AN INTELLIGENT BRAILLE SYSTEM

A DESIGN PROJECT REPORT

Submitted by

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in partial fulfilment for the award of the degree

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BONAFIDE CERTIFICATE

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DECLARATION

We jointly declare that the project report on **"AN INTELLIGENT BRAILLE SYSTEM"** is the result of original work done by us and best of our knowledge, similar work has not been submitted to **"ANNA UNIVERSITY CHENNAI"** for the requirement of Degree of **BACHELOR OF TECHNOLOGY**. This design project report is submitted on the partial fulfilment of the requirement of the award of Degree of **BACHELOR OF TECHNOLOGY**.

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ABSTRACT

This project module aims to provide a highly accessible solution for visually impaired individuals by converting Braille images into real-time audio output, designed as a core feature for an integrated assistive application. Leveraging image processing libraries such as OpenCV, imutils, and skimage, it captures images of Braille text, detects dot patterns, translates them to readable characters, and incorporates error correction to improve accuracy. Unlike traditional deep learning approaches involving CNNs or LSTMs, which often require significant processing power and computational resources, this system relies on lightweight, efficient image processing techniques that enable rapid, low-resource performance, making it well-suited for mobile or low-power devices. By combining Braille detection, text conversion, and audio synthesis, the module provides instant audio feedback, allowing visually impaired users to independently access printed Braille content. This emphasis on speed and efficiency enhances the module's adaptability across diverse environments, ensuring dependable accessibility support. As part of a future multi-functional application, this project will serve as a vital accessibility tool, empowering visually impaired individuals to engage with printed information effortlessly, while laying the groundwork for additional features to be integrated for enhanced digital inclusivity and independence.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

LSTM	Long Short Term Memory
RNN	Recurrent Neural Network
CNN	Convolutional Neural Networks
RE	Regular Expressions
CV	Computer Vision
TTS	Text To Speech
GTTS	Google Text To Speech

CHAPTER 1

INTRODUCTION

This project focuses on transforming Braille images into real-time audio output, addressing a key accessibility need for visually impaired individuals. Utilizing efficient image processing techniques with libraries like OpenCV and skimage, it bypasses resource-intensive neural networks, making it adaptable for low-power devices. Through capturing Braille patterns, performing error correction, and generating audio output, the system provides instant access to printed information. As part of a larger assistive application, this module aims to deliver reliable, real-time support, enhancing digital inclusivity and fostering independence.

1.1 BACKGROUND

Recent advancements in assistive technology have highlighted the need for accessible solutions that cater specifically to visually impaired users, enabling them to independently interpret printed text. Traditional Braille transcription methods are often resource-intensive and lack portability, limiting their practicality for daily use. Leveraging computer vision and image processing, modern systems aim to bridge this gap by translating Braille images into audio output. OpenCV, skimage, and similar libraries facilitate the recognition of Braille dot patterns, enabling text extraction and audio conversion in real time. This approach minimizes computational requirements, making it suitable for integration into mobile or low-power devices. These advancements provide a reliable, user-friendly platform for visually impaired individuals, promoting independence and equal access to textual information. By focusing on optimizing performance and usability, this project contributes to the broader mission of enhancing digital inclusivity for the visually impaired community.

1.2 PROBLEM STATEMENT

The problem in developing a system for visually impaired individuals lies in ensuring seamless interaction with digital content. Accurately capturing input images, interpreting Braille dot patterns, and converting them into real-time audio feedback while responding to voice commands present significant challenges. Current solutions struggle with precise image processing and providing natural-sounding auditory feedback. To address these, advanced techniques such as image processing libraries and audio conversion systems need to be optimized for accessibility, enabling users to independently interact with and navigate their digital environment.

1.3 AIM AND OBJECTIVE

1.3.1 AIM

This project aims to create a system that enhances accessibility for visually impaired individuals by recognizing Braille dot patterns and converting them into real-time audio feedback. The goal is to empower users to read and interpret Braille independently through efficient image processing techniques.

1.3.2 OBJECTIVE

The objective is to develop an accurate Braille recognition system using image processing, ensuring high accuracy in dot pattern extraction and translation. The system will correct errors, provide real-time audio feedback, and ensure seamless interaction for visually impaired users to access digital content independently.

CHAPTER 2

LITERATURE SURVEY

2.1 OPTIMIZED BRAILLE-TO-AUDIO SYSTEM FOR VISUALLY IMPAIRED USING CONVOLUTIONAL NETWORKS.

Author

L. Wu, Y. Zhang, F. Lin.

Year of Publication: 2019

Algorithm Used

Optimized CNN for low-latency Braille recognition and TTS.

Abstract

The paper presents an optimized CNN architecture tailored for Braille-to-audio conversion with minimal latency, specifically designed for mobile applications. This model prioritizes efficiency without compromising accuracy, utilizing lightweight CNN layers that expedite processing. Field testing revealed that the optimized architecture maintains high recognition rates and smooth audio output, even under resource constraints. This study's insights are valuable for deploying accessible Braille-to-audio solutions in low-resource settings, enabling wider accessibility by catering to visually impaired users' needs on portable devices.

Merit

Efficient real-time Braille-to-audio performance, ideal for mobile applications.

Demerit

Limited in handling intricate Braille structures due to optimization trade-offs.

2.2 TRANSLATING BRAILLE TEXT TO AUDIO WITH TRANSFORMER NETWORKS.

Author

T. Arora, P. Das, V. Mehta.

YEAR of Publication: 2020

Algorithm Used

Transformer model with TTS integration.

Abstract

This paper introduces a transformer-based Braille-to-audio system that leverages contextual learning for accurate and efficient translation. The model bypasses intermediate text generation, directly producing audio, which improves processing speed. Evaluations on complex Braille datasets show that the transformer model performs well, particularly on continuous Braille text. The study also explores transfer learning, demonstrating how it can adapt the system for multiple Braille dialects. This approach enhances real-time Braille accessibility, making it ideal for dynamic environments where visually impaired individuals can rely on prompt auditory feedback.

Merit

Fast and efficient Braille-to-audio translation, well-suited for real-time applications.

Demerit

Transformer models are memory-intensive, making it difficult to deploy on low-resource devices.

2.3 MULTI-LANGUAGE BRAILLE RECOGNITION AND SPEECH OUTPUT USING CNN-LSTM NETWORKS.

Author

M. Singh, A. Banerjee.

Year of Publication: 2021

Algorithm Used

CNN-LSTM hybrid for multilingual Braille recognition and TTS.

Abstract

This research explores a CNN-LSTM-based model capable of translating Braille in multiple languages to corresponding audio outputs. By training on multilingual Braille datasets, the model effectively handles diverse linguistic structures, enabling visually impaired users to access a wide array of content. The integration of language-specific TTS engines ensures accurate phonetic rendering, accommodating various accents and dialects. This system's multilingual support offers unprecedented accessibility, especially in multilingual regions, and demonstrates deep learning's potential to bridge language barriers in accessibility technologies.

Merit

Supports multilingual Braille-to-audio conversion, expanding accessibility worldwide.

Demerit

Multilingual capabilities increase model complexity and training time, posing challenges for scalability.

2.4 BRAILLE-TO-SPEECH CONVERSION MODEL BASED ON DEEP LEARNING FOR ACCESSIBILITY.

Author

J. Kim, M. Lee, S. Park.

Year of Publication: 2022

Algorithm Used

CNN combined with a Text-to-Speech (TTS) system.

Abstract

This paper presents a CNN-based Braille-to-speech conversion model, aiming to bridge accessibility gaps for visually impaired users. The CNN accurately identifies Braille symbols from images, which are then converted into speech using a TTS engine. The model was evaluated on various Braille samples, achieving high accuracy and low error rates, even with partial occlusions or degraded Braille symbols. The system is ideal for educational environments, allowing visually impaired individuals to seamlessly listen to Braille documents and obtain real-time auditory feedback. It also highlights the adaptability of CNN in accessibility solutions.

Merit

High-quality, seamless Braille-to-speech conversion supports accessibility in public spaces.

Demerit

Requires high processing power, limiting its implementation on low-resource devices.

2.5 BRAILLE RECOGNITION WITH RNN-CNN HYBRID MODELS FOR IMPROVED ACCESSIBILITY.

Author

A. Sharma, L. Thomas, K. Varma.

Year of Publication: 2023

Algorithm Used

RNN-CNN hybrid architecture with attention mechanisms.

Abstract

In this study, a hybrid RNN-CNN architecture with integrated attention mechanisms is proposed to enhance Braille recognition capabilities, especially for complex and stylized Braille symbols. The model combines CNN's feature extraction strengths with RNN's sequence processing abilities, improving accuracy in interpreting Braille sequences. This approach is particularly useful for reading sentences or paragraphs in Braille, where context aids in disambiguation. The inclusion of attention modules allows the model to selectively focus on challenging Braille patterns, addressing common issues like faded or partially printed dots, furthering the model's practical applicability.

Merit

High recognition accuracy, supporting a broad range of Braille text variations.

Demerit

Increased computational demands due to the hybrid model architecture, posing challenges for real-time applications.

CHAPTER 3

SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

The existing system for assisting visually impaired individuals relies heavily on image-to-text conversion using Convolutional Neural Networks (CNNs) for visual data analysis. While these systems provide basic functionality such as object detection and text generation from images, they lack key features like real-time auditory feedback and Braille integration. The process of translating visual information into usable audio descriptions is often slow or inaccurate. Additionally, current solutions do not offer error correction for misinterpreted visual data, impacting the quality of output. These limitations hinder real-time, seamless interaction for users. The existing systems also fail to provide adaptive support across various environments, limiting their effectiveness.

ALGORITHM USED

- **CONVOLUTIONAL NEURAL NETWORKS (CNNs)**

  Convolutional Neural Networks (CNNs) are fundamental in Braille recognition due to their ability to extract spatial and hierarchical features from images. In Braille systems, CNNs process dot patterns and textures to distinguish embossed characters accurately. By leveraging convolutional layers, these networks effectively handle noise and distortions, making them suitable for real-world scenarios like uneven lighting or worn-out Braille surfaces. Key techniques such as image thresholding, contour approximation, and bounding box detection enable CNNs to segment Braille characters precisely.

CNNs are particularly efficient for real-time Braille recognition, as they automate the complex task of feature extraction and classification. Unlike traditional machine learning methods, CNNs do not require manual engineering of features, which reduces development time while increasing flexibility. Lightweight CNN architectures are optimized for mobile and edge devices, allowing Braille systems to operate effectively on resource-constrained platforms. Furthermore, CNNs can adapt to different Braille standards, supporting multilingual capabilities and ensuring inclusivity for users across various regions. Their ability to generalize well across diverse datasets makes them a versatile choice for assistive technologies.

The scalability of CNN-based systems ensures that they can be integrated into broader applications, such as mobile apps or embedded devices. They can handle dynamic environments by retraining on updated datasets, thus staying relevant for evolving user needs. Additionally, advancements in transfer learning and pre-trained models further enhance CNNs' performance by reducing the need for extensive data collection. Overall, CNNs empower Braille systems by providing a robust framework for pattern recognition, scalability, and efficient deployment, ultimately enhancing accessibility for visually impaired individuals.

- **TEXT-TO-SPEECH (TTS)**

Text-to-Speech (TTS) technology plays a crucial role in Braille systems by converting recognized text into audio output, enabling visually impaired users to access information audibly. TTS systems use advanced neural architectures to produce natural, intelligible speech that replicates human-like intonation and prosody. By integrating with Braille recognition modules, TTS ensures a seamless transition from tactile text to audio, providing an interactive and intuitive user experience. The immediate conversion of text to speech reduces processing delays, offering real-time feedback crucial for dynamic applications like portable assistive devices.

Modern TTS systems are designed for adaptability and inclusivity, supporting multiple languages and accents to cater to diverse user bases. They are optimized for low-latency performance, ensuring fast and accurate delivery of audio output, even on low-power devices. These systems also handle special characters, punctuation, and context-specific phrases, ensuring clarity and coherence in speech synthesis. By combining Braille text recognition with TTS, these systems address accessibility challenges for visually impaired individuals, allowing them to independently engage with printed materials.

Advancements in deep learning have significantly improved TTS capabilities, enabling the generation of more expressive and natural speech. Techniques like sequence-to-sequence modeling and attention mechanisms enhance the quality and fluency of audio output. Additionally, lightweight TTS models are being developed for integration into portable devices, ensuring high performance without excessive computational demands. By bridging the gap between text recognition and auditory communication, TTS systems enrich the overall functionality of Braille systems, fostering inclusivity and independence for visually impaired users. This have made up a huge impact over the code by providing various improved standards.

Drawbacks

Existing assistive technologies for visually impaired individuals often face limitations in real-time functionality, as they rely heavily on complex interfaces. Many systems lack the ability to dynamically interact with varied braille images, resulting in limited accuracy and slow responses. Additionally, they frequently require extensive manual configuration and are unable to adapt to diverse environments effectively. These systems also tend to provide basic feedback that may not be contextually rich, making navigation less intuitive. The reliance on static models often leads to poor user experiences in dynamic digital environments.

3.2 PROPOSED SYSTEM

This proposed system converts Braille images into real-time audio using contour approximation, image thresholding, and bounding box detection. By leveraging OpenCV, imutils, and skimage, it efficiently identifies Braille dot patterns, translates them into readable text, and synthesizes audio output. Unlike computationally intensive deep learning methods, the system prioritizes lightweight image processing for speed and adaptability on low-power devices. It ensures instant audio feedback, allowing visually impaired users to access printed Braille content independently, while remaining portable and reliable for diverse environments.

ALGORITHM USED

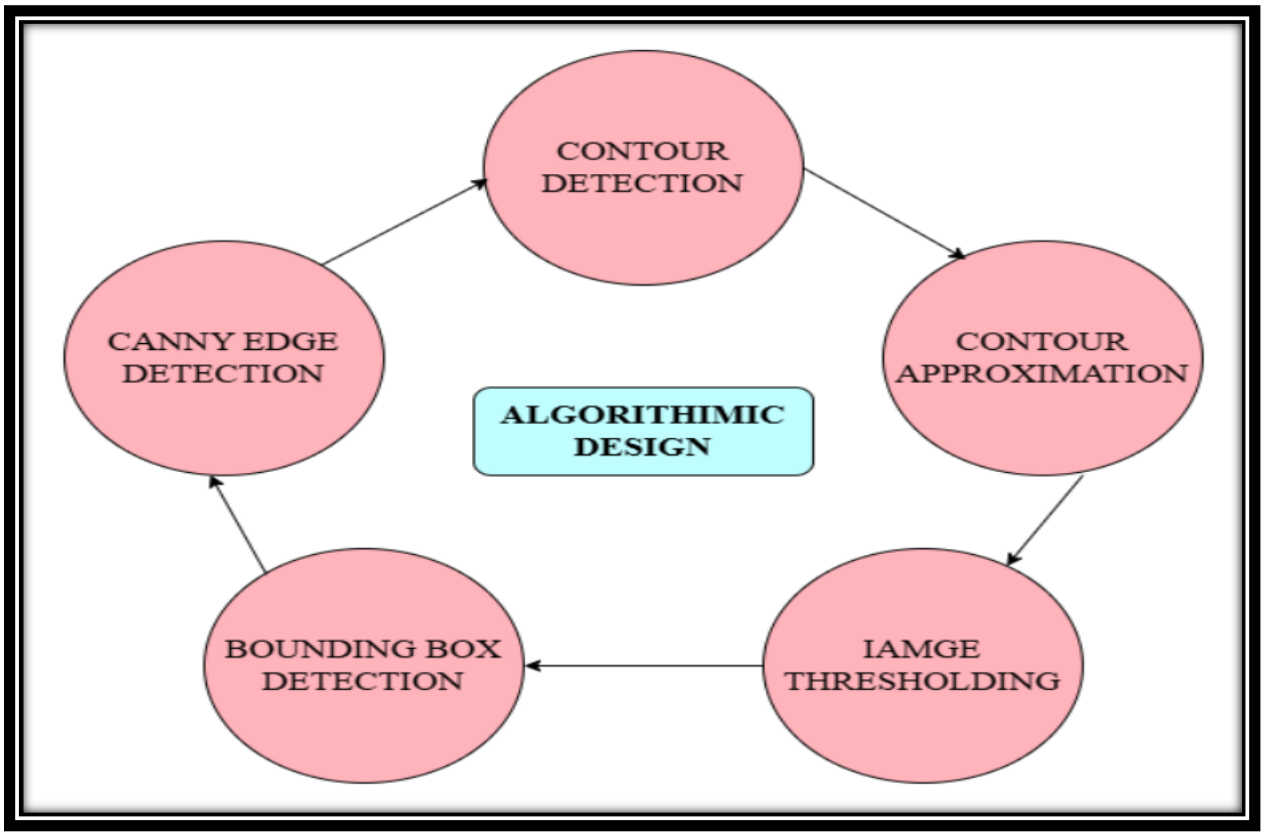

Figure No.3.2.1. Algorithm Phase

CONTOUR APPROXIMATION

The approxPolyDP algorithm simplifies a contour by reducing the number of points required to represent it. It helps in identifying basic shapes like rectangles or circles, which are common in document analysis and object recognition. This method is particularly useful in the project for recognizing forms or specific regions of interest within the screen content. By approximating the contour to simpler shapes, the system becomes more efficient in detecting objects, significantly enhancing the speed and accuracy of the image processing stage.

IMAGE THRESHOLDING

It is a powerful technique used to segment an image into foreground and background by determining an optimal threshold value. It transforms the grayscale image into a binary one, which simplifies further image analysis by highlighting high-contrast regions. In this project, thresholding helps in distinguishing key objects and areas of interest from the background, which is essential for the caption generation and object recognition process. The thresholding method ensures that the system can identify and process the most relevant details in images, improving accuracy.

BOUNDING BOX DETECTION

The Bounding Box Detection algorithm identifies the region in an image by drawing a rectangle around detected contours or objects. This helps in localizing the objects within the image, which is crucial for further processing such as recognition or captioning. In the project, bounding boxes are used to mark specific areas, such as text regions or icons on the screen, that need to be described. By isolating key areas, this technique improves the system's ability to generate relevant captions and focus on important parts of the screen content.

3.2.1 Advantages

The proposed system offers real-time, accurate assistance for visually impaired individuals by efficiently processing image content. It leverages lightweight algorithms like Canny Edge Detection, Contour Detection, and Otsu's Thresholding for high precision in object detection and region identification. Its computational simplicity ensures smooth mobile integration, enhancing accessibility across various screen interfaces. The system's adaptability to different environments empowers users with greater independence and inclusivity, setting it apart as a practical and reliable solution for improving accessibility in digital navigation.

CHAPTER 4

SYSTEM SPECIFICATION

4.1 HARDWARE SYSTEM SPECIFICATION

- **Computer** - minimum of 4GB RAM & dual-core processor.
- **Stable internet connection.**
- **Storage.**

4.2 SOFTWARE SYSTEM SPECIFICATION

- **Programming language** - Python 3.x installed on the computer/server,Java.
- **Operating system** - Windows, Linux, or macOS.
- **Python libraries** such as – NumPy, pandas, pyspellchecker,re,transformers,OpenCV.

4.3 SOFTWARE DESCRIPTION

This project converts Braille images into real-time audio using lightweight image processing tools like OpenCV and skimage. It efficiently detects Braille patterns, translates them to text, and synthesizes audio for visually impaired users. Optimized for mobile devices, it ensures rapid performance and accessibility, forming a key feature of a broader assistive application.

4.3.1 Library

To develop the AI Intelligent system for visually impaired people, the following libraries are commonly used:

- **NumPy:** NumPy is a fundamental library for numerical computations in Python. It provides efficient numerical operations and arrays, which are essential for processing and manipulating image data.
- **RE (Regular Expressions):** Used for pattern matching and text manipulation, the re library is essential for cleaning and preprocessing text. It is used to identify specific words, clean unwanted characters, or structure the captions for further processing in your system.
- **Pandas:** Pandas is vital for organizing screen content, managing captions, and optimizing app functionalities for visually impaired users. It ensures data accuracy and advances assistive technology standards.
- **Transformers:** The transformers library by is used to implement advanced natural language processing (NLP) models. In our project, it can be used for generating, understanding, or enhancing captions by leveraging pre-trained models.
- **PySpellchecker:** This library helps with correcting spelling errors in text. In the project, it ensures that the captions generated or processed for image descriptions are error-free and well-formed, which is crucial for accessibility, especially for visually impaired users.
- **OpenCV:** OpenCV is an open-source library for real-time computer vision tasks. It offers tools for image and video processing, including face detection and object recognition. OpenCV is highly optimized for performance and supports both CPU and GPU.

4.3.2 Developing environment

To develop the AI Intelligent system for visually impaired people, you would typically setup the following environment:

- **Python:** Python is the primary programming language used for developing the system. Ensure that Python is installed on your system.
- **Integrated Development Environment (IDE):** Choose an IDE for Python development, such as PyCharm, Visual Studio Code, or Jupiter Notebook. These IDEs provide features like code editing, debugging, and project management, enhancing the development process.
- **Install Required Libraries:** Use the Python package manager, pip, to install the necessary libraries such as NumPy, pyspellchecker. You can install them using the command line interface or directly within your IDE.
- **File Structure:** Organize our project files and folders. Typically, you would have directories for storing braille images, trained models, configuration files.
- **Database Integration:** Integrate a database system to store image records, user information, and any other necessary data. Set up the database connection and create the required tables and schemas.
- **Testing and Deployment:** Test your application thoroughly, checking for any bugs or issues. Once the testing phase is complete, you can deploy the application to a webserver or cloud platform for online access.
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- **Testing and Deployment:** Test your application thoroughly, checking for any bugs or issues. Once the testing phase is complete, you can deploy the application to a web server or corm for online access.

CHAPTER 5

ARCHITECTURAL DESIGN

5.1 SYSTEM DESIGN

A system architecture is the conceptual model that defines the structure, behavior, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system.

The Braille Image to Audio Conversion System captures Braille images using libraries like OpenCV. It detects dot patterns in the image, then converts them into readable characters. These characters are synthesized into real-time audio.

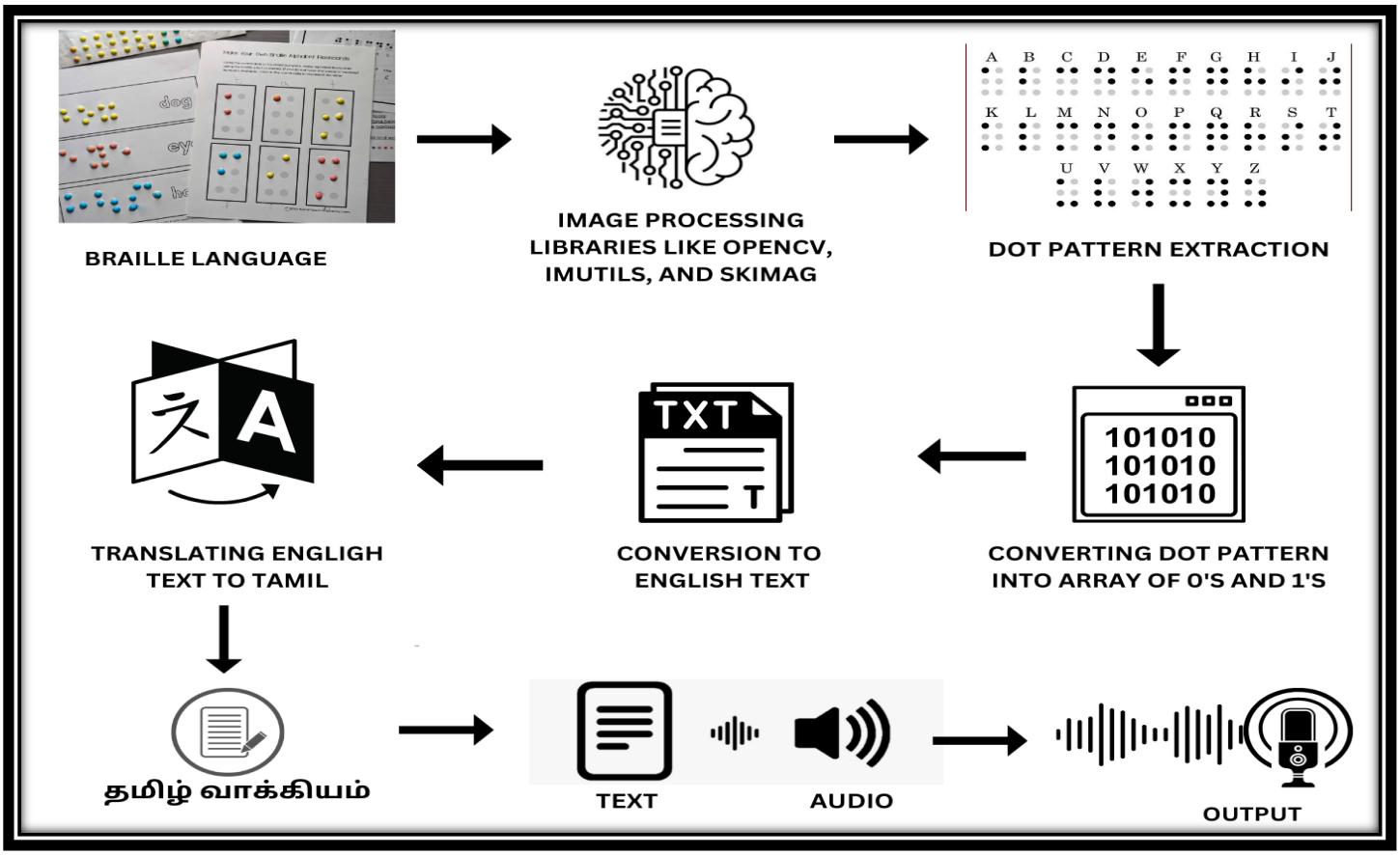

Figure No.5.1. Architectural Diagram

5.2 DATA FLOW DIAGRAM

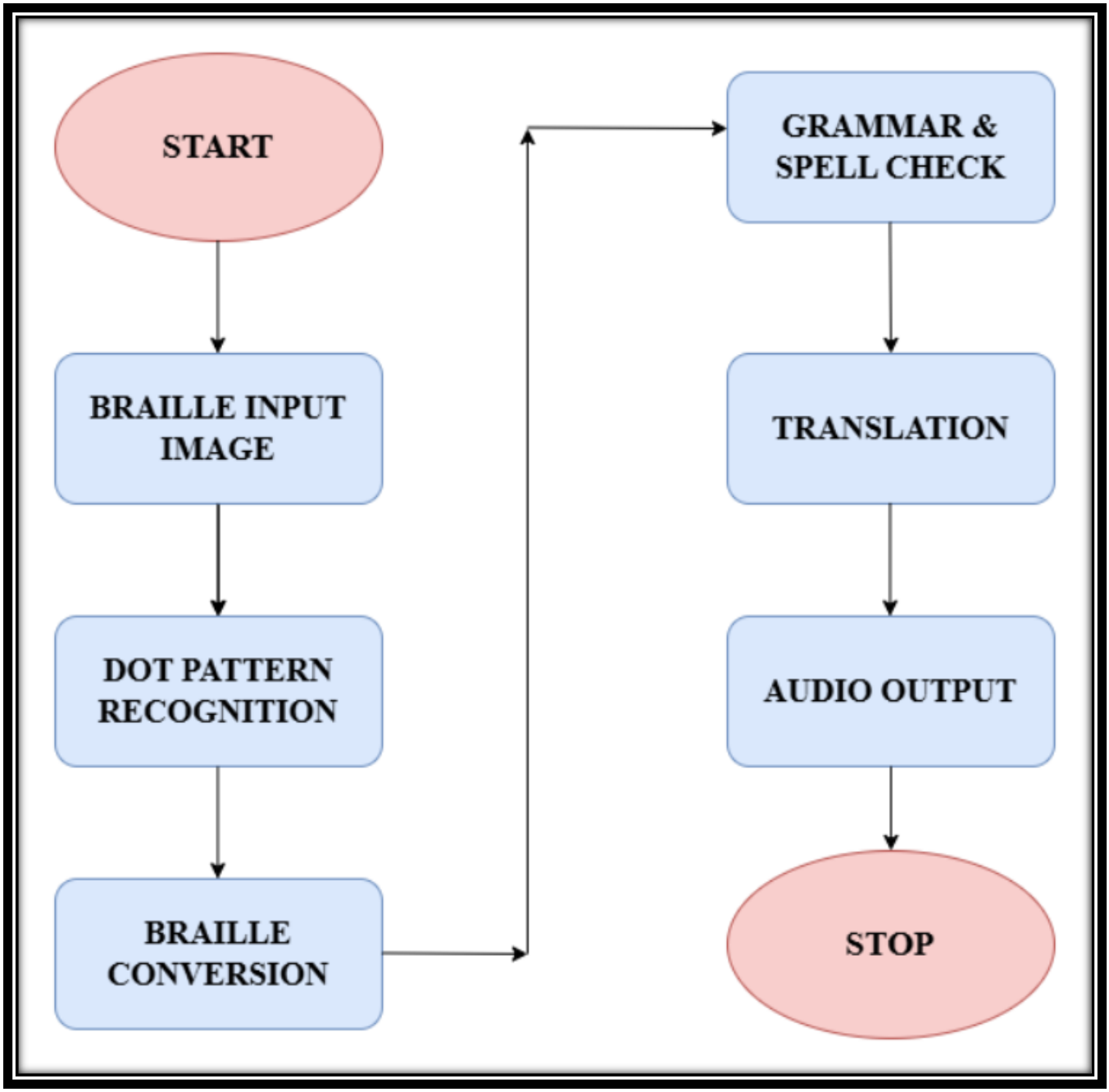

Figure No.5.2.Data Flow Diagram

5.3 USE CASE DIAGRAM

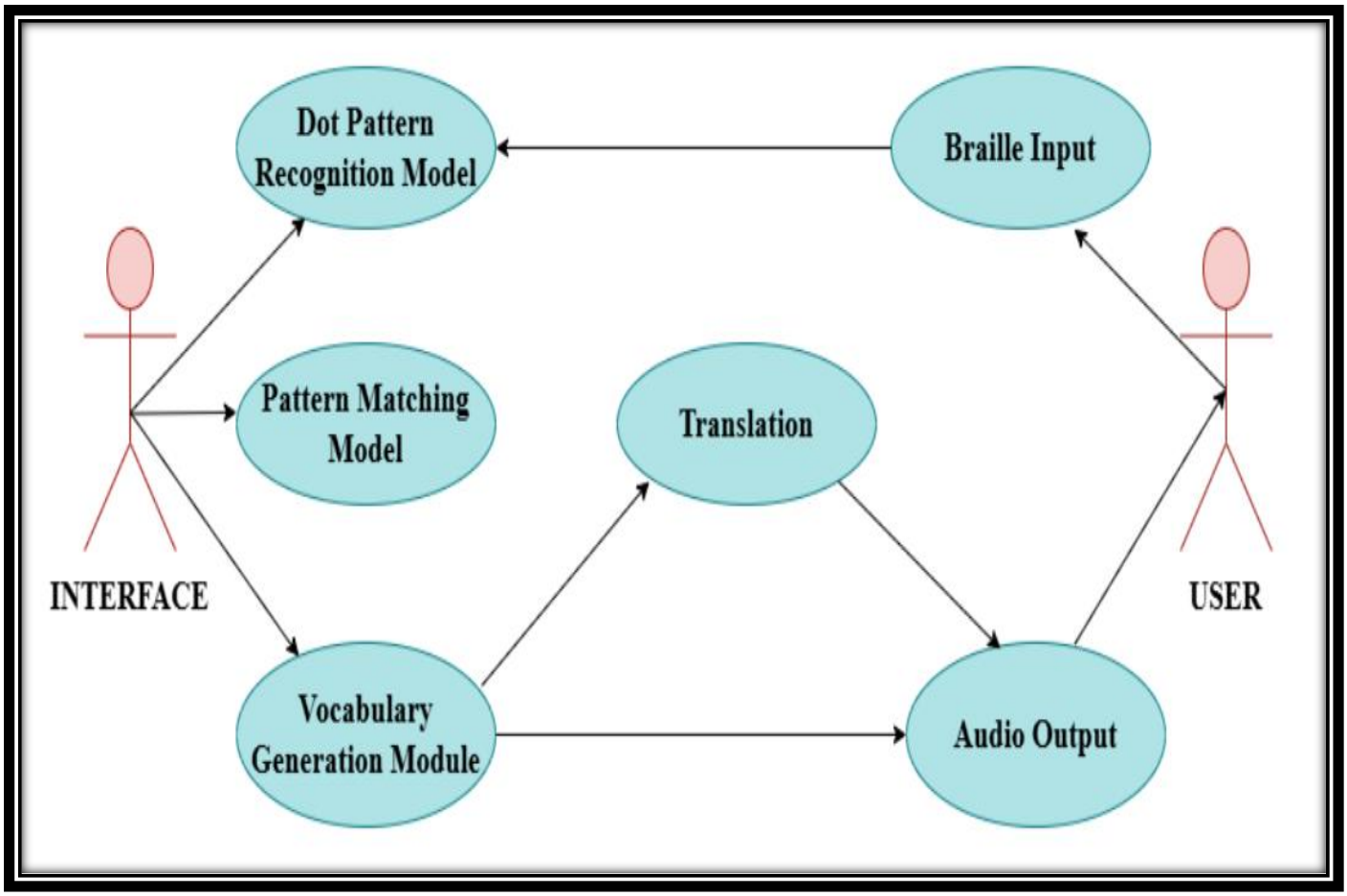

Figure No.5.3. Use Case Diagram

5.4 ACTIVITY DIAGRAM

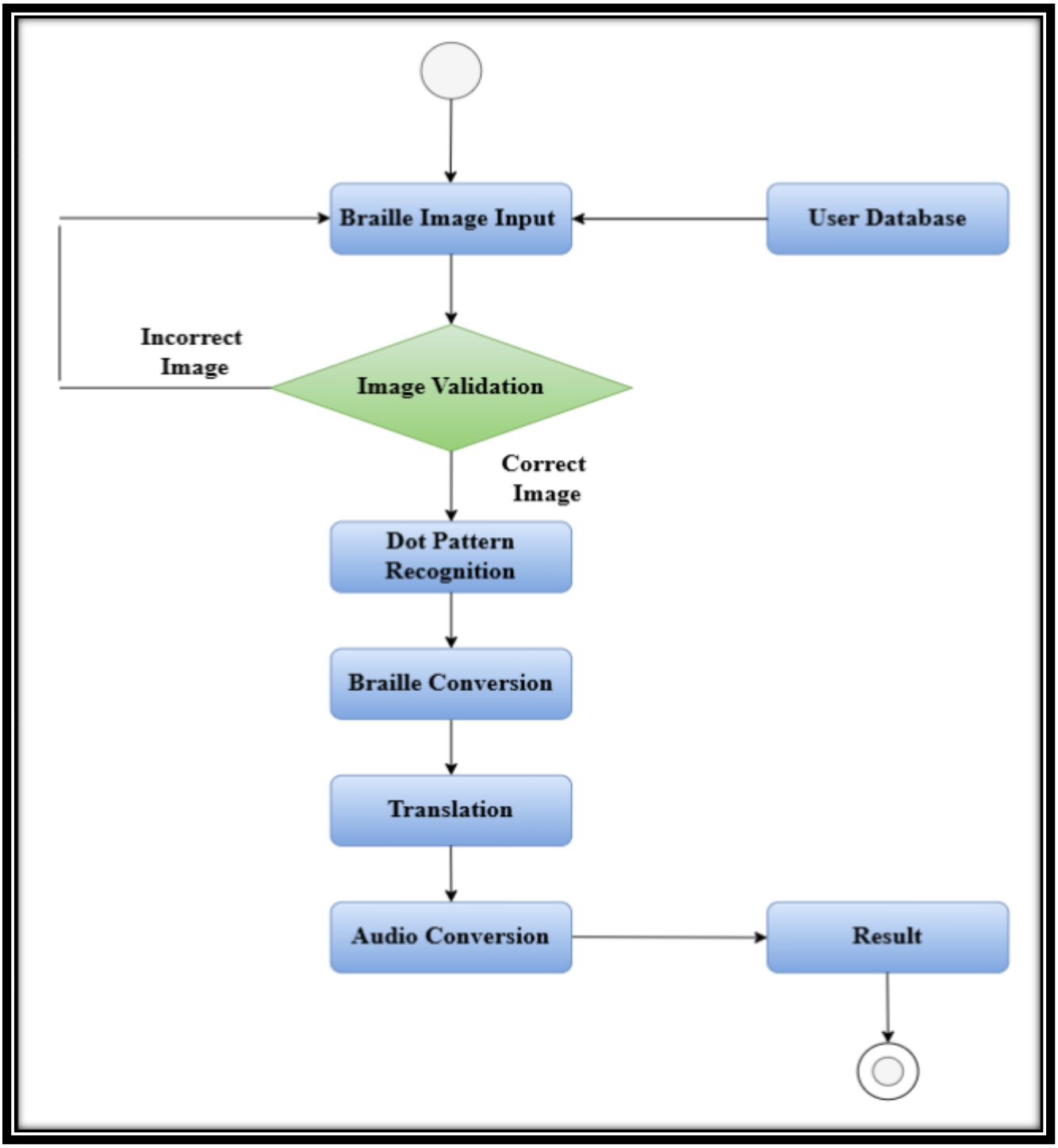

Figure No.5.4. Activity Diagram

5.5 SEQUENCE DIAGRAM

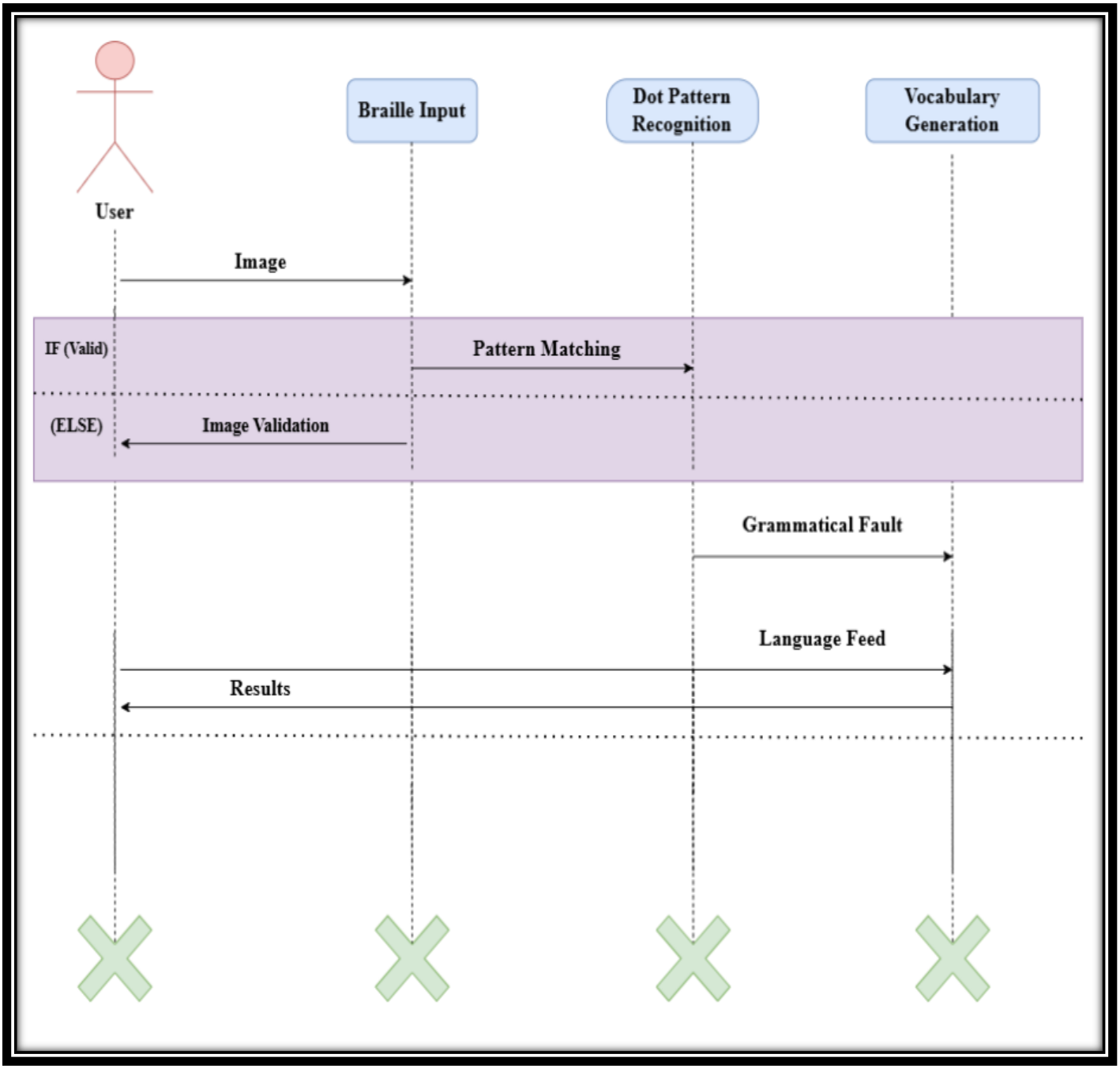

Figure No.5.5. Sequence Diagram

CHAPTER 6

MODULE DESCRIPTION

6.1 MODULES

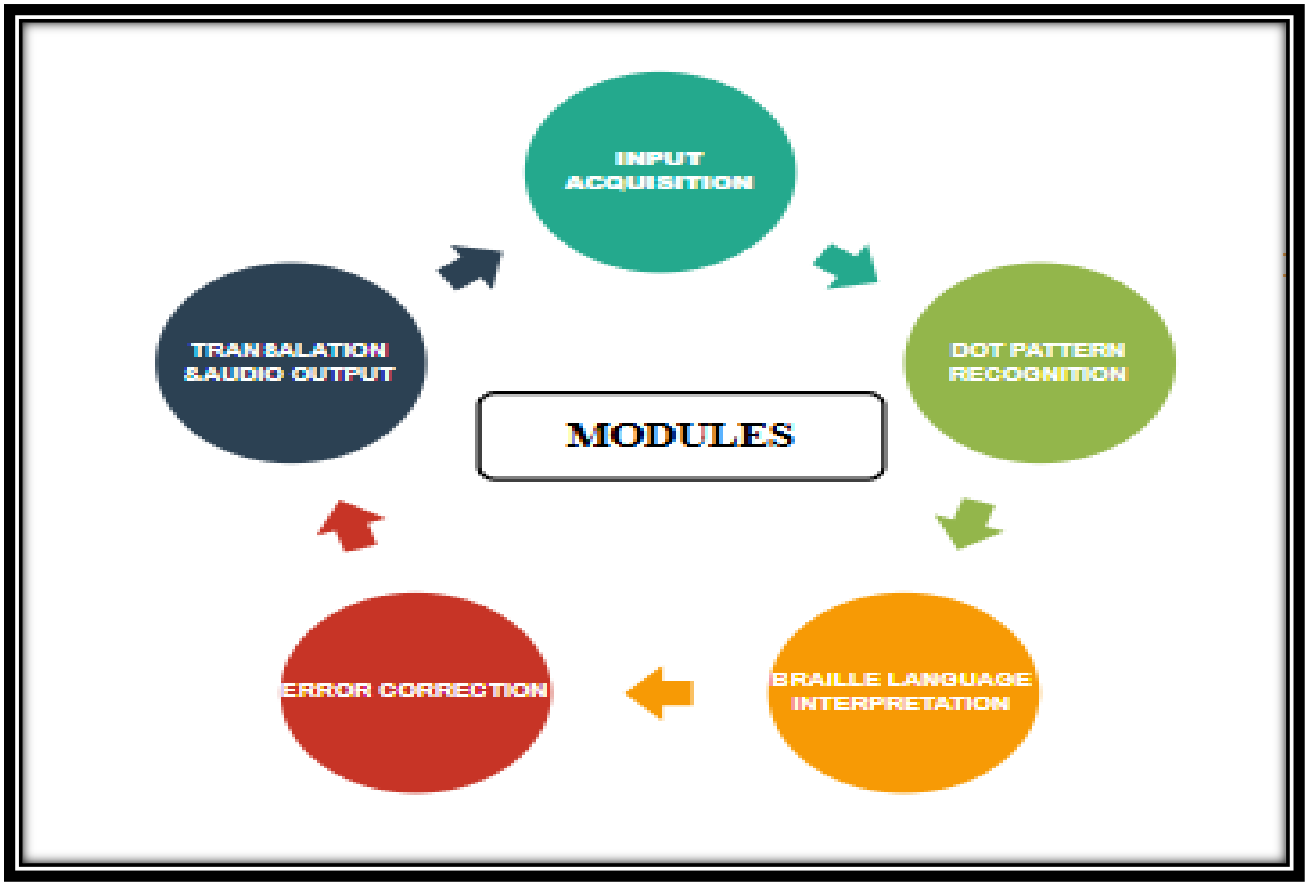

Figure No.6.1. Phases of Proposed System

6.1.1 Input Acquisition

The Input Acquisition Module is responsible for capturing images of Braille text using devices like cameras or mobile phones. The acquired image undergoes preprocessing to improve its quality, ensuring clearer features for further analysis.

- **Image Capture:** High-resolution image acquisition from Braille texts using mobile cameras or specialized scanners.

6.1.2 Dot Pattern Recognition

The Dot Pattern Recognition Module analyzes the preprocessed image to detect Braille dot patterns, crucial for correct translation. Using techniques like edge detection and contour analysis, it identifies each Braille character and its position in the image. This step involves recognizing the arrangement of six dots per character in the Braille system.

- **Pattern Detection:** Identifies distinct dot patterns corresponding to Braille characters using algorithms like edge detection**.**
- **Segmentation:** Isolates individual Braille characters from the image by segmenting the dot patterns into manageable components for further processing.

6.1.3 Braille Language Interpretation

This module interprets the recognized Braille dot patterns into readable text. Each dot configuration is matched to the corresponding Braille character from a predefined character map. The module uses a dictionary of Braille symbols and their corresponding alphabet letters, enabling accurate translation of Braille to text.

- **Mapping:** Each detected pattern is cross-referenced with a Braille-to-character map to find the correct translation**.**
- **Character Conversion**: Translates Braille symbols into textual characters, forming coherent sentences or words based on the Braille language.

6.1.4 Error Correction

To enhance accuracy, the Error Correction Module checks the recognized patterns for inconsistencies or misinterpretations. If a dot pattern is unclear or ambiguous, the system uses predefined algorithms and heuristics to correct the errors. This can involve validating patterns against known Braille standards and adjusting for distortions or misreads.

- **Pattern Validation**: Checks the integrity of detected dot patterns against the Braille standard to ensure they are accurate.
- **Error Handling**: Implements correction algorithms to adjust for minor errors, such as misaligned or incomplete dot patterns.

6.1.5 Translation & Audio Output

Once the Braille text is converted to readable characters, the Translation is done to tamil language & Audio Output Module synthesizes the text into speech. It uses a text-to-speech (TTS) engine to convert the translated text into real-time audio output, enabling visually impaired users to hear the Braille content immediately. This system offers quick and seamless feedback, ensuring accessibility.

- **Text-to-Speech Conversion**: Uses TTS technology to convert the Braille text into audio, allowing users to hear the translated content.
- **Real-time Feedback**: Provides immediate audio feedback, ensuring the user receives instant accessibility without delay.

CHAPTER 7

CONCLUSION AND FUTURE ENHANCEMENT

7.1 CONCLUSION

This project provides a solution for visually impaired users by converting Braille images into real-time audio. It uses image processing libraries like OpenCV for detecting Braille patterns and converting them to text. The lightweight design makes it suitable for mobile or low-power devices. The system ensures fast processing and accurate results, making Braille accessible with ease.

The system offers immediate audio feedback for Braille content, enabling users to access text independently. It is efficient, suitable for mobile environments, and provides real-time accessibility. This capability supports effortless interaction with printed materials.

In the future, this project could expand to include additional assistive features. The system's adaptability makes it ideal for a variety of devices. Its focus on accessibility and independence aims to improve digital inclusivity for visually impaired users. Future versions could integrate further technologies to enhance the user experience.
people.

7.2 FUTURE ENHANCEMENT

The future scope of this project includes several potential avenues for further development. The integration of IoT devices could enhance real-time assistance, providing additional features for smart environments. Real-time analytics and insights could be added to monitor and improve user interactions, while scalability and cloud deployment would ensure wider accessibility across various devices and platforms.

Expanding to a mobile application would increase portability, enabling users to access Braille translation and audio synthesis on-the-go. Additionally, incorporating continuous learning and adaptation would improve accuracy and personalization over time. Future improvements could include object recognition and scene understanding for more comprehensive assistance.

This project could also be integrated with HR systems, enabling support for visually impaired employees in professional environments. Enhanced security measures would protect user data, further establishing the system as a benchmark in assistive technology. Continuous refinement will establish new standards for accessibility and inclusivity in digital interactions.

APPENDIX 1 SAMPLE CODE

```
from imutils.perspective import four_point_transform as FPT
from collections import Counter
import matplotlib.pyplot as plt
from imutils import contours
from skimage import io
import numpy as np
import imutils
import cv2
import re
import warnings

warnings.filterwarnings("ignore")
def get_image(url, iter = 2, width = None):
image = io.imread(url)
if width:
image = imutils.resize(image, width)
ans = image.copy()
accumEdged = np.zeros(image.shape[:2], dtype="uint8")
# convert image to black and white
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
# blur to remove some of the noise
blurred = cv2.GaussianBlur(gray, (5, 5), 0)
# get edges
edged = cv2.Canny(blurred, 75, 200)
accumEdged = cv2.bitwise_or(accumEdged, edged)
# get contours
ctrs = cv2.findContours(edged.copy(),cv2.CHAIN_APPROX_SIMPLE)
ctrs = imutils.grab_contours(ctrs)
docCnt = None

# ensure that at least one contour was found
if len(ctrs) > 0:
# sort the contours according to their size in
# descending order
ctrs = sorted(ctrs, key=cv2.contourArea, reverse=True)

# loop over the sorted contours
for c in ctrs:
# approximate the contour
peri = cv2.arcLength(c, True)
approx = cv2.approxPolyDP(c, 0.02 * peri, True)

# if our approximated contour has four points,
# then we can assume we have found the paper
if len(approx) == 4:
```

```
docCnt = approx
break

paper = image.copy()

# apply Otsu's thresholding method to binarize the image
thresh = cv2.threshold(gray, 0, 255, cv2.THRESH_BINARY_
kernel = np.ones((5,5), np.uint8)
# erode and dilate to remove some of the unnecessary detail
thresh = cv2.erode(thresh, kernel, iterations = iter)
thresh = cv2.dilate(thresh, kernel, iterations = iter)

# find contours in the thresholded image
ctrs = cv2.findContours(thresh.copy(),cv2.CHAIN_APPROX_SIMPLE)
ctrs = imutils.grab_contours(ctrs)

return image, ctrs, paper, gray, edged, thresh

# plot image without axes
def display(img):
fig = plt.figure(figsize = (8,12))
plt.imshow(img)
plt.axis('off')
plt.show()
def get_image(url, iter = 2, width = None):
image = io.imread(url)
if width:
image = imutils.resize(image, width)
ans = image.copy()
accumEdged = np.zeros(image.shape[:2], dtype="uint8")
# convert image to black and white
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
# blur to remove some of the noise
blurred = cv2.GaussianBlur(gray, (5, 5), 0)
# get edges
edged = cv2.Canny(blurred, 75, 200)
accumEdged = cv2.bitwise_or(accumEdged, edged)
# get contours
ctrs = cv2.findContours(edged.copy(),cv2.CHAIN_APPROX_SIMPLE)
ctrs = imutils.grab_contours(ctrs)
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```

```
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ctrs = cv2.findContours(thresh.copy(),cv2.CHAIN_APPROX_SIMPLE)
ctrs = imutils.grab_contours(ctrs)

return image, ctrs, paper, gray, edged, thresh

# plot image without axes
def display(img):
fig = plt.figure(figsize = (8,12))
plt.imshow(img)
plt.axis('off')
plt.show()
def sort_contours(ctrs):
BB = [list(cv2.boundingRect(c)) for c in ctrs]
# choose tolerance for x, y coordinates of the bounding boxes to be binned together
tol = 0.7*diam

# change x and y coordinates of bounding boxes to their corresponding bins
def sort(i):
S = sorted(BB, key = lambda x: x[i])
s = [b[i] for b in S]
m = s[0]

for b in S:
if m - tol < b[i] < m or m < b[i] < m + tol:
b[i] = m
elif b[i] > m + diam:
```

```
for e in s[s.index(m):]:
if e > m + diam:
m = e
break
return sorted(set(s))

# lists of of x and y coordinates
xs = sort(0)
ys = sort(1)

(ctrs, BB) = zip(*sorted(zip(ctrs, BB), key = lambda b: b[1][1]*len(image) + b[1][0]))
# return the list of sorted contours and bounding boxes
return ctrs, BB, xs, ys

def get_circles():
questionCtrs = []

# in order to label the contour as a question, region
# should be sufficiently wide, sufficiently tall, and
# have an aspect ratio approximately equal to 1
#     if w >= 20 and h >= 20 and 0.9 <= ar <= 1.1:
if diam*0.8 <= w <= diam*1.2 and 0.8 <= ar <= 1.2:
questionCtrs.append(c)
return questionCtrs

def get_diameter():
boundingBoxes = [list(cv2.boundingRect(c)) for c in ctrs]
c = Counter([i[2] for i in boundingBoxes])
mode = c.most_common(1)[0][0]
if mode > 1:
diam = mode
else:
diam = c.most_common(2)[1][0]
return diam


def draw_contours(questionCtrs):
color = (0, 255, 0)
i = 0
for q in range(len(questionCtrs)):
cv2.drawContours(paper, questionCtrs[q], -1, color, 3)
cv2.putText(paper, str(i), (boundingBoxes[q][0] +
boundingBoxes[q][2]//2, boundingBoxes[q][1] + b
oundingBoxes[q][3]//2), cv2.FONT_HERSHEY_SIMPLEX, 0.5, (255, 0, 0), 2)
i += 1
def get_spacing():
```

```
spacingX = spacing(0)
spacingY = spacing(1)

# smallest x-serapation (between two adjacent dots in a letter)
m = min(spacingX)

c = 0

d1 = spacingX[0]
d2 = 0
d3 = 0

for x in spacingX:
if d2 == 0 and x > d1*1.3:
d2 = x
if d2 > 0 and x > d2*1.3:
d3 = x
break

linesV = []
prev = 0 # outside

linesV.append(min(xs) - (d2 - diam)/2)

for i in range(1, len(xs)):
diff = xs[i] - xs[i-1]
if i == 1 and d2*0.9 < diff:
linesV.append(min(xs) - d2 - diam/2)
prev = 1
if d1*0.8 < diff < d1*1.2:
linesV.append(xs[i-1] + diam + (d1 - diam)/2)
prev = 1
elif d2*0.8 < diff < d2*1.1:
linesV.append(xs[i-1] + diam + (d2 - diam)/2)
prev = 0
elif d3*0.9 < diff < d3*1.1:
if prev == 1:
linesV.append(xs[i-1] + diam + (d2 - diam)/2)
linesV.append(xs[i-1] + d2 + diam + (d1 - diam)/2)
else:
linesV.append(xs[i-1] + diam + (d1 - diam)/2)
linesV.append(xs[i-1] + d1 + diam + (d2 - diam)/2)
elif d3*1.1 < diff:
if prev == 1:
linesV.append(xs[i-1] + diam + (d2 - diam)/2)
linesV.append(xs[i-1] + d2 + diam + (d1 - diam)/2)
linesV.append(xs[i-1] + d3 + diam + (d2 - diam)/2)
#         if d2 + d3 < diff:
```

```
#           linesV.append(xs[i-1] + 2*d3 - (d2 - diam)/2)
prev = 0
else:
linesV.append(xs[i-1] + diam + (d1 - diam)/2)
linesV.append(xs[i-1] + d1 + diam + (d2 - diam)/2)
linesV.append(xs[i-1] + d1 + d2 + diam + (d1 - diam)/2)
linesV.append(xs[i-1] + d1 + d3 + diam + (d2 - diam)/2)
#         if d2 + d3 < diff:
#           linesV.append(xs[i-1] + d1 + 2*d3 - (d2 - diam)/2)
prev = 1

linesV.append(max(xs) + diam*1.5)
if len(linesV)%2 == 0:
linesV.append(max(xs) + d2 + diam)

return linesV, d1, d2, d3, spacingX, spacingY


def display_contours(figsize = (15,30), lines = False):

fig = plt.figure(figsize = figsize)
plt.rcParams['axes.grid'] = False
plt.rcParams['axes.spines.left'] = False
plt.axis('off')
plt.imshow(paper)
if lines:
for x in linesV:
plt.axvline(x)

plt.show()
def get_letters(showID = False):

Bxs = list(boundingBoxes)
Bxs.append((100000, 0))

dots = [[]]
for y in sorted(list(set(spacingY))):
if y > 1.3*diam:
minYD = y*1.5
break

# get lines of dots
for b in range(len(Bxs)-1):
if Bxs[b][0] < Bxs[b+1][0]:
if showID: dots[-1].append((b, Bxs[b][0:2]))
else: dots[-1].append(Bxs[b][0])
else:
if abs(Bxs[b+1][1] - Bxs[b][1]) < minYD:
```

```
if showID: dots[-1].append((b, Bxs[b][0:2]))
else: dots[-1].append(Bxs[b][0])
dots.append([])
else:
if showID: dots[-1].append((b, Bxs[b][0:2]))
else: dots[-1].append(Bxs[b][0])
dots.append([])
if len(dots)%3 == 0 and not dots[-1]:
dots.append([])

#   for d in dots: print(d)

letters = []

count = 0

for r in range(len(dots)):
if not dots[r]:
letters.append([0 for _ in range(len(linesV)-1)])
continue

else:
letters.append([])
c = 0
i = 0
while i < len(linesV)-1:
if c < len(dots[r]):
if linesV[i] < dots[r][c] < linesV[i+1]:
letters[-1].append(1)
c += 1
else:
letters[-1].append(0)
else:
letters[-1].append(0)
i += 1

#   print(letters[-1])
for l in range(len(letters)):
if l%3 == 0: print()
print(letters[l])
print()

return letters
import numpy as np
import re

def translate(letters):
alpha = {'a': '1', 'b': '13', 'c': '12', 'd': '124', 'e': '14', 'f': '123',
```

```
'g': '1234', 'h': '134', 'i': '23', 'j': '234', 'k': '15',
'l': '135', 'm': '125', 'n': '1245', 'o': '145', 'p': '1235',
'q': '12345', 'r': '1345', 's': '235', 't': '2345', 'u': '156',
'v': '1356', 'w': '2346', 'x': '1256', 'y': '12456', 'z': '1456',
'#': '2456', '^': '6', ',': '3', '.': '346', '\"': '356', '^': '26',
':': '34', '\": '5'}

nums = {'a': '1', 'b': '2', 'c': '3', 'd': '4', 'e': '5', 'f': '6', 'g': '7', 'h': '8', 'i': '9', 'j': '0'}

braille = {v: k for k, v in alpha.items()}

letters = np.array([np.array(l) for l in letters])

ans  = ''

for r in range(0, len(letters), 3):
for c in range(0, len(letters[0]), 2):
f = letters[r:r+3, c:c+2].flatten()
f = ''.join([str(i + 1) for i, d in enumerate(f) if d == 1])
if f == '6': f = '26'
if not f:
if ans and ans[-1] != ' ': ans += ' '
elif f in braille:
ans += braille[f]
else:
ans += '?'
if ans and ans[-1] != ' ': ans += ' '

# Replace numbers
def replace_nums(m):
return nums.get(m.group('key'), m.group(0))
ans = re.sub(r'#(?P<key>[a-zA-Z])', replace_nums, ans)

# Capitalize
def capitalize(m):
return m.group(0)[1].upper()
ans = re.sub(r'\^(?P<key>[a-zA-Z])', capitalize, ans)

return ans

uploaded = files.upload()  # Opens a dialog to upload a file

# Retrieve the uploaded file path
url = next(iter(uploaded))    # works (iter = 0, width = 1500)

image, ctrs, paper, gray, edged, thresh = get_image(url, iter = 0, width = 1500)
```

```
diam = get_diameter()
dotCtrs = get_circles()

questionCtrs, boundingBoxes, xs, ys = sort_contours(dotCtrs)
draw_contours(questionCtrs)

linesV, d1, d2, d3, spacingX, spacingY = get_spacing()

letters = get_letters()
ans = translate(letters)
from textwrap import wrap

plt.axis('off')
io.imshow(image)
plt.show()
for l in wrap(ans, width = 80):
print(l)
from spellchecker import SpellChecker
import language_tool_python

# Initialize the spell checker
spell = SpellChecker()

# Initialize the language tool for grammar correction
tool = language_tool_python.LanguageTool('en-US')
# Function to remove special characters
text=ans
def remove_special_characters(text):
return re.sub(r'[^A-Za-z0-9\s]', ' ', text)  spaces

# Function to correct spelling
def correct_spelling(text):
words = text.split()  # Split sentence into words
corrected_words = []
for word in words:
corrected = spell.correction(word)
if corrected is None:  # If no correction, use the original word
corrected_words.append(word)
else:
corrected_words.append(corrected)
return ' '.join(corrected_words)

# Function to correct grammar
def correct_grammar(text):
matches = tool.check(text)  # Check the text for grammar mistakes
corrected_text = language_tool_python.utils.correct(text, matches) sentence
return corrected_text
```

```
# Function to process text by removing special characters, correcting spelling, and grammar

text = remove_special_characters(text)       # Step 1: Remove special characters
print(text)
text = correct_spelling(text)               # Step 2: Correct spelling
print(text)
text = correct_grammar(text)                 # Step 3: Correct grammar

print(text)
from transformers import T5ForConditionalGeneration

def correct_grammar(text):
model_name = "vennify/t5-base-grammar-correction"
tokenizer = T5Tokenizer.from_pretrained(model_name)
model = T5ForConditionalGeneration.from_pretrained(model_name)

# Prepare the text for the T5 model
input_text = f"grammar: {text}"
inputs = tokenizer.encode(input_text, return_tensors="pt", max_length=512, truncation=True)

# Generate the corrected sentence
outputs = model.generate(inputs, max_length=512, num_beams=5, early_stopping=True)
corrected_sentence = tokenizer.decode(outputs[0], skip_special_tokens=True)

return corrected_sentence

# Example usage
input_text =  text
corrected_text = correct_grammar(input_text)
print(corrected_text)
from deep_translator import GoogleTranslator

# Define the English text to translate
english_text = corrected_text

# Translate the text to Tamil
translation = GoogleTranslator(source='en', target='ta').translate(english_text)

# Print the translated text
print("Original Text:", english_text)
print("Translated Text:", translation)

import io
from IPython.display import Audio


# Convert Tamil text to speech in-memory
tts = gTTS(text=translation, lang='ta')
```

```
mp3_fp = io.BytesIO()
tts.write_to_fp(mp3_fp)
mp3_fp.seek(0)

# Use IPython's Audio to play the audio directly in the notebook
Audio(mp3_fp.read())
```

APPENDIX 2 SCREENSHOTS

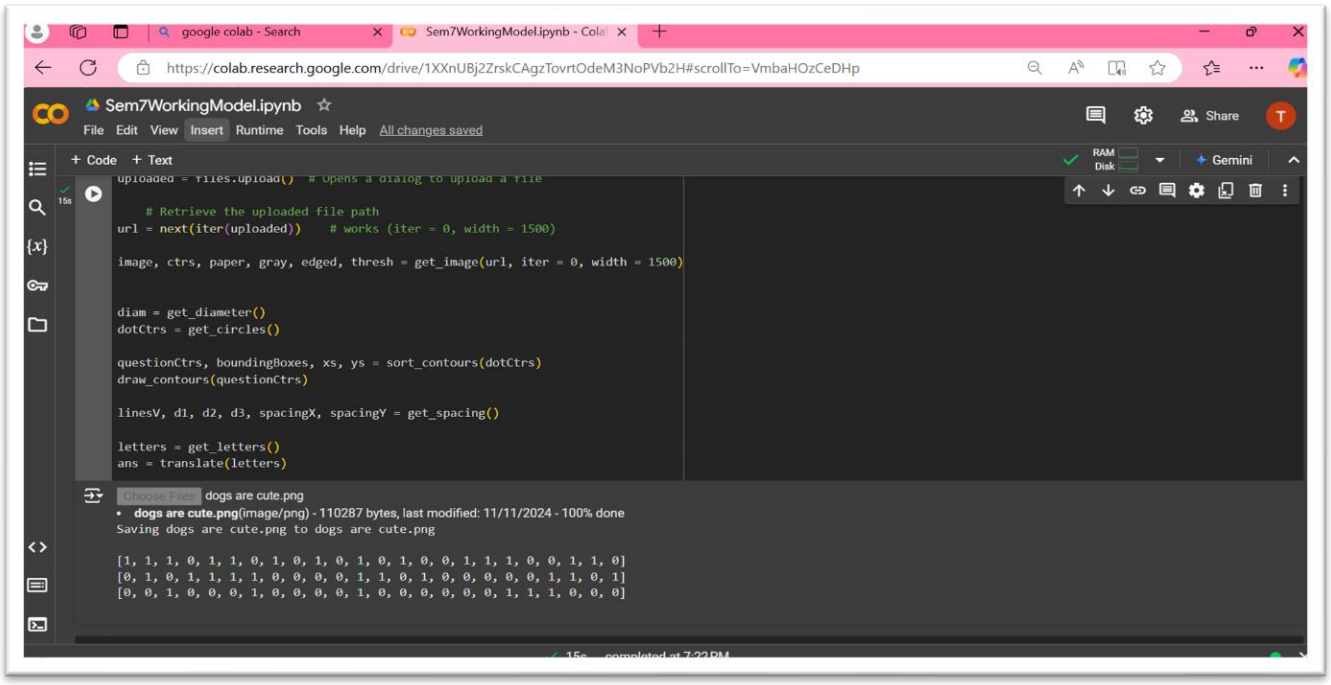

Figure No.A.2.1. Input Acquisition

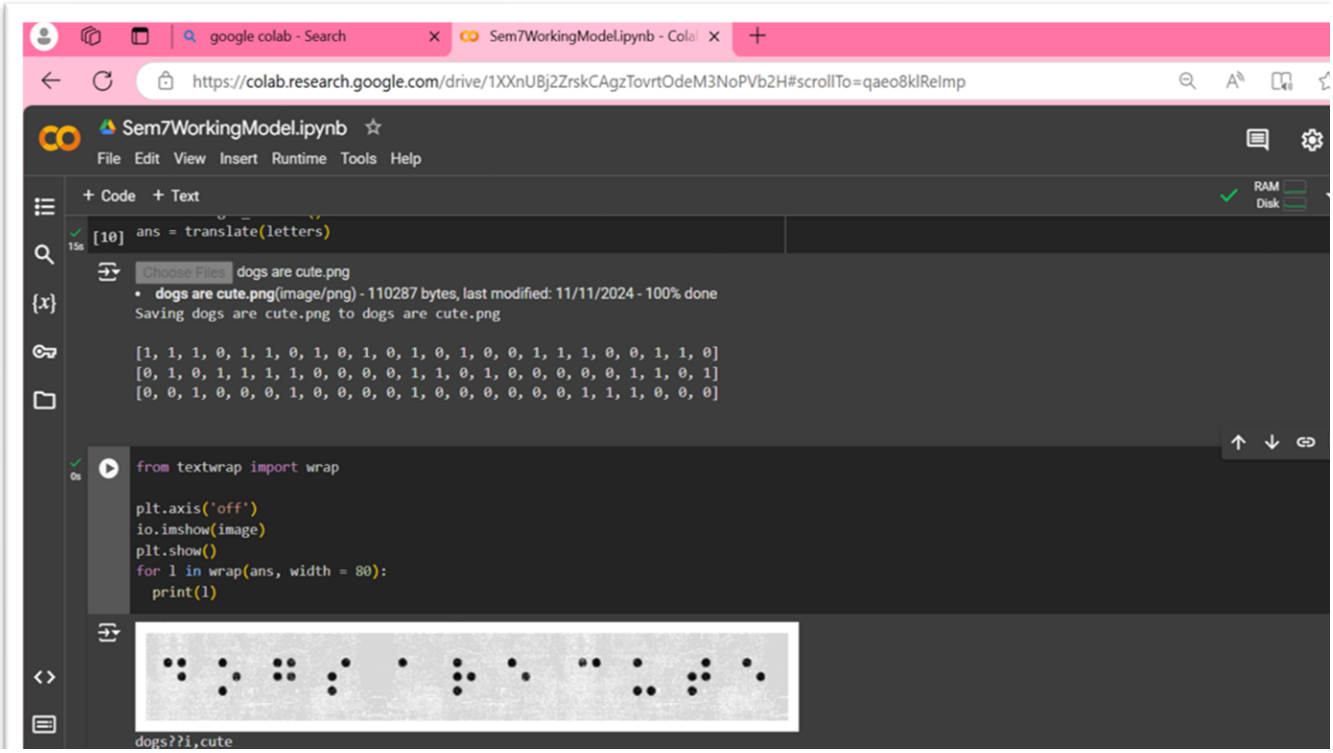

Figure No.A.2.2. Dot Pattern Recognition

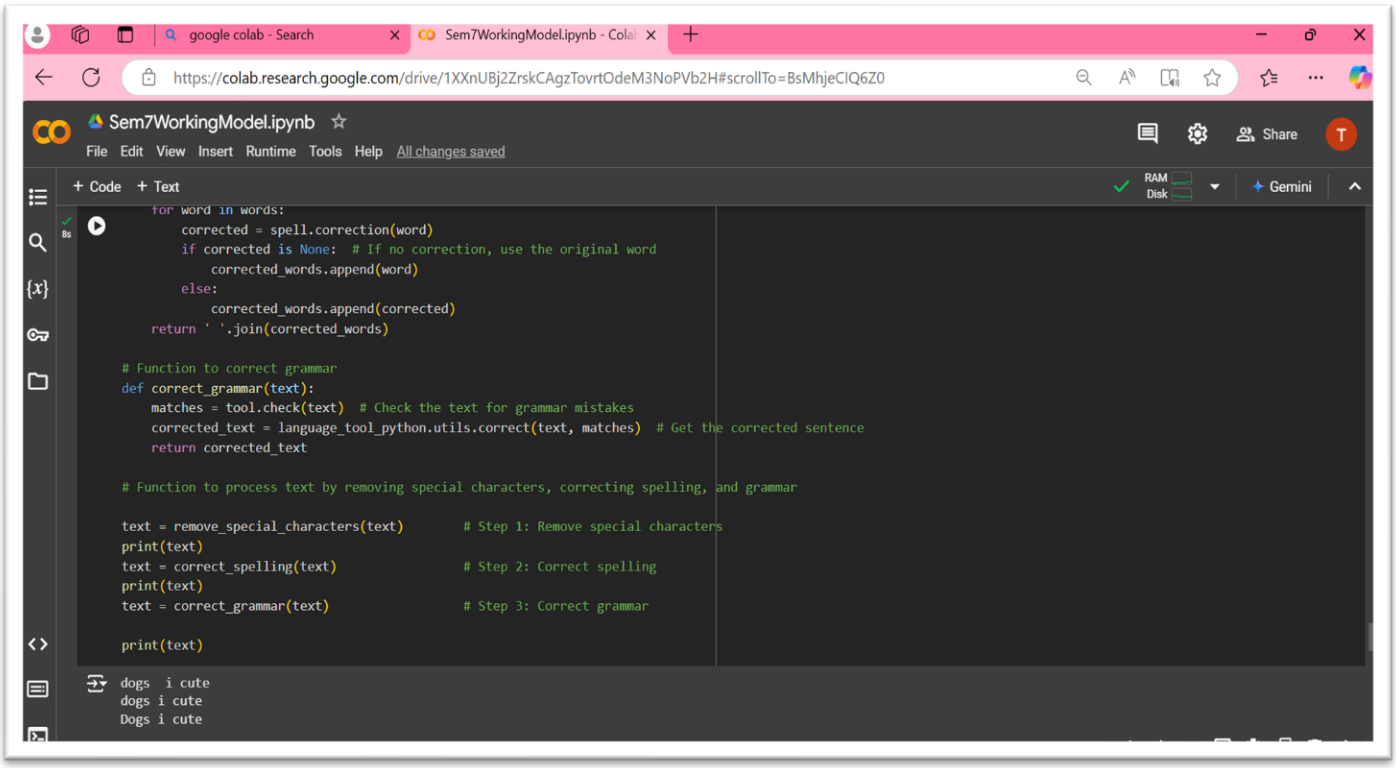

Figure No.A.2.3. Braille Language Interpretation

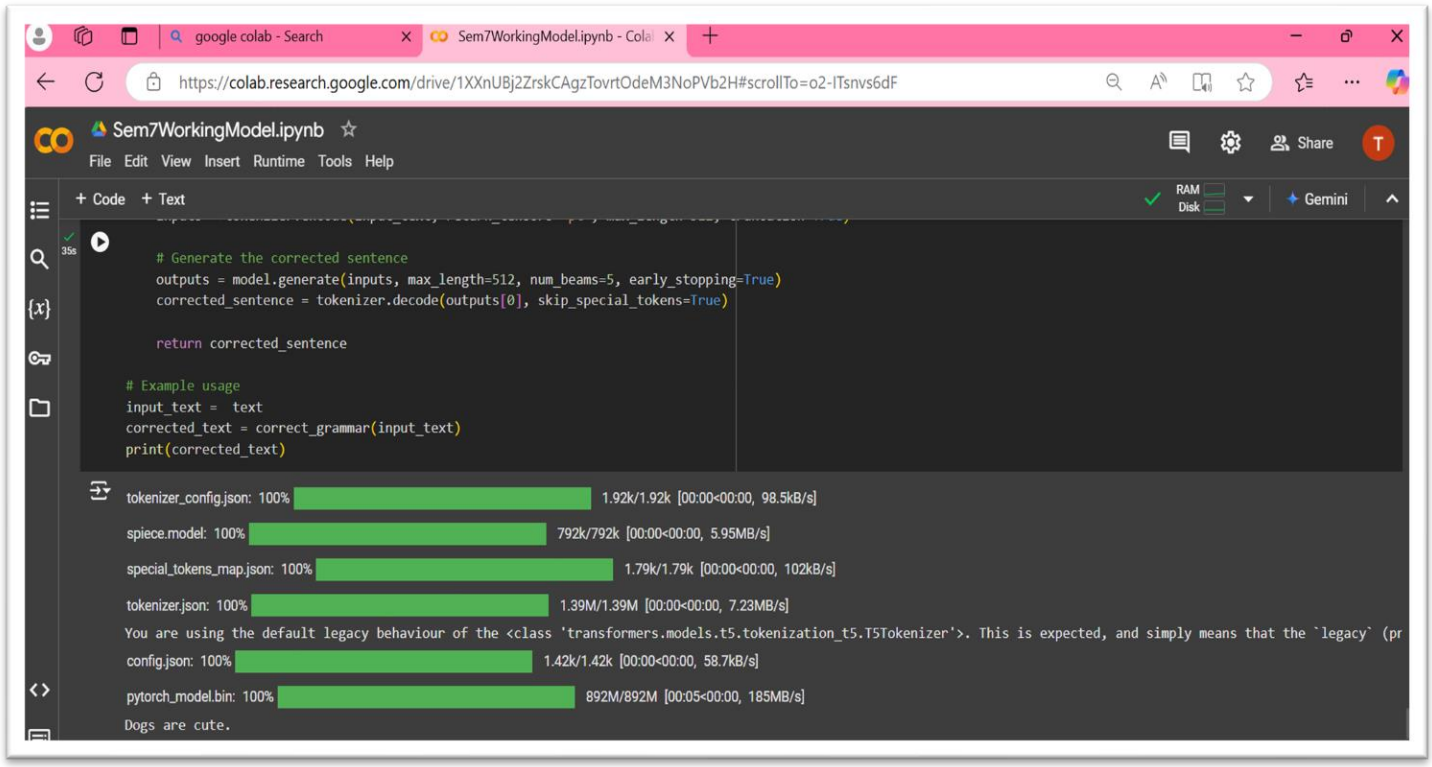

Figure No.A.2.4. Error Correction

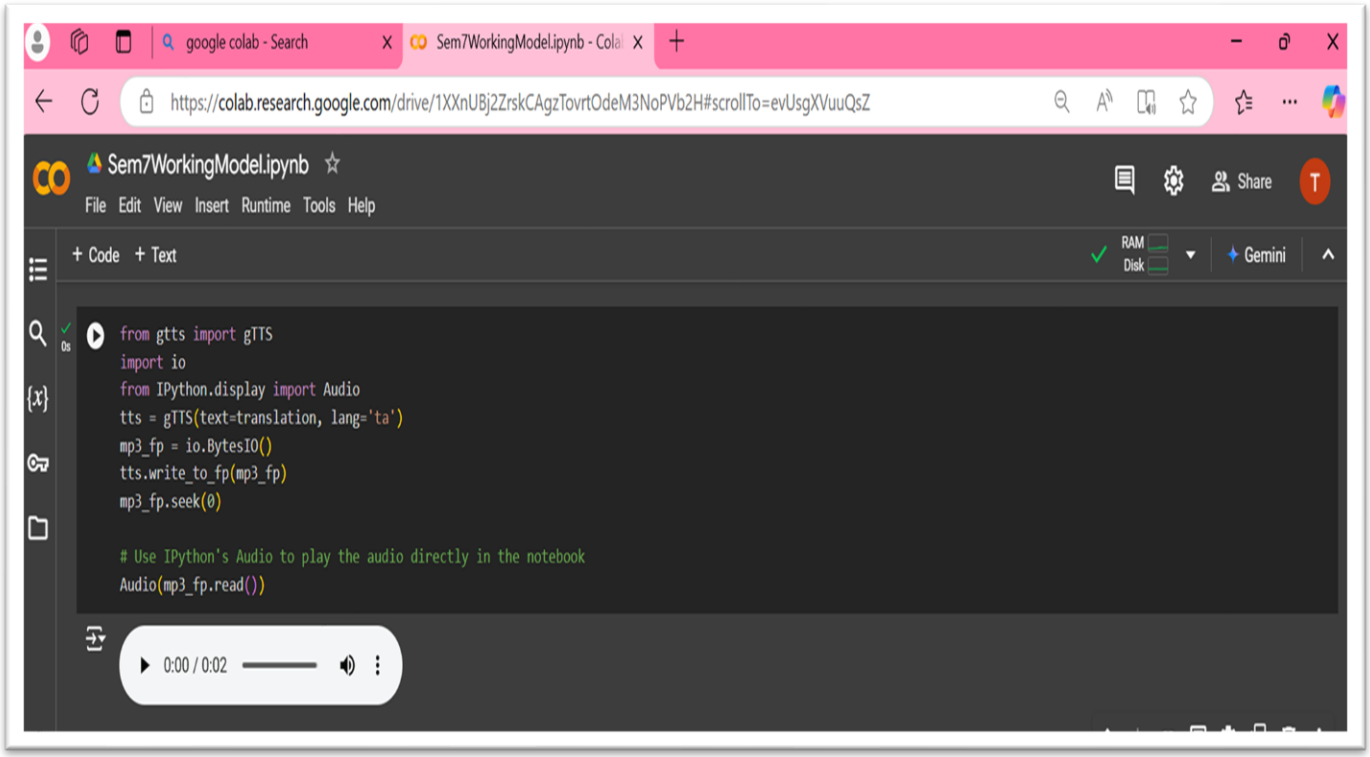

Figure No.A.2.5. Translation And Audio Output

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