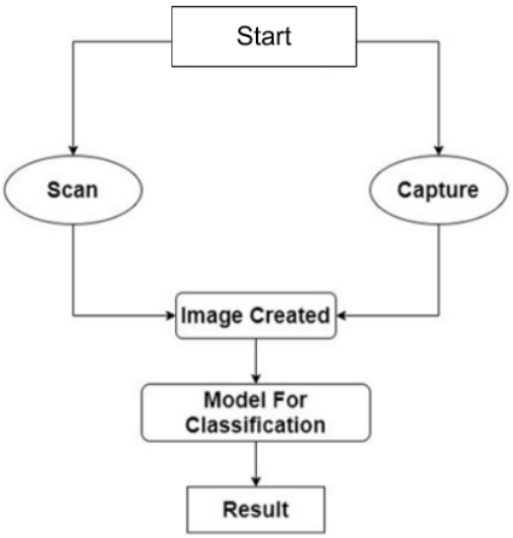

Fig 4.1.1 This figure shows the architecture of the system.

4.2 Class Diagram

Class diagrams serve as a visual representation of the system's static view and several application-related characteristics. The complete system is represented by a set of class diagrams.

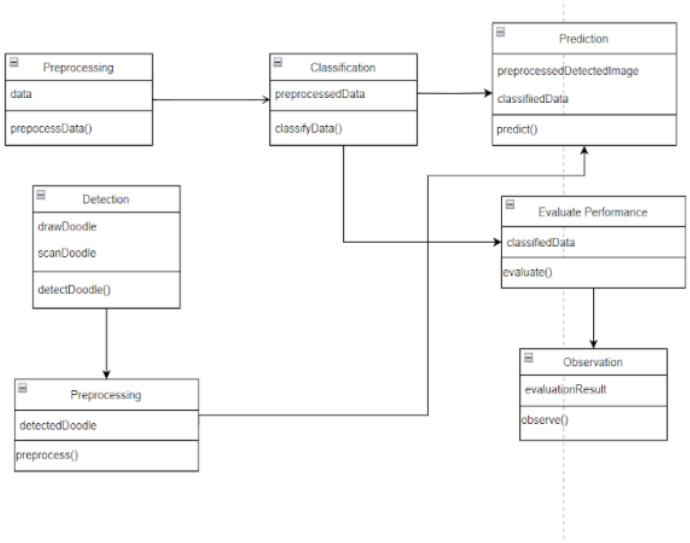

Fig 4.2.1 This figure shows the class diagram for the system.

- Initially the data is preprocessed and the preprocessed data is classified using an appropriate classification technique.
- The preprocessed data and classified data is used for prediction.The classified data is used to evaluate and evaluation result is observed.
- The doodle is detected through scanning or drawing the doodle in air, and this detected doodle is preprocessed and is used for prediction.

4.3 Sequence diagram

A sequence diagram is a diagram created using the Unified Modeling Language (UML) that shows the flow of messages sent and received by objects during an interaction.

- Connection is being established between user, device and the database first, user opens the application and device provides the user with two options, either to draw the doodle in air or to scan the doodle.
- Later the device detects the doodle image and from the database it retrieves the label for that doodle and displays the result.

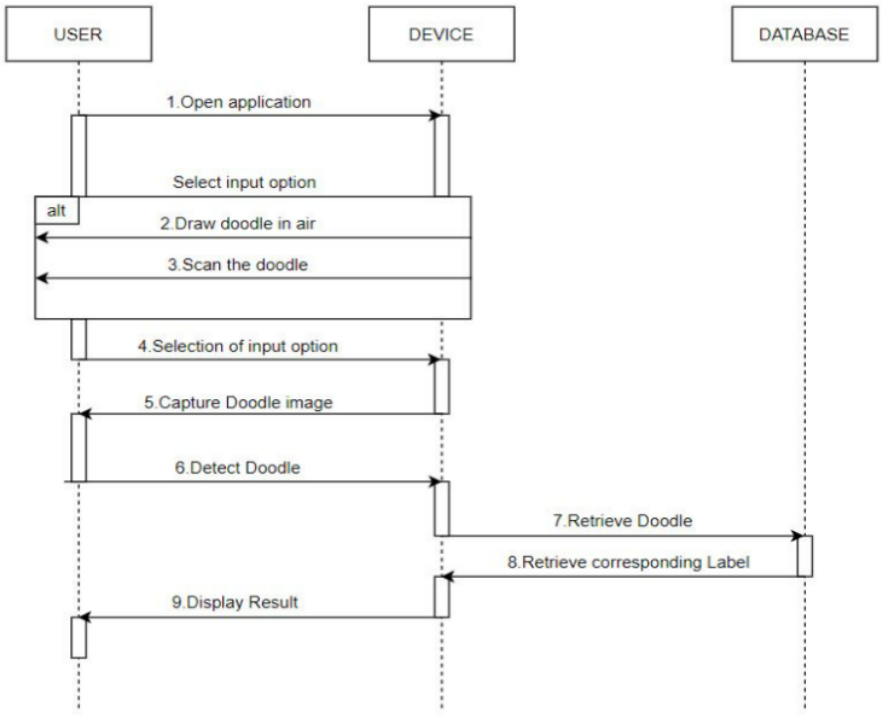

Fig 4.3.1 This figure shows the sequence diagram for the system.

4.4 Data structure used

4.4.1 Numpy Array

Images are represented using standard NumPy arrays. They are of shape (image_size, image_size, 3) where 3 is for RGB channels. The image size can be 64x64 or 28x28. Each image pixel is given a value corresponding to the RGB channel.

4.5 Data Set Description

- The Kaggle dataset contains more than 1 billion drawings and has a size of 227.61GB with drawings in 340 label classes.
- Our dataset contains 26 label classes.
- It contains the 4 CSV files: test_raw.csv, test_simplified.csv, train_raw.csv and train_simplified.csv.

- Useful features in the dataset: Word (contains the class label of that drawing) and Drawing (contains a set of x and y data points that describes how the user draws the painting).
- Since the dataset is fairly large, we use Google Collab API to help us download the dataset.
- We then only keep the processed dataset and save it to our Google Drive for future usage.

5. IMPLEMENTATION

Now, we will look into the details of the implementations of our application.

5.1 Proposed Methodology

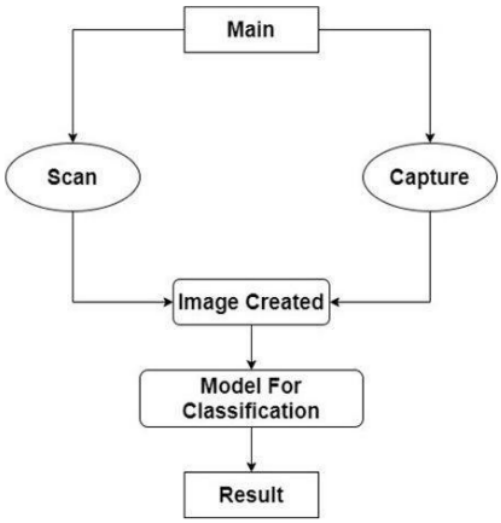

Fig 5.1.1 This figure shows the flowchart for the proposed methodology.

- Application will provide us with two options. First, doodles can be created on paper and scanned so that the application can recognize them. Second, it can be obtained by drawing in the air in front of the camera.
- Following the input mode selection, the application will create the doodle image and classify the doodle.
- The result will be displayed.

5.2 Description of Modules

A module is a collection of source files and build settings that allow you to divide your project into discrete units of functionality.

5.2.1 Modules descriptions

The two major modules are Scan and capture the brief description of scan and capture with their input and output are described below:

- Module Name : Scan()

Input : Drawn Doodle in a Paper or Mobile
Output : Name of the Doodle, classified in the correct category

- Module Name : Capture()

Input : Drawn Doodle in Air(in front of the camera)
Output : Name of the Doodle, classified in the correct category

6 TESTING

Software testing is the process of assessing and confirming that a software programme or product performs as intended. Testing has advantages such as bug prevention, lower development costs, and better performance.

6.1 Test Plan and Test Cases

A test plan is a document that outlines the approach to testing a doodle recognition system, including the objectives, scope, resources, and schedule for the testing process. A test case is a specific scenario or set of inputs that is used to test the system's functionality and behavior.

6.1.1 Acceptance test plan & test cases

Acceptance Testing is the last phase of software testing performed after System Testing and before making the system available for actual use.

Test ID	Test Case Description	Test steps	Test Input Data	Excepted result	Actual Result	Pass/ Fail
1.	Check if the doodle is predicted correctly.	1.Select the mode of input. 2.Capture the doodle of apple	Mode = Scan	Apple	mango	Fail

6.1.2 Unit test plan & test cases

Unit Testing is defined as a type of software testing where individual components of a software are tested.

Test ID	Test Case Description	Test steps	Test Input Data	Excepted result	Actual Result	Pass/ Fail
1.	Check if the doodle drawn in air is captured within the bounding box.	1.Select the mode of input as doodle in air 2.Capture the doodle of apple	Mode = Doodle in Air	Apple should be captured within the bounding box	Apple image captured	Pass

7. RESULTS & DISCUSSIONS

- Once the image is captured by the camera it may be either scanned in front of the camera or through doodle in air it is classified into a correct category and output is displayed with its accuracy.
- CNN and Resnet models are being used to classify the doodle images and we ended up with the accuracy as follows:
- CNN model with 97.12% accuracy and Resnet with 97.46% accuracy
- Enhancement of this project could be sketch-based modeling and sketch-based image retrieval.

8. CONCLUSION AND FUTURE SCOPE

- This project mainly provides two features, one of them is, scan, in which the doodle can be drawn on a paper and scanned. Second is, capture, in which the doodle is drawn in air and captured by a camera in front of it.
- Doodle recognition is a type of artificial intelligence (AI) technology that is used to recognize and classify drawings or sketches made by humans. It involves the use of machine learning algorithms, image processing techniques, to analyze and interpret doodles. There are a variety of tools and technologies available for doodle recognition, including PyCharm, Google Colab, and graphical user interfaces (GUIs).
- Further it can be implemented as the fundamental model for sketch-based modeling and sketch-based image retrieval.

9. REFERENCES

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Recognition." (2018).
2. Monica, Evangelyn D., et al. "Doodle Recognition using machine learning for hearing and speech-impaired people." *2019 2nd International Conference on Signal Processing and Communication (ICSPC)*. IEEE, 2019.
3. Towards Data Science, Akhilesh Reddy, Vincent Kuo, Kirti Pande, Tiffany Sung, Helena Shi, "Doodling with Deep Learning!"
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8. Kristine Guo, James WoMa, Eric Xu, "Quick, Draw! Doodle Recognition" Stanford University, 2018.

10. Appendix

Here is the brief description of the structure of our model doodle recognition, the data sets are being taken from Kaggle website and further proceeded by data preprocessing and using Opencv we have done image scanning and creating doodles and CNN model to classify the doodles.We have reached accuracy of about 97.12 using CNN and 97.46 using Resnet.Further accuracy can be increased by tuning the hyperparameters.

In the further part we will see how our model completion is done in a specified period of time using the Gantt chart and the tools and technologies used in the project.

10.1 Gantt Chart

The beginning and ending dates of numerous tasks within a project are displayed on a Gantt chart, a form of bar chart.The vertical axis of a Gantt chart depicts the

various tasks that make up the project, while the horizontal axis indicates duration.

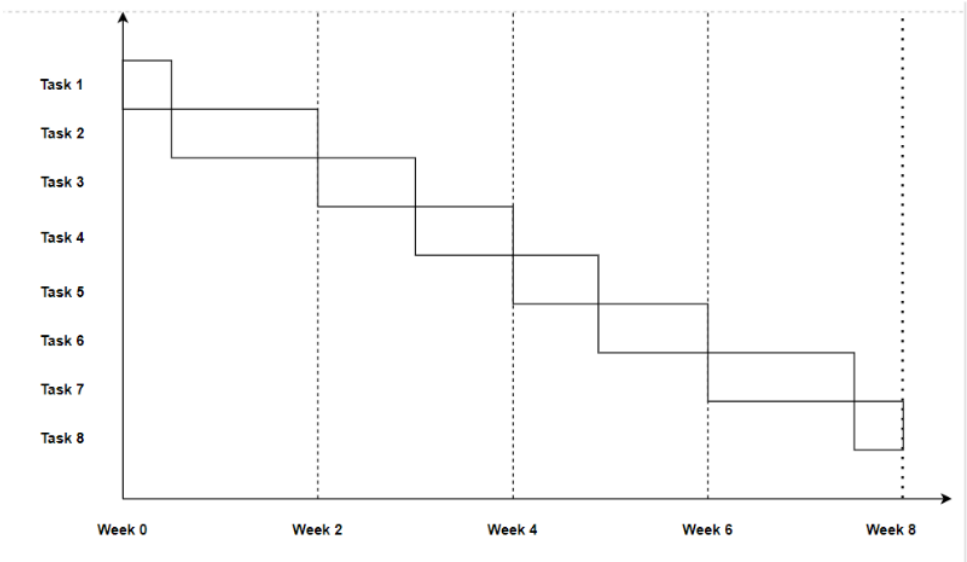

Fig 10.1 Gantt chart used to depict the project completion.

The tasks for the above mentioned figure are described below:
Task 1 - Download and study dataset.
Task 2 - Data preprocessing.
Task 3 - Image Scanning using OpenCV.
Task 4 - Create Doodles using OpenCV.
Task 5 - Build sample CNN model to classify doodles.
Task 6 - Tuning hyperparameters for better accuracy.
Task 7 - Build ResNet for classifying doodles.
Task 8 - Combine all parts to form the final framework.

10.2. Description of Tools & Technology used

Doodle recognition is a type of artificial intelligence (AI) technology that is used to recognize and classify drawings or sketches made by humans. There are a variety of tools and technologies that can be used for doodle recognition, including:

- Machine learning algorithms: These algorithms are used to train a model to recognize and classify doodles.CNN and ResNet models are being used.
- PyCharm and Google Colab are both tools that can be used to develop and

run doodle recognition projects. Here is a brief overview of each tool:

- PyCharm: PyCharm is a powerful integrated development environment (IDE) for Python.PyCharm is a popular choice for Python developers working on a variety of projects, including machine learning and AI.
- Google Colab: Google Colab is a free cloud-based Jupyter notebook environment that allows you to write and execute code, as well as collaborate with others.
- Camera: Camera with better resolution is required as it needs to capture the images that will be either scanned or drawn in front of it.

DOODLE RECOGNITION

ORIGINALITY REPORT

17%	17%	5%	%
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