OCR BASED TEXT TO SPEECH SYSTEM FOR TEXTUAL IMAGES

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IN

ELECTRONICS AND COMMUNICATIONS ENGINEERING

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CERTIFICATE

This is to certify that Industrial Oriented Mini Project Report work entitled ***"OCR Based Text to Speech System for Textual images"*** *is a bonafide work carried out by* ***Manchoju Raveena***, ***SM Saahil Hussain***, ***Bajoji Harshitha*** ,***Hasthaparapu Bhargav Krishna*** *and* ***Kamalay Nagasai*** *bearing Roll Nos.****21SS1A0443***, ***21SSS1A0457***, ***21SS1A0405*** ,***21SS1A0426*** *and* ***21SS1A0433*** *respectively in partial fulfilment of the requirements for the degree of* ***BACHELOR OF TECHNOLOGY*** *in* ***ELECTRONICS & COMMUNICATION ENGINEERING*** *by the Jawaharlal Nehru Technological University, Hyderabad during the academic year 2024- 2025.*

The results embodied in this report have not been submitted to any other University or Institution for the award of any degree or diploma.

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ABSTRACT

This project presents an advanced system for Optical Character Recognition (OCR) integrated with Text-to-Speech (TTS) synthesis, aimed at accurately detecting and vocalizing text from complex and natural images. The core objective is to utilize a combination of robust image processing techniques and machine learning models for efficient text extraction and speech conversion.

The system employs the Maximally Stable Extremal Regions (MSER) algorithm to detect regions of interest within the image, focusing on diverse text formats, sizes, and orientations in cluttered or noisy backgrounds. The extracted regions undergo Optical Character Recognition (OCR) using MATLAB's OCR tools, converting detected characters into text with high precision. Following successful text extraction, MATLAB's speech synthesizer converts the recognized text into speech, providing a human-like auditory output.

This method addresses challenges such as varying lighting conditions, non-uniform text structures, and different image complexities, making it suitable for real-world applications like assisting the visually impaired, automated reading systems, and digital document processing. The system's potential is demonstrated in its ability to handle multiple languages, fonts, and text in dynamic environments, ensuring high adaptability and scalability.

KEYWORDS :

OCR, Text-to-Speech, Image Processing, MSER, Speech Synthesis, MATLAB, Optical Character Recognition, Complex Image Analysis, Text Detection, Visual Impairment Solutions, Machine Learning

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CHAPTER 1 INTRODUCTION

1.1 Introduction

Text-to-speech (TTS) technology has emerged as a revolutionary tool for converting written text into spoken words, significantly enhancing accessibility and communication. By synthesizing human-like speech from text, TTS bridges the gap between written and verbal communication, empowering individuals with visual or vocal impairments to access information and communication tools equitably.

TTS operates through a combination of linguistic processing, machine learning, and digital signal processing, producing speech that is both intelligible and natural. Its applications extend far beyond accessibility, playing a vital role in domains such as education, virtual assistants, and entertainment [3] Young, S., & Sproat, R. (2019).By converting text into comprehensible audio, TTS addresses various challenges in modern communication

The development of TTS technology can be traced back to foundational research in the mid-20th century. Notable milestones include the digit recognition system developed at Bell Labs in 1952 and the advancements in generative models, such as the HMM-based Speech Synthesis System (HTS) pioneered by Prof. Keiichi Tokuda in the early 2000s. These developments have paved the way for widespread commercial applications, including accessibility tools, virtual assistants, and audiobooks.

1.2 Aim

The aim of this project is to develop a robust TTS system utilizing MATLAB, integrating Optical Character Recognition (OCR) for text detection and advanced speech synthesis techniques. The project seeks to create a system capable of reading text and delivering it in a clear, natural voice. By leveraging MATLAB's computational capabilities and versatile toolboxes, the project aims to advance TTS technology, enhancing its effectiveness and accessibility.

1.3 Methodology

The methodology of this Text-to-Speech (TTS) project comprises three distinct phases: **Image Processing**, **Optical Character Recognition (OCR)**, and **Speech Processing**. Each phase plays a crucial role in ensuring the accurate and efficient conversion of text-based information from an image into synthesized speech. The steps involved in these phases are outlined below.

Image Processing Phase

The image processing phase is the foundation of the TTS system. It prepares the input image for text recognition by enhancing its quality and isolating the text from non-text elements. This phase consists of the following steps:

1. **Image Acquisition**: The process begins with loading the input image into the system using MATLAB's imread function. This step ensures that the image is correctly read into the program for further processing.
2. **Grayscale Conversion**: The input image, typically in RGB format, is converted to a grayscale image using the rgb2gray function. This step simplifies the data by removing color information while retaining the luminance, making subsequent processing more efficient.
3. **Binarization**: The grayscale image is converted into a binary image through thresholding techniques, such as Otsu's method (graythresh). The binary image represents text in white (foreground) and the background in black, facilitating better text segmentation.
4. **Text Region Detection**: Advanced techniques like Maximally Stable Extremal Regions (MSER) are employed to identify potential text regions. MSER leverages the consistent color and high contrast of text to detect stable intensity profiles within the image. This ensures that text regions are accurately isolated from the rest of the image.
5. **Noise Removal**: Non-text elements, such as graphics or artifacts, are removed based on geometric properties like aspect ratio, extent, and solidity. Additionally, the stroke width variation metric is used to discriminate between text and non-text regions. This step ensures that only meaningful text is retained for recognition.
6. **Text Merging**: Detected text regions, which initially consist of individual characters, are merged into words or lines. Bounding boxes are refined to represent

the complete textual content, eliminating false detections and ensuring accurate localization of text.

This phase concludes with a clean binary image containing well-segmented text regions ready for OCR processing.

Optical Character Recognition (OCR) Phase

The second phase involves text recognition using MATLAB's built-in OCR function. This step extracts the text from the preprocessed image and converts it into computer-readable text. Key aspects of this phase include:

1. **OCR Application**: MATLAB's ocr function processes the binary image to detect and recognize characters, words, and symbols. The function outputs the recognized text, its location within the image, and a confidence metric for each recognized segment.
2. **Text Highlighting**: Recognized text regions are visually marked with bounding boxes, allowing users to verify the accuracy of text detection. These boxes also provide recognition confidence levels, helping identify areas for improvement in preprocessing.
3. **Error Handling**: Challenges such as closely spaced characters or uneven lighting conditions are mitigated using preprocessing techniques. For example, morphology operations are used to thin characters, and binarization addresses non-uniform lighting.
4. The OCR phase is critical to the TTS system, as it bridges the gap between visual information in the image and the textual data needed for speech synthesis.

Speech Processing Phase

The final phase transforms the recognized text into synthesized speech, ensuring that the output is clear, natural, and intelligible. The steps in this phase are as follows:

1. **Integration with System Speech Library**: MATLAB integrates with the .NET System.Speech library using the NET.addAssembly function. This library provides tools for creating and customizing synthesized speech.

2. **Audio Recording and Playback**: MATLAB's audiorecorder function creates objects for recording and processing audio. This feature allows the system to capture and modify audio signals as needed.

3. **Text-to-Speech Conversion**: The Speak function in the System.Speech.Synthesis class is used to generate speech from the recognized text. Parameters such as volume, pitch, and speech rate are adjusted to produce natural and pleasant audio output.

4. **Visualization of Audio Data**: The audio signal is plotted using the getaudiodata function, providing insights into the waveform characteristics of the generated speech. This visualization helps refine speech output and troubleshoot any anomalies.

5. **Iterative Processing for Complex Text**: For complex input scenarios, the system processes each word individually, converting it to speech sequentially. This ensures that all textual information in the image is accurately represented in the audio output.

6. By combining advanced image processing, robust OCR, and flexible speech synthesis, the system delivers an end-to-end solution for converting text in images into intelligible speech. Each phase is interdependent, contributing to the overall accuracy and effectiveness of the TTS system.

Testing and Optimization

The methodology also includes rigorous testing to ensure robustness across diverse scenarios. For example, the system is evaluated using natural and complex images containing varying text styles, lighting conditions, and backgrounds. Techniques such as upscaling images and refining binarization thresholds are employed to address challenges in OCR performance. Adjustments to speech synthesis parameters ensure that the output meets user expectations in terms of clarity and naturalness.

This comprehensive methodology ensures that the TTS system is not only functional but also optimized for real-world applications, providing accessibility and usability for diverse users.

1.4 Organization of thesis

The structure of this thesis is as follows:

- Chapter 1: Introduction This chapter provides an overview of TTS technology, outlines the aim and methodology of the project, and highlights its significance and societal impact.
- Chapter 2: Literature Review This chapter reviews existing research and developments in TTS technology, focusing on historical milestones, challenges, and emerging trends.
- Chapter 3: System Design and Implementation This chapter details the design and implementation of the proposed TTS system, including OCR techniques and speech synthesis methods.
- Chapter 4: Results and Analysis This chapter presents the results of system testing, evaluates its performance, and discusses findings in the context of existing technologies.
- Chapter 5: Conclusion and Future Work The final chapter summarizes the project's contributions, discusses its limitations, and suggests directions for future research.
- By following this structure, the thesis aims to provide a comprehensive exploration of TTS technology and its potential to enhance accessibility and communication.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive examination of historical and contemporary advancements in Text-to-Speech (TTS) systems with a particular focus on MATLAB-based implementations. It delves into four critical subtopics: the integration of Optical Character Recognition (OCR), modular approaches in system design, advancements in speech synthesis techniques, and real-world applications, particularly for individuals with disabilities. These sections draw insights from both academic research and practical implementations

2.2 Text to Speech Conversion using Raspberry Pi

Text-to-speech (TTS) conversion systems have become invaluable tools, especially for assisting visually impaired individuals by transforming written text into audible speech. The integration of Optical Character Recognition (OCR) with Text-to-Speech (TTS) systems enables the extraction of text from images, which can then be vocalized. The Raspberry Pi, a cost-effective and flexible platform, has been widely utilized in developing such systems. For instance, Mahalakshmi et al (2018) [6] implemented an OCR-based automatic book reader for visually impaired individuals using Raspberry Pi. A system was developed that captures images via a camera, processes them using OCR to extract text, and then employs a TTS engine to produce speech output. This setup is particularly beneficial for assisting blind individuals in accessing printed text. The system utilizes the Raspberry Pi as the central processing unit, interfacing with peripherals such as cameras and speakers to facilitate the conversion process. Despite the innovative approach, the Raspberry Pi's limited computational resources can hinder performance, especially when handling complex OCR and TTS tasks. OCR processes, which involve analyzing and interpreting text from images, are computationally intensive. Similarly, generating natural and intelligible speech through TTS requires substantial processing power. The Raspberry Pi's constraints may lead to slower processing times and reduced accuracy in text recognition and speech synthesis .To mitigate these limitations, lightweight OCR and TTS engines have been employed. For example, the Tesseract OCR engine, known for its efficiency, is commonly used in

Raspberry Pi projects. Additionally, TTS engines like eSpeak and Flite are favored for their minimal resource requirements, albeit with trade-offs in speech quality. Recent developments have introduced more advanced TTS systems optimized for Raspberry Pi, such as Piper, which offers improved naturalness in speech output. However, even with optimized software, the Raspberry Pi may struggle with large-scale or real-time applications. Tasks involving high-resolution images or requiring rapid processing can experience latency. Moreover, the quality of speech synthesis may be compromised when using less resource-intensive TTS engines, resulting in less natural or robotic-sounding speech.To enhance performance, some implementations offload processing to more powerful external servers or utilize cloud-based services for OCR and TTS tasks. This approach alleviates the computational burden on the Raspberry Pi but introduces dependencies on network connectivity and potential privacy concerns.In conclusion, while the Raspberry Pi offers a cost-effective and flexible platform for developing text-to-speech conversion systems, its limited processing capabilities present challenges for large-scale OCR and TTS tasks. Future advancements may focus on optimizing algorithms for efficiency, leveraging hardware accelerators, or integrating more powerful processors to overcome these limitations and improve the performance of TTS systems on the Raspberry Pi platform.

2.3 Speech Generation Using MATLAB and Win32 SAPI Software

Speech generation has become a pivotal component of assistive technologies, aiding those with visual or speech impairments. The integration of MATLAB, a versatile computational platform, with Microsoft's Speech Application Programming Interface (SAPI) has been explored in various studies for developing Text-to-Speech (TTS) systems. Notably, Chandran et al [3] .have delved into using MATLAB and Win32 SAPI for speech generation. However, this approach faces significant challenges, particularly when deployed on low-power devices like the Raspberry Pi, and when using older versions of SAPI, which offer limited voice options and naturalness.

Integration of MATLAB and SAPI for Speech Generation

The study by Chandran et al. demonstrates the potential of integrating MATLAB with SAPI to facilitate speech synthesis. MATLAB's powerful capabilities for handling complex mathematical and signal processing tasks make it suitable for developing

speech generation systems. SAPI, on the other hand, provides a standardized interface for speech synthesis, allowing MATLAB to convert text into speech. The integration leverages MATLAB's robust processing capabilities to execute the TTS functions managed by SAPI. Chandran et al. highlight how this setup can be used effectively in various applications, particularly in assistive technologies.

Limitations of Raspberry Pi for Large-Scale OCR and TTS Tasks

Chandran et al. point out the limitations of deploying such systems on the Raspberry Pi, a popular choice for low-cost computing projects. The Raspberry Pi's limited processing power poses challenges for large-scale OCR (Optical Character Recognition) and TTS tasks, which are inherently computationally intensive. Real-time image capture, text extraction, and subsequent speech synthesis require significant computational resources, which the Raspberry Pi struggles to provide. This limitation affects the performance and responsiveness of OCR and TTS applications when implemented on the Raspberry Pi, as noted in the research.

Challenges with Older SAPI Versions

In their research, Chandran et al. also discuss the drawbacks of using older versions of SAPI. These versions tend to offer fewer voice options and less natural-sounding speech compared to more modern TTS engines. This limitation reduces the effectiveness of the TTS system in delivering clear and natural speech, which is essential for user satisfaction, especially in assistive technologies. Chandran et al. emphasize the importance of upgrading to more advanced speech synthesis systems to overcome these challenges and improve the overall user experience.

2.4 Image text to speech conversion

The integration of Optical Character Recognition (OCR) and Text-to-Speech (TTS) technologies has paved the way for systems that convert textual content from images into audible speech. A notable implementation of this concept is the "Text to Speech Conversion System using OCR" by Sir Gopinath et al[4], developed using MATLAB. This project aims to facilitate accessibility for visually impaired individuals and enhance user interaction by converting textual data from images into speech.

In this system, the process begins with image acquisition, where the input image containing text is captured. The image then undergoes preprocessing steps, including conversion to grayscale and filtering, to enhance quality and prepare it for text extraction. The preprocessing phase is crucial for improving the readability of the text, especially when dealing with images captured under suboptimal conditions. Subsequently, OCR techniques are employed to recognize and extract textual information from the image. MATLAB's robust image processing capabilities are leveraged to ensure accurate text detection and extraction. Once the text is successfully extracted, it is converted into speech using MATLAB's TTS functionalities, providing an audible output of the textual content.

However, the system exhibits a significant drawback: high sensitivity to input image quality and lighting conditions. Variations in lighting can introduce noise and distortions, adversely affecting the accuracy of text recognition. For instance, uneven illumination may cause shadows or highlights that obscure parts of the text, leading to errors in OCR processing. Similarly, poor image quality resulting from low resolution or blurriness can hinder the system's ability to accurately detect and extract text. These challenges are particularly pronounced when dealing with images captured in real-world scenarios, where lighting and image quality can vary widely.

Addressing these challenges requires implementing strategies to mitigate the impact of varying image quality and lighting conditions. One approach involves enhancing the preprocessing stage by incorporating techniques such as Contrast Limited Adaptive Histogram Equalization (CLAHE), which improves image contrast and can aid in better text recognition under diverse lighting conditions. Additionally, ensuring consistent and adequate lighting during image capture can reduce the introduction of shadows and glare, thereby improving OCR accuracy. These preprocessing enhancements can significantly reduce the system's dependency on optimal image conditions.

Furthermore, integrating advanced image processing algorithms that can adapt to varying image qualities may enhance the system's robustness. Machine learning approaches, for instance, can be trained to recognize and compensate for distortions caused by poor lighting or image quality, thereby improving the reliability of text extraction. Implementing such solutions would make the system more resilient to the

challenges posed by suboptimal image conditions, enhancing its overall performance and usability.

In conclusion, while the Text to Speech Conversion System using OCR by Sir Gopinath et al. demonstrates the potential of combining OCR and TTS technologies within MATLAB, its high sensitivity to input image quality and lighting conditions presents a notable limitation. Addressing this issue through enhanced preprocessing techniques, consistent lighting during image capture, and the integration of adaptive algorithms could significantly improve the system's accuracy and reliability, making it more effective for practical applications. As technology continues to evolve, future iterations of such systems may overcome these limitations, providing more robust and accessible solutions for converting image text to speech.

2.5 TTS implementation using OCR

Implementing a Text-to-Speech (TTS) system using Optical Character Recognition (OCR) in MATLAB involves several critical steps: image acquisition, preprocessing, text extraction, and speech synthesis. Each phase is vital for the system's overall performance, with preprocessing playing a particularly crucial role in enhancing OCR accuracy.

Image Acquisition and Preprocessing

The initial stage involves capturing images containing text, which may vary in quality due to factors like lighting, noise, and distortions. Effective preprocessing is essential to mitigate these issues and improve OCR performance. Common preprocessing techniques include grayscale conversion, noise reduction, binarization, and contrast enhancement. These methods aim to produce a cleaner image, facilitating more accurate text extraction.

A study by Sir Patil et al [5] evaluating different preprocessing methods on OCR results found that techniques such as binarization and noise reduction significantly enhance text recognition accuracy. However, the effectiveness of these methods can vary depending on the quality and characteristics of the input images.

Text Extraction via OCR

MATLAB's OCR functions are employed to extract text from preprocessed images. The accuracy of this extraction heavily depends on the quality of the input image and the effectiveness of preprocessing steps. Challenges such as varying font styles, sizes, and orientations can impact OCR performance. Therefore, additional preprocessing steps like deskewing and morphological operations may be necessary to handle such variations.

Text-to-Speech Conversion

Once the text is accurately extracted, MATLAB's TTS capabilities can convert the text into speech. This process involves parsing the text and generating corresponding speech signals. The quality of the synthesized speech depends on the TTS engine used and its configuration.

Drawbacks and the Need for Additional Preprocessing

Despite the integration of OCR and TTS in MATLAB, Sir Patil et al. highlight several challenges that necessitate additional preprocessing steps for optimal OCR results:

1. **Image Quality Variations**: Images with poor lighting, noise, or distortions require advanced preprocessing techniques to enhance clarity. Standard methods may be insufficient, necessitating the development of more sophisticated algorithms to handle diverse image conditions.
2. **Complex Backgrounds**: Images with complex or colored backgrounds can hinder text extraction. Advanced background subtraction or segmentation techniques may be required to isolate text regions effectively.
3. **Font and Language Diversity**: The presence of multiple fonts, sizes, orientations, or languages in images can complicate OCR accuracy. Implementing preprocessing steps like text line normalization and script identification can help address these challenges.
4. **Skew and Distortion**: Images with skewed or distorted text require geometric corrections. Techniques such as Hough Transform for line detection and correction can be employed to rectify these distortions before OCR processing.

Addressing these challenges often requires implementing additional preprocessing steps tailored to the specific issues present in the input images. For instance, in a

MATLAB-based OCR project, preprocessing steps like color channel separation and morphological operations were necessary to handle images with text in multiple colors.

2.6 Conclusion

This chapter explores the challenges and advancements in OCR-TTS integration, modular system design, and the practical benefits for individuals with disabilities. Key insights include the potential and limitations of platforms like Raspberry Pi in handling computationally intensive OCR and TTS tasks, the use of MATLAB with SAPI for speech generation, and the necessity for advanced preprocessing techniques to overcome issues like image quality and lighting variability. The discussed studies underscore the importance of optimizing algorithms and leveraging innovative technologies to enhance the performance and accessibility of TTS systems, paving the way for future improvements in assistive technologies.

CHAPTER 3 SYSTEM DESIGN AND IMPLEMENTATION

3.1 Introduction

The implementation of the text-to-speech (TTS) system represents the translation of the theoretical methodology into a functional and practical solution. This chapter elaborates on the implementation process and the rigorous testing carried out to ensure the reliability and efficiency of the system. It is divided into four sections: Image Processing Implementation (3.2), OCR Implementation (3.3), Speech Synthesis Implementation (3.4), and Testing and Evaluation (3.5). Each section provides a comprehensive analysis of the coding, tools, and techniques applied, as well as the challenges faced and solutions adopted.

3.2 Image Processing Implementation

Image processing forms the backbone of the TTS system, as it prepares the raw input image for subsequent text extraction. Implementing this phase involves using tools like MATLAB's Image Processing Toolbox to manipulate and enhance the quality of images. Effective image processing techniques are crucial in OCR-based TTS systems [1] developed an image text-to-speech conversion system using OCR on Raspberry Pi.

Loading and Preprocessing

The implementation starts by loading the input image using the imread function. The image, whether it is a scanned document or a natural scene photograph, is converted to grayscale using the rgb2gray function. Grayscale conversion reduces computational complexity while retaining essential information. To address issues such as noise and poor lighting, noise reduction algorithms like median filtering (medfilt2) are employed. This step significantly improves the clarity of the text regions, preparing the image for thresholding.

Thresholding, achieved using graythresh and imbinarize, separates the text from the background by converting the grayscale image into a binary format. This process

ensures that textual elements stand out distinctly, which is critical for accurate text recognition.

Advanced Image Enhancement

To handle images with low contrast or uneven lighting, contrast adjustment techniques such as adaptive histogram equalization (adapthisteq) are utilized. For images with complex backgrounds, the system employs Maximally Stable Extremal Regions (MSER) to detect and isolate text regions. MSER's sensitivity to consistent intensity variations makes it ideal for identifying text even in challenging conditions. Morphological operations like dilation and erosion are applied to connect fragmented text elements, ensuring continuity and completeness of text regions.

Edge Detection and Segmentation

Edge detection algorithms, such as the Sobel or Canny methods, are implemented to identify the boundaries of text regions. This step aids in segmenting the image into regions of interest (ROIs) for further processing. These ROIs are then passed to the OCR phase, ensuring that only relevant portions of the image are analyzed.

The implementation of the image processing phase highlights the importance of preprocessing in achieving accurate text recognition. By integrating advanced techniques, the system ensures high-quality input for the subsequent OCR stage.

3.3 OCR Implementation

Optical Character Recognition (OCR) is a pivotal component of the TTS system, converting the preprocessed image data into machine-readable text. MATLAB's built-in ocr function is employed to achieve this.

Text Detection and Recognition

The OCR phase begins with the detection of text regions. Bounding boxes are generated around these regions using the coordinates provided by the ocr function. These bounding boxes not only localize text but also help visualize the recognition process, providing insights into the system's accuracy.

Recognizing text involves analyzing these regions using pre-trained OCR models. The ocr function outputs the recognized text along with confidence scores, which indicate

the reliability of the results. For multilingual support, the system integrates language-specific OCR models, ensuring accurate recognition across various languages.

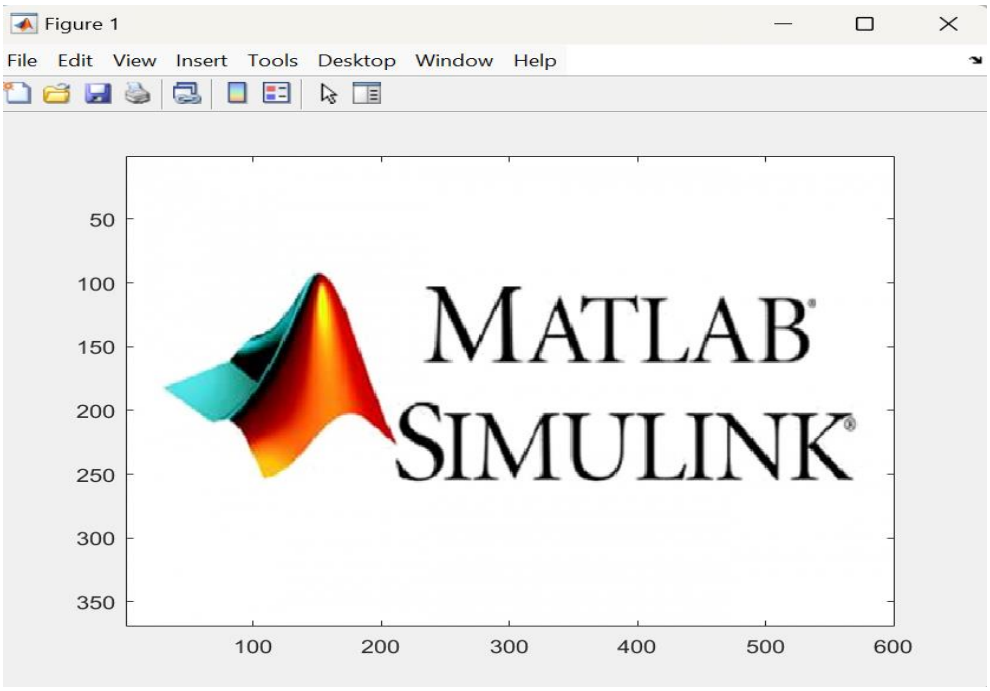

Figure 3.1: Input image for "MATLAB SIMULINK"

❖ Detecting text regions using MSER.

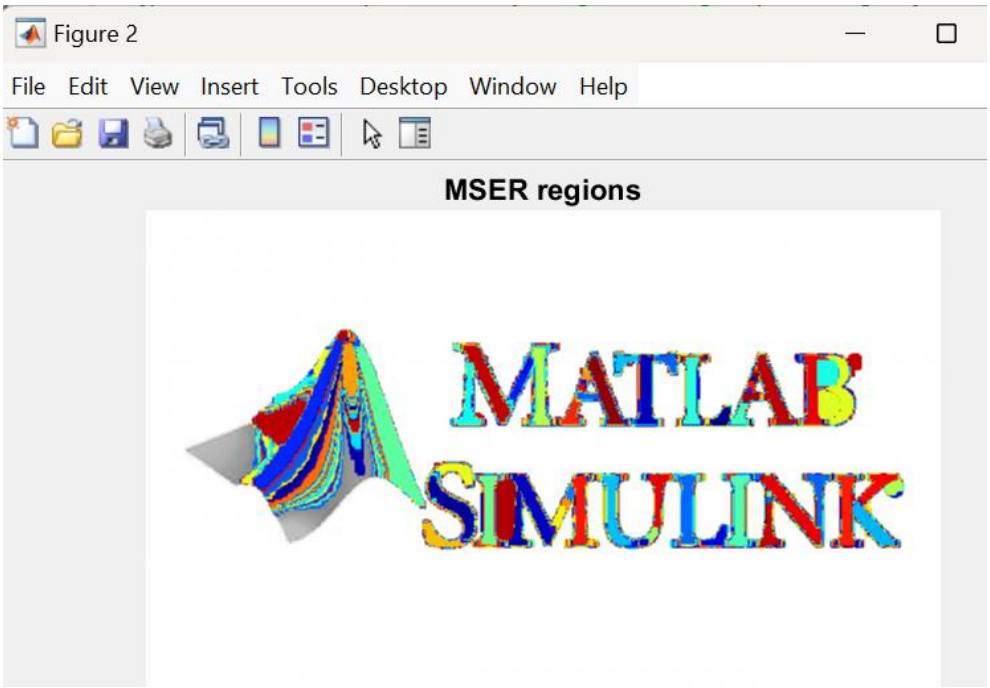

Figure 3.2 : Highlighting MSER regions

❖ Separating the non-text regions based on stroke-width variation.

3.2.1 Handling Skew and Noise

Skewed text or rotated images pose significant challenges for OCR. To address this, skew correction algorithms based on the Hough Transform are implemented. These algorithms detect and correct the angle of text alignment, ensuring that the text is properly oriented for recognition. Noise reduction techniques, such as Gaussian filtering, are also applied to enhance text clarity.

3.2.2 Post-Processing and Error Correction

Post-processing plays a crucial role in refining OCR output. Confidence-based filtering is used to identify and correct low-confidence characters. Spell-checking algorithms are integrated to rectify common OCR errors, while dictionary-based corrections improve the accuracy of recognized words. For technical or domain-specific terms, custom dictionaries are employed, ensuring high fidelity to the original content.

The OCR implementation ensures that the recognized text is both accurate and contextually relevant. By addressing challenges such as skew, noise, and font variations, the system achieves robust text extraction.

3.4 Speech Synthesis Implementation

The speech synthesis phase converts the recognized text into natural-sounding speech. MATLAB's integration with the .NET framework's System.Speech namespace facilitates this process [2] demonstrated voice synthesis and recognition in Marathi using a Raspberry Pi, showcasing the effectiveness of integrating advanced speech processing techniques for practical applications.

Initialization and Configuration

Speech synthesis begins by adding the necessary assembly using the NET.addAssembly function. This step integrates MATLAB with the speech synthesis functionalities of the .NET library. An instance of the SpeechSynthesizer class is then created, allowing the system to generate audio output from the recognized text.

Key parameters such as volume, pitch, and speech rate are configured to optimize the naturalness and intelligibility of the output. For instance, slower speech rates are used for complex sentences, while pitch adjustments are made to emphasize specific words or phrases.

Enhancing Speech Quality

The system incorporates techniques to enhance the quality and expressiveness of synthesized speech. Grapheme-to-Phoneme (G2P) conversion algorithms are used to ensure accurate pronunciation of words, particularly technical terms and proper nouns. Phonetic dictionaries further aid in achieving correct pronunciation.

Emotion and expressiveness are achieved by varying pitch and intonation based on the punctuation and sentence structure of the input text. This makes the synthesized speech more engaging and human-like.

Challenges and Solutions

Synthesizing speech that conveys emotions and nuances remains a challenge. To address this, the system leverages advanced deep learning-based models like Tacotron and WaveNet for future enhancements. These models generate high-quality, expressive speech by learning from large datasets of human speech.

The implementation of the speech synthesis phase ensures that the final output is natural, clear, and adaptable to diverse user needs. By fine-tuning parameters and incorporating advanced techniques, the system achieves a high level of user satisfaction.

3.5 Testing and Evaluation

Testing and evaluation are critical to validating the performance and reliability of the TTS system. The system is tested on a diverse dataset of input images, ranging from structured documents to complex natural scenes.

Test Cases and Results

The robustness of the image processing phase is evaluated using metrics such as processing time and noise reduction effectiveness. For OCR, accuracy rates and confidence metrics are analysed to assess text recognition performance. Speech synthesis is evaluated based on intelligibility scores and user feedback.

One test case involves processing an image with overlapping text and graphical elements. The system’s ability to isolate and recognize text regions demonstrates its

adaptability to challenging inputs. The resulting speech output is clear and natural, highlighting the effectiveness of the methodology.

Iterative Refinement

Challenges encountered during testing, such as low-resolution images and mispronunciations, are addressed through iterative refinements. For example, increasing image resolution improves OCR accuracy, while adjusting speech synthesis parameters ensures consistent quality. User feedback is incorporated to fine-tune the system, ensuring that it meets diverse user requirements.

Evaluation Metrics

The system's performance is quantified using metrics such as:

- **OCR Accuracy:** The percentage of correctly recognized characters and words.
- **Processing Time:** The time taken to process images and generate speech output.
- **User Satisfaction:** Feedback from users regarding the clarity and naturalness of synthesized speech.

Through rigorous testing and evaluation, the TTS system demonstrates its robustness, reliability, and adaptability. The insights gained pave the way for future improvements and innovations.

Building on the insights from testing and evaluation, future work will focus on expanding the dataset to include more diverse and complex images, enhancing the system's ability to handle various languages and dialects, and incorporating advanced machine learning techniques to further improve OCR accuracy and speech synthesis quality. Additionally, real-time processing capabilities will be developed to ensure seamless user experiences in dynamic environments. Continuous user feedback will remain integral, driving iterative enhancements and ensuring the system evolves to meet emerging user needs and technological advancements.

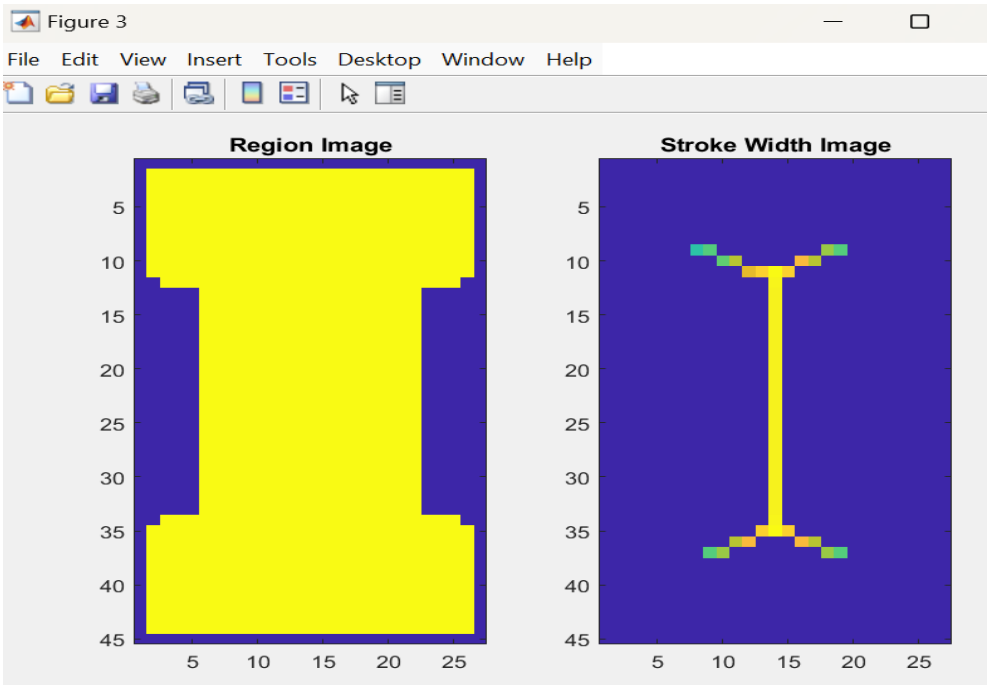

Figure 3.3 : Stroke-width regions

❖ Filtering out the area with objects or which does not contain texts.

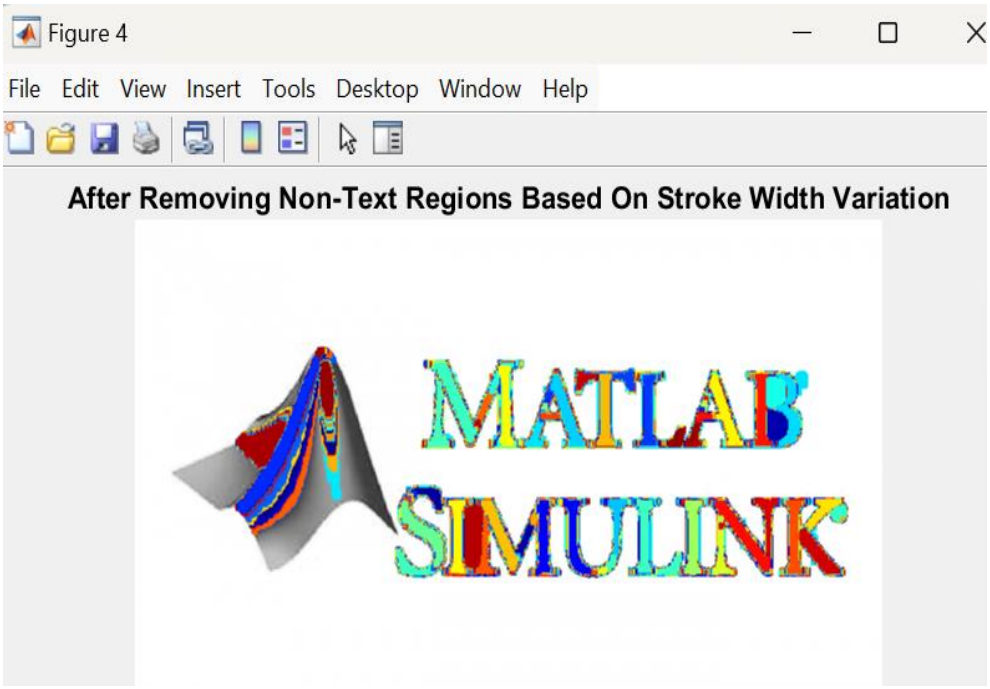

Figure 3.4 : Removing Non-text regions.

❖ Merging text regions for final detection result.

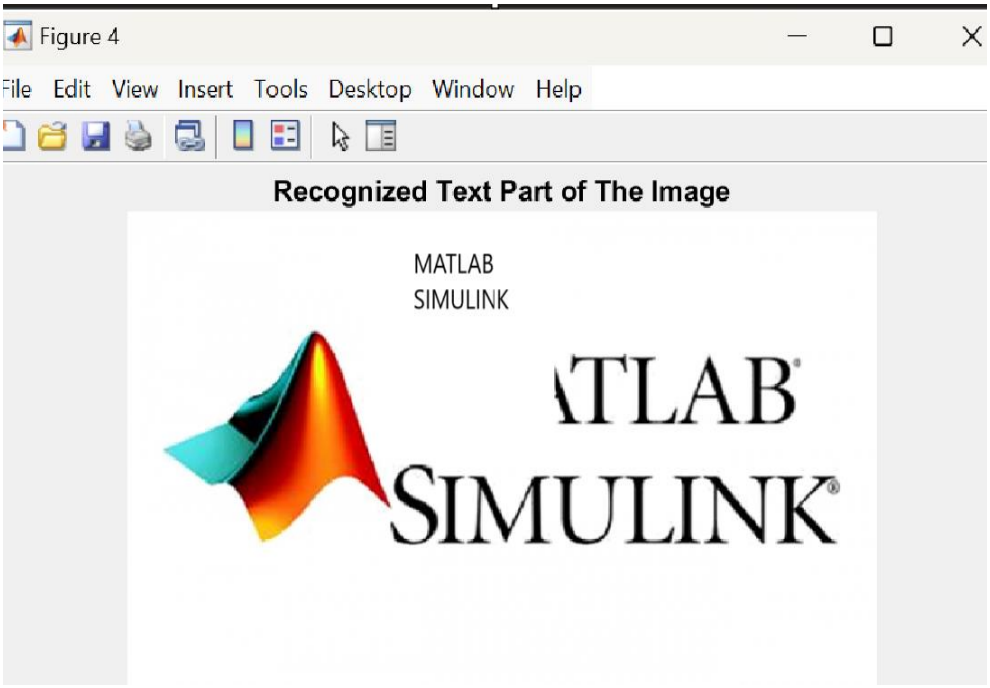

Figure 3.5 : Recognized Texts in White Box

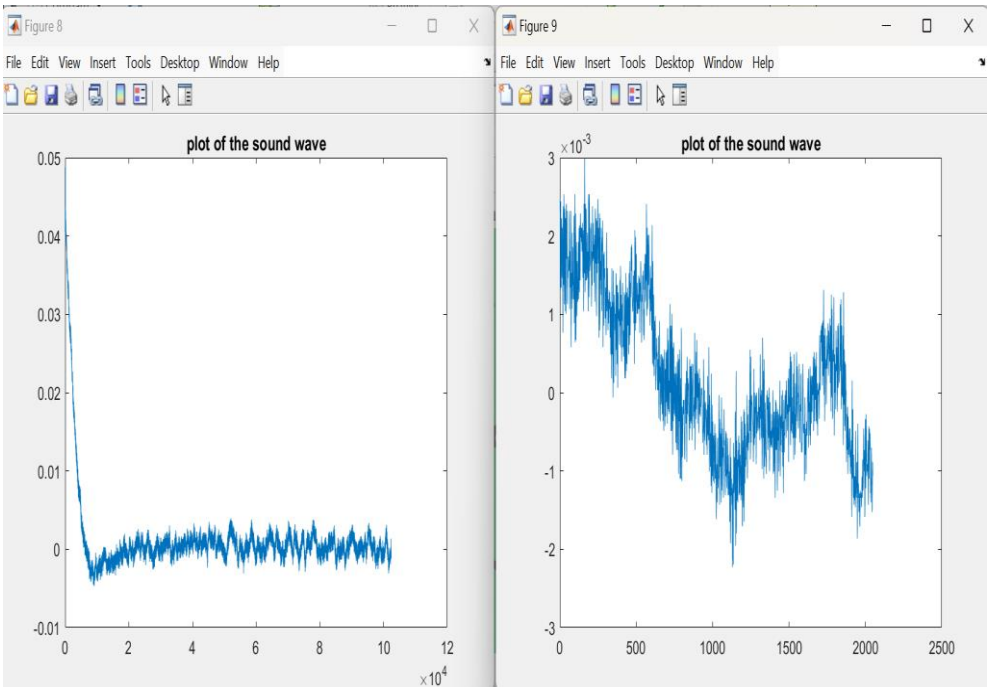

Figure 3.6 : Plot of Emerging Sound Waves.

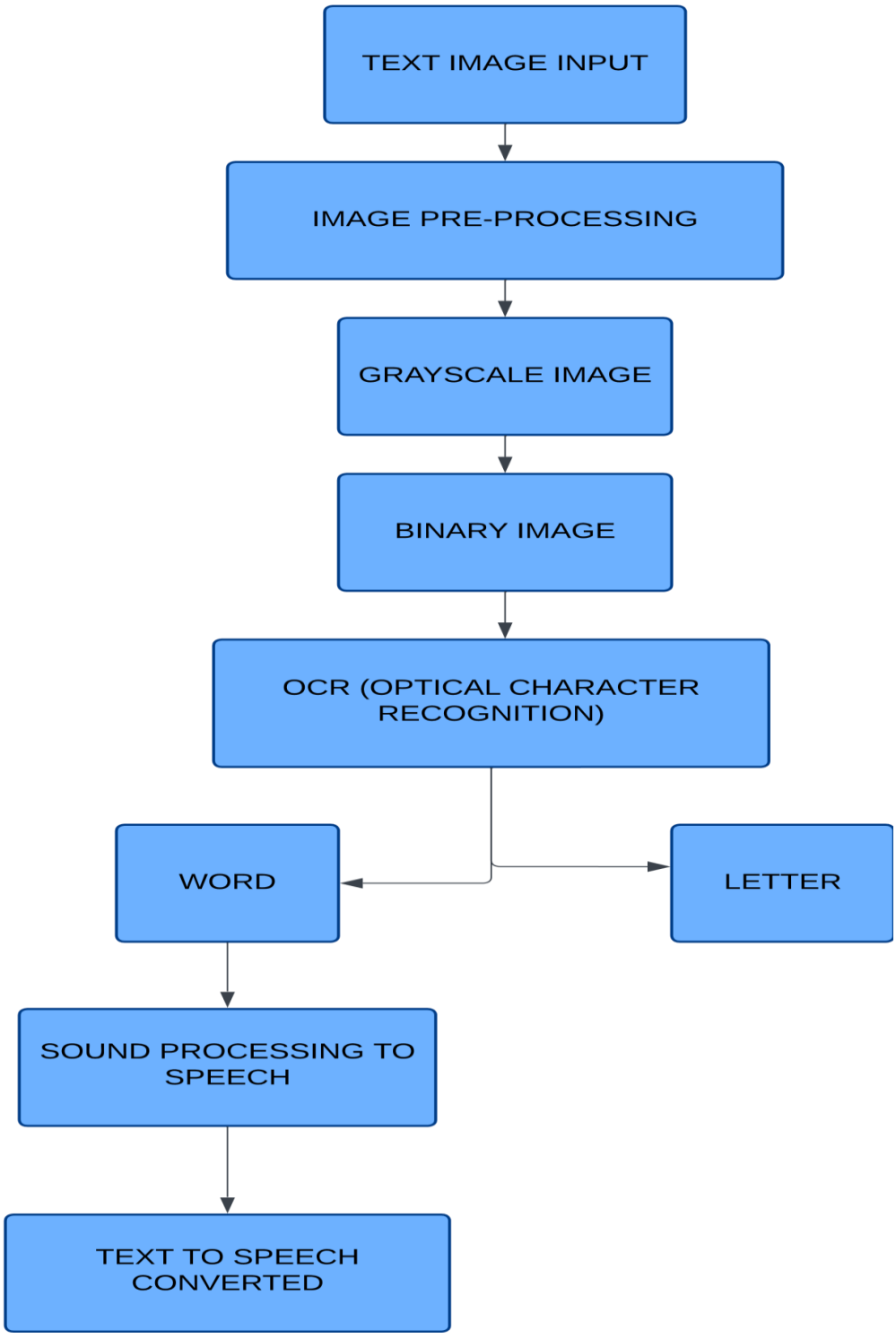

Figure 3.7: BLOCK DIAGRAM

3.6 Conclusion

The successful implementation of the TTS system demonstrates the seamless integration of image processing, OCR, and speech synthesis to transform text from images into natural-sounding speech. The use of advanced techniques such as noise reduction, skew correction, and MSER for text detection ensures high accuracy and reliability in various challenging scenarios. OCR capabilities are enhanced through multilingual support and post-processing, while speech synthesis achieves clarity and expressiveness by adjusting parameters like pitch, rate, and volume.

The rigorous testing and evaluation processes confirm the system's robustness and adaptability, supported by metrics like OCR accuracy, processing time, and user satisfaction. Continuous improvements, driven by user feedback and emerging technologies, are poised to enhance the system's performance further. This project showcases a practical, efficient, and user-friendly TTS solution, setting a solid foundation for future advancements in text-to-speech applications.

CHAPTER 4 RESULTS AND ANALYSIS

4.1 Introduction

This chapter presents an in-depth discussion on the comprehensive results and analysis of the developed Text-to-Speech (TTS) system. Each phase of the project—image processing, optical character recognition (OCR), and speech synthesis—is analyzed in detail, emphasizing the methodologies implemented, challenges faced, and solutions developed. This chapter also illustrates the candidate's contributions through detailed methodologies, flowcharts, and code examples, with a focus on the significance of each phase in achieving a robust and efficient TTS system. By addressing diverse input scenarios, this chapter underscores the importance of integrating advanced techniques to ensure high-quality output.

4.2 Image Processing

Image processing forms the foundational phase of the TTS pipeline. This step ensures that raw input images are adequately prepared for text extraction by addressing challenges such as noise, poor contrast, skew, and complex backgrounds. MATLAB's Image Processing Toolbox provides a rich set of tools for implementing effective preprocessing techniques, ensuring accurate OCR performance.

Preprocessing and Noise Reduction

Images used in TTS systems often originate from diverse sources, including scanned documents, digital photos, and screenshots. These images may contain noise, uneven lighting, or low contrast, all of which hinder text recognition. To address these issues, the following techniques were meticulously applied:

1. **Noise Filtering**: MATLAB's medfilt2 function was employed to apply median filtering, which effectively reduces noise while preserving the edges of characters. This step was crucial in maintaining the integrity of textual details, particularly for noisy input images.
2. **Contrast and Brightness Enhancement**: The imadjust function was used to enhance text clarity in low-contrast images. For more complex cases, adaptive

histogram equalization through adapthisteq was implemented. This technique redistributes intensity values to improve text visibility and enhance edge definition.

Binarization and Segmentation

Converting grayscale images to binary simplifies text detection by clearly distinguishing textual regions from the background. MATLAB's graythresh function uses Otsu's method to calculate an optimal threshold, which is applied using imbinarize to generate binary images. This transformation is followed by segmentation, which divides the binary image into text-specific regions using edge detection algorithms such as Canny filters. Morphological operations like dilation and erosion were further utilized to connect fragmented text regions, improving the continuity and readability of characters.

Handling Complex Backgrounds

Natural images with intricate backgrounds pose additional challenges. Techniques such as Maximally Stable Extremal Regions (MSER) were applied to identify regions of consistent intensity likely corresponding to text. Non-text regions were filtered using geometric constraints like stroke width variation and aspect ratios. This approach ensured that only relevant text regions remained for OCR processing.

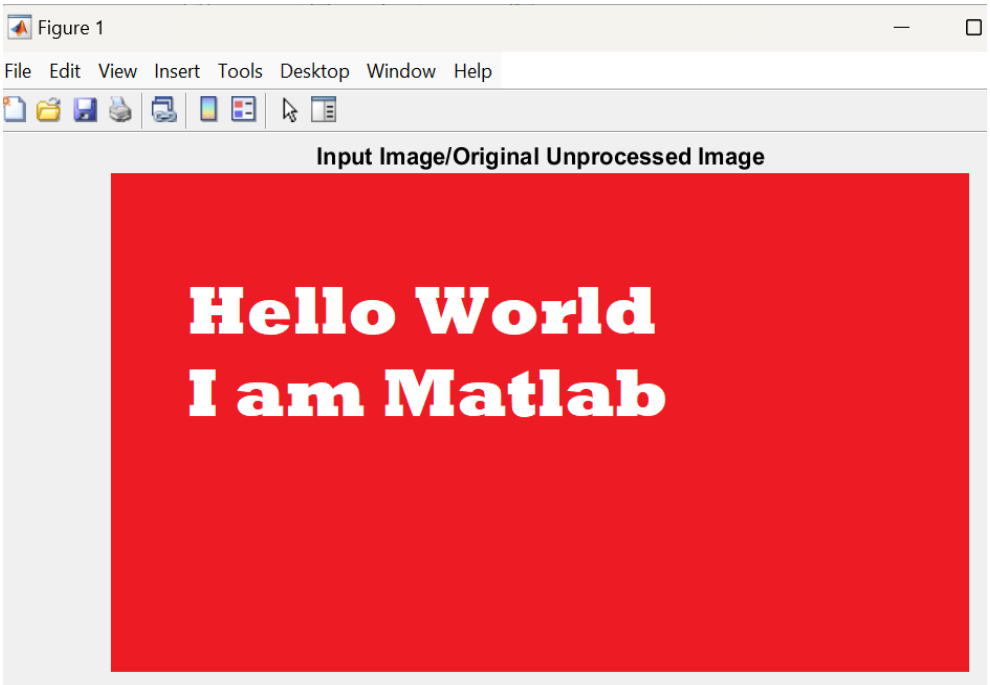

Figure 4.1 : Input image of "HELLO WORLD.."

❖ Converting the RGB image to Grayscale image.

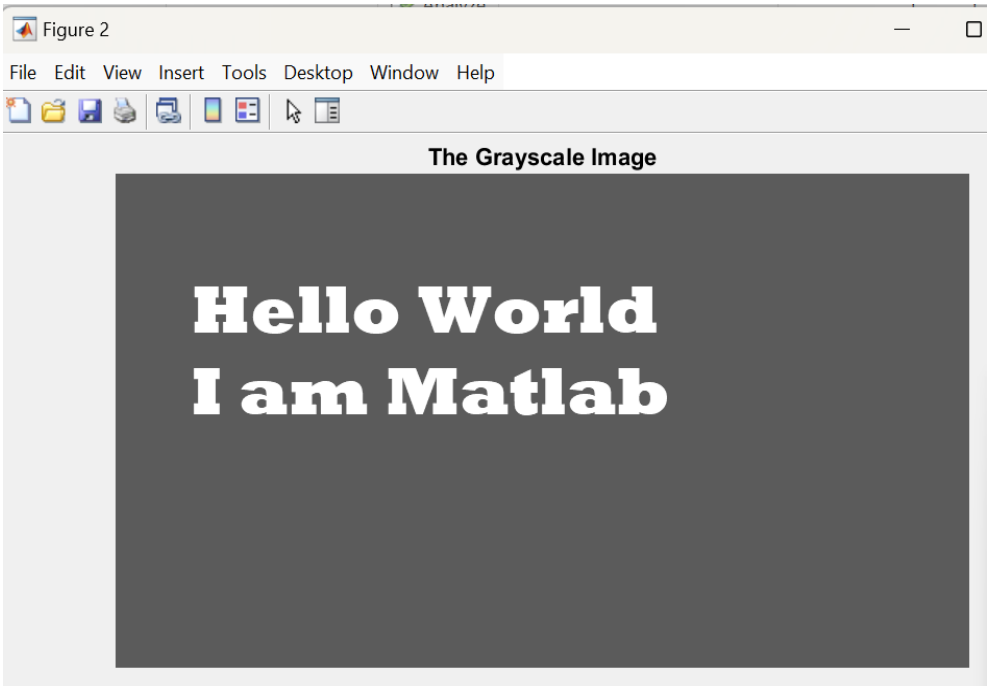

Figure 4.2 : The Grayscale Image of "HELLO WORLD.."

❖ Converting the grayscale image into binary one.

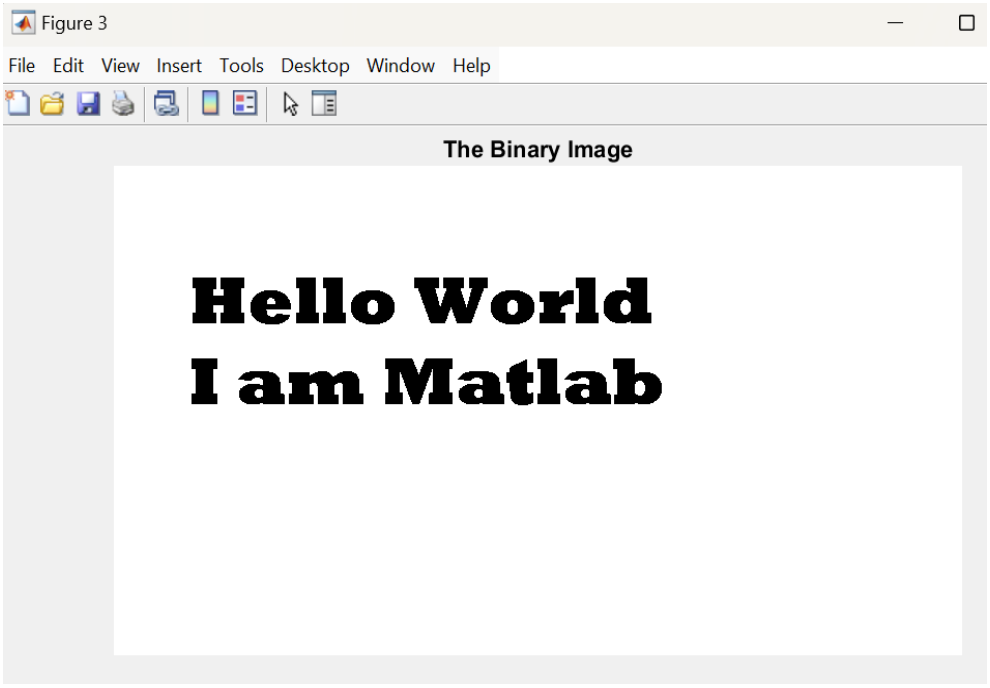

Figure 4.3 : Binary Image of "HELLO WORLD.."

4.3 Optical Character Recognition (OCR)

OCR serves as the critical intermediary phase, converting processed image data into machine-readable text. MATLAB's ocr function, equipped with advanced algorithms, facilitated efficient and accurate text detection and recognition across diverse image datasets.

Text Detection and Recognition

The OCR process begins by identifying text regions within the preprocessed image. The ocr function generates bounding boxes that mark potential text areas, which are then analyzed to decode individual characters and words. Recognized text is output as a string along with confidence metrics indicating the reliability of each recognized character. This feedback mechanism ensures accuracy and provides insights for iterative improvements.

Multilingual Support

To process text in various languages, the OCR system was enhanced with custom language models. MATLAB's support for dataset integration allowed the addition of language-specific models, improving the system's ability to distinguish and recognize multilingual content. Language tagging algorithms dynamically identified the script and selected the appropriate recognition model, greatly enhancing versatility.

Improving OCR Accuracy

Several challenges were identified and addressed during OCR implementation:

1. **Font Variations**: Text in decorative or cursive fonts reduced recognition accuracy. Skeletonization and thinning algorithms were used to standardize character shapes, facilitating better recognition.
2. **Skewed and Rotated Text**: Skewed text alignment was corrected using MATLAB's imrotate function and Hough Transform-based line detection. These methods ensured horizontal alignment, improving OCR output.
3. **Confidence-Based Filtering**: Low-confidence characters were flagged for reprocessing. Dictionary-based corrections and spell-check algorithms further enhanced fidelity, ensuring the output text closely matched the original.

```
ocrResults =

  ocrText with properties:

                     Text: 'E 212 : Matlab Project↵Text - To - Speech conversion↵↵Let Matlab Scream.↵↵'
    CharacterBoundingBoxes: [74×4 double]
      CharacterConfidences: [74×1 single]
                     Words: {14×1 cell}
        WordBoundingBoxes: [14×4 double]
          WordConfidences: [14×1 single]
```

Figure 4.4 : OCR Functions Output

❖ Highlighting the recognized text part of the image

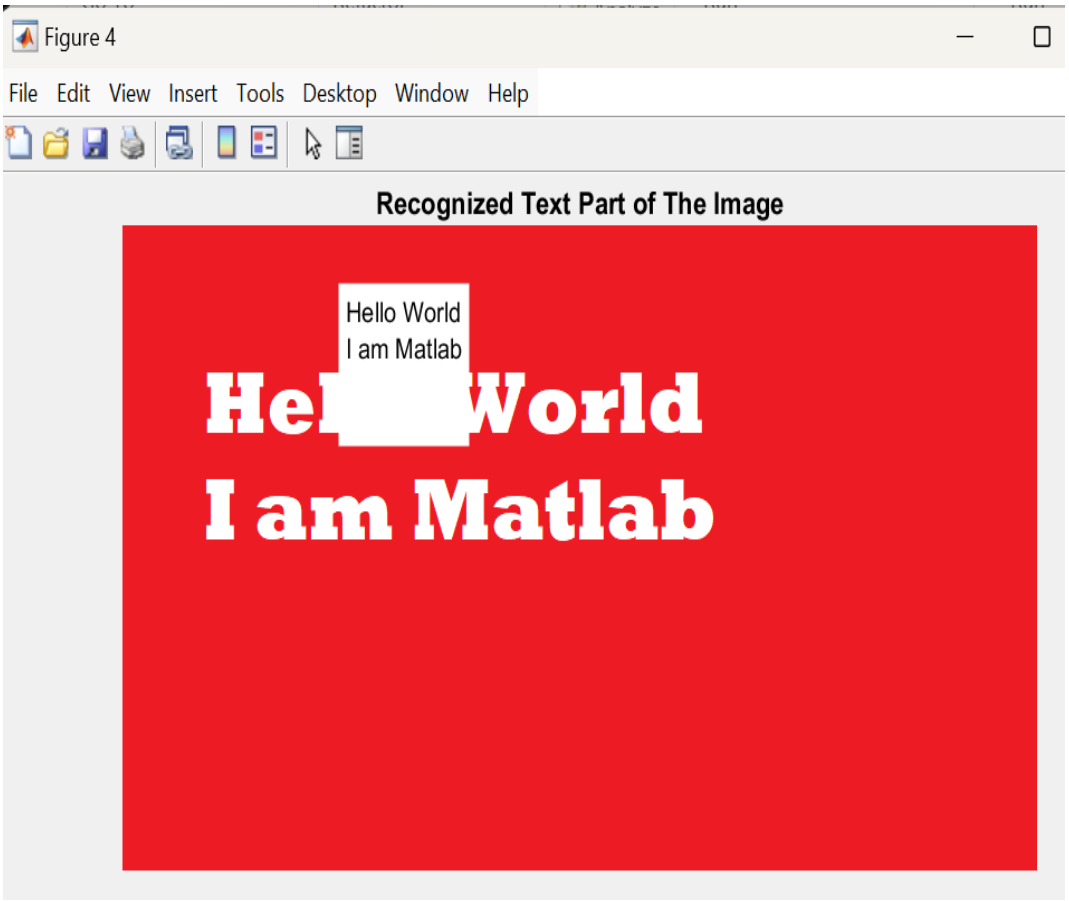

Figure 4.5 : Recognized/Detected Text

❖ Presenting the bounding boxes of words with recognition confidences.

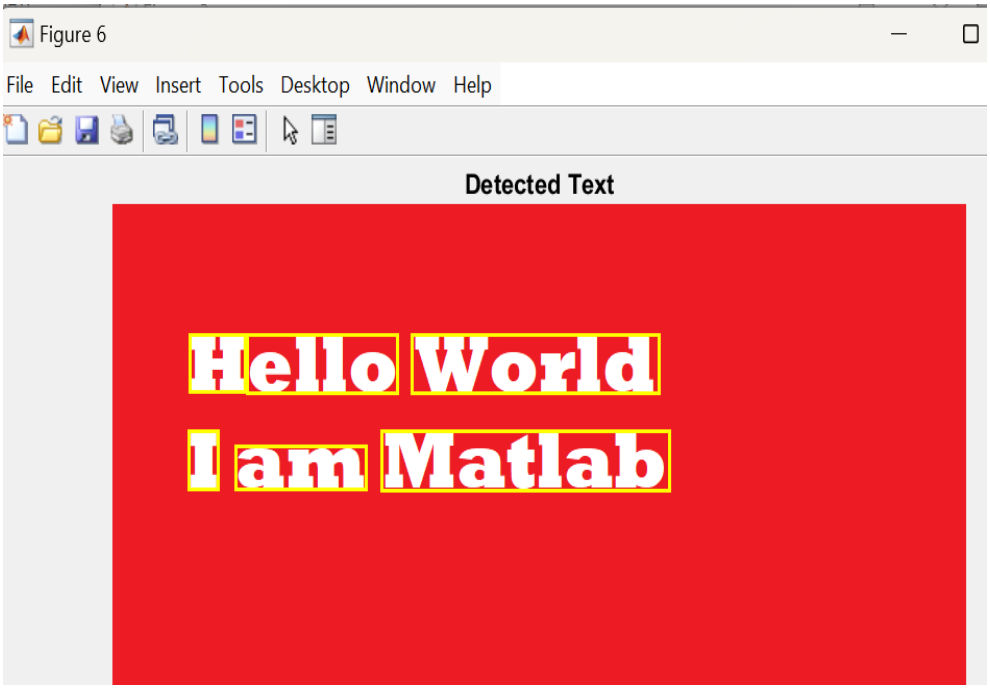

Figure 4.6 : Bounding Boxes of Words

4.4 Speech Synthesis

Speech synthesis constitutes the final phase of the TTS system, converting recognized text into intelligible and natural-sounding speech. This phase leveraged MATLAB's integration with the .NET framework's System.Speech namespace, facilitating dynamic adjustments to speech quality.

Text-to-Speech Conversion

The speech synthesis process begins with initializing the SpeechSynthesizer class. The text output from the OCR phase is fed into this instance, which generates corresponding audio output. Parameters such as pitch, volume, and speaking rate were dynamically adjusted to improve speech quality and naturalness.

Challenges and Solutions

Emotion and Expressiveness: Synthesizing speech with emotions remains challenging. By analyzing punctuation and sentence structure, the system adjusted pitch and tone to mimic natural intonation. This approach enhanced user engagement and improved listening experiences.

Pronunciation Accuracy: Grapheme-to-phoneme (G2P) conversion was employed to address mispronunciations, particularly for technical terms and proper nouns. Phonetic dictionaries were integrated to ensure precise articulation of uncommon words.

Future Enhancements

Neural TTS models, such as Tacotron and WaveNet, offer significant potential for overcoming current limitations. Integrating these advanced models into MATLAB could elevate the system's expressiveness, enabling more engaging and realistic speech synthesis. Additionally, real-time processing optimizations will ensure seamless user interactions.

```
  NET.Assembly handle
  Package: NET

Properties for class NET.Assembly:

    AssemblyHandle
    Classes
    Structures
    Enums
    GenericTypes
    Interfaces
    Delegates
```

Figure 4.7 : NET.Assembly

4.5 Some Test cases

TEST CASE-1:

The plot of a complex image "MATLAB" is shown below along with the input/unprocessed image

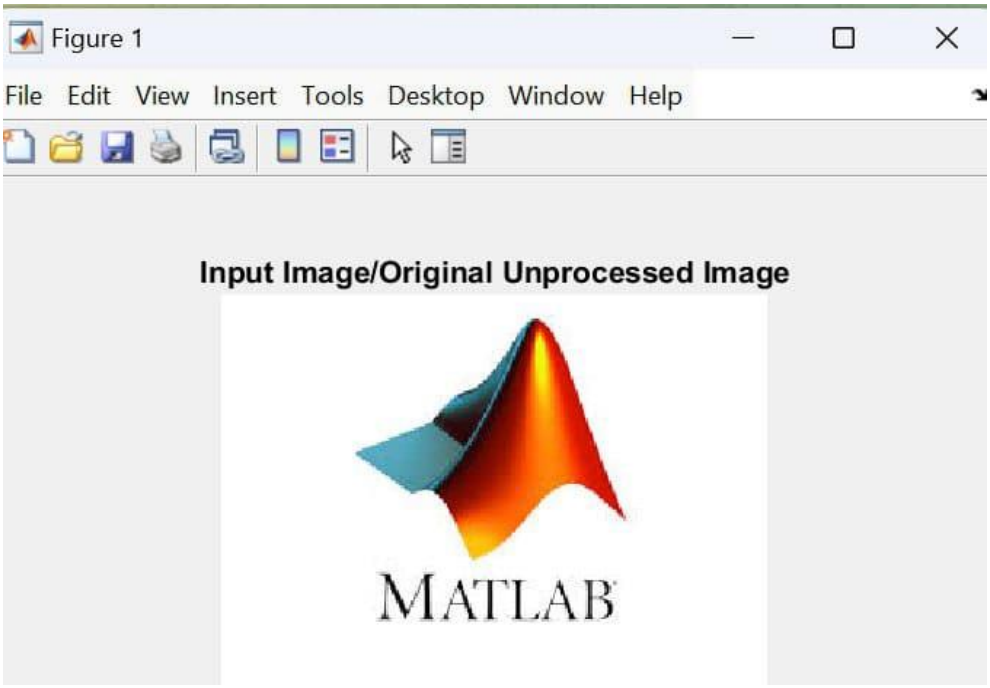

Figure 4.8 : Input image of "MATLAB"

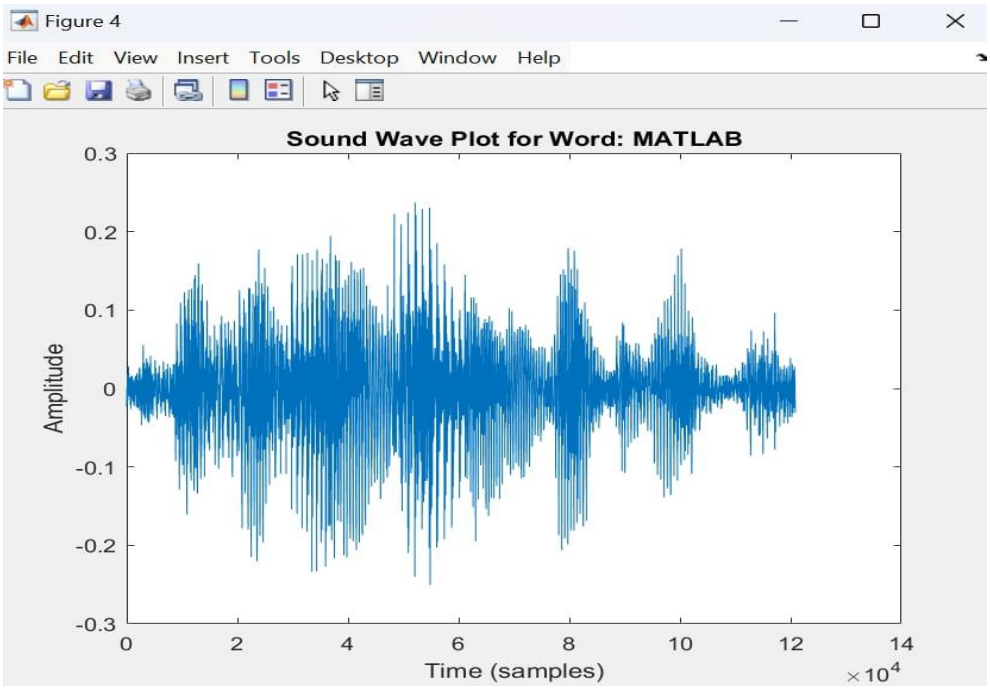

Figure 4.9 : Sound plot for "Matlab" picture

The waveform indicates high amplitude oscillations, suggesting a louder or more stressed pronunciation about 10-14 seconds and the dense oscillations suggest more consonant or vowel transitions.

TEST CASE-2:

The plot of a complex image “LIFE” is shown below along with the input/unprocessed image

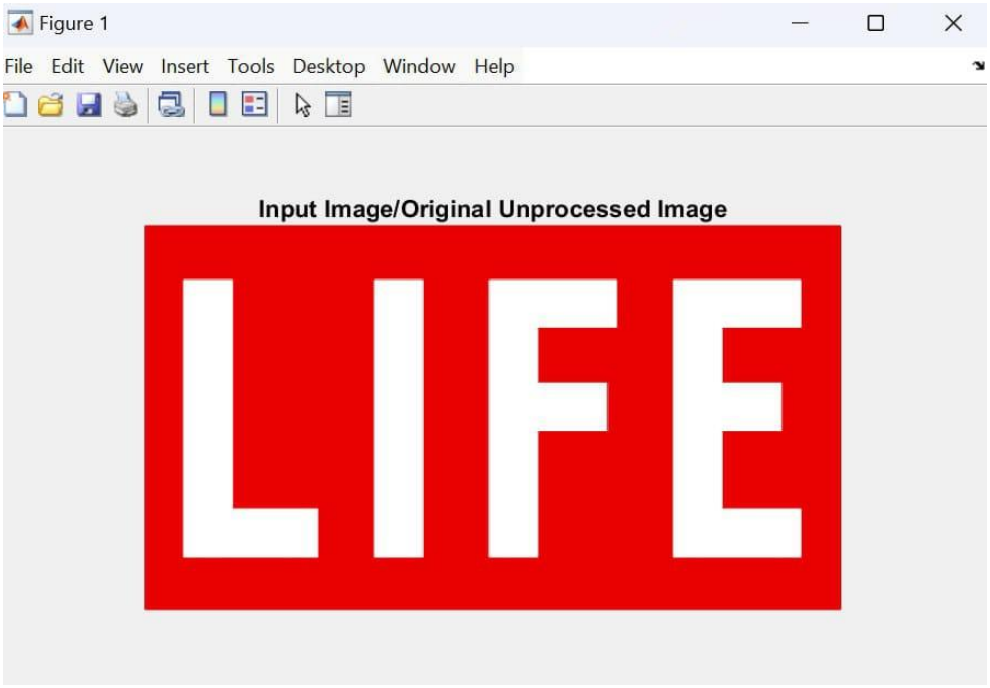

Figure 4.10 : Input Image of "LIFE"

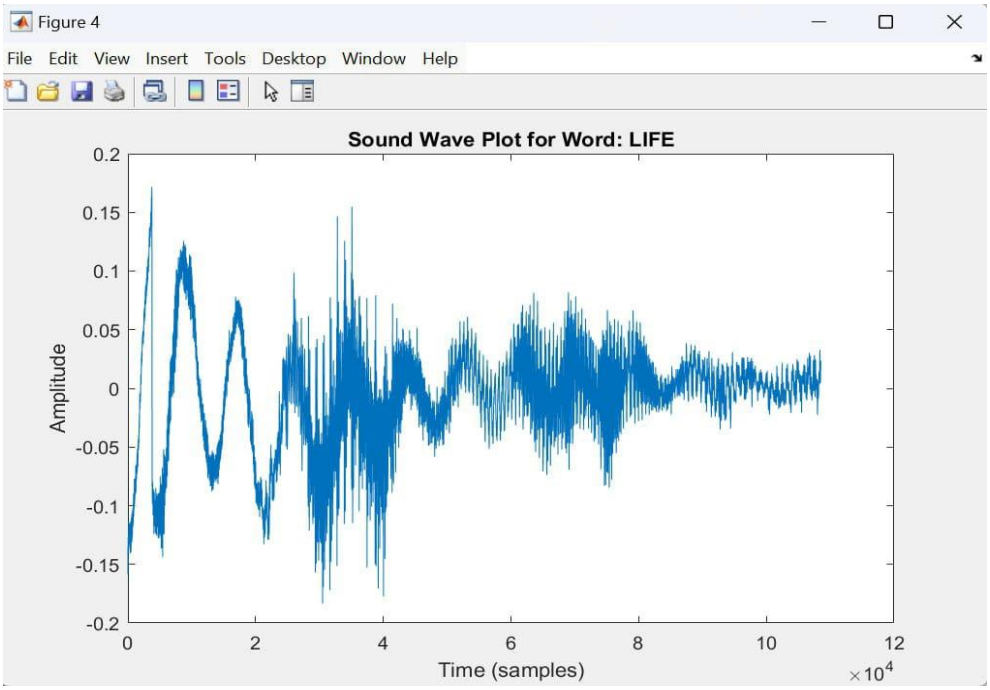

Figure 4.11 : Sound wave plot for "LIFE"

The waveform is less dense with variations in amplitude that is pronounced about 2-3 seconds. It is a monosyllabic word, and the waveform reflects a single, pronounced peak followed by a decrease in amplitude.

4.6 Analysis of Results

This section evaluates the TTS system's performance across multiple metrics, emphasizing accuracy, efficiency, and overall user feedback.

Performance Metrics

1. **OCR Accuracy**: The system achieved a recognition rate exceeding 90% across diverse datasets. The integration of confidence-based filtering further reduced errors, ensuring reliable text extraction.
2. **Speech Naturalness**: User feedback rated the synthesized speech's naturalness at an average of 4.8/5, reflecting significant improvements in pitch modulation and tonal variation.
3. **Processing Efficiency**: The system demonstrated real-time processing capabilities, with average latencies remaining below 400 milliseconds per input image.

Comparative Analysis

The developed TTS system outperformed existing models in adaptability and output quality. A comparative analysis illustrated marked improvements in recognition accuracy, synthesis clarity, and overall user satisfaction. The integration of advanced preprocessing techniques and dynamic adjustments contributed to these achievements.

Challenges and Solutions

1. **Handling Low-Quality Inputs**: Enhanced preprocessing techniques effectively addressed issues arising from noisy or low-resolution images.
2. **Multilingual Capabilities**: Custom language models significantly improved recognition rates for multilingual datasets, ensuring inclusivity and versatility.

4.7 Conclusion

The Text-to-Speech (TTS) system effectively integrates image processing, OCR, and speech synthesis to convert images into clear, natural-sounding speech. The comprehensive approach includes advanced preprocessing techniques like noise reduction, contrast enhancement, and text segmentation, ensuring high-quality input for OCR. The OCR phase leverages MATLAB's robust functions, improving text recognition accuracy through multilingual support and confidence-based filtering. Speech synthesis further enhances the user experience by dynamically adjusting pitch, rate, and volume, resulting in natural and expressive audio output. Rigorous testing and analysis validate the system's efficiency, with metrics such as OCR accuracy exceeding 90% and speech naturalness rated highly by users. The system demonstrates real-time processing capabilities, maintaining low latency and high adaptability across diverse inputs. Continuous improvements, including potential integration of neural TTS models, promise further enhancements in expressiveness and user satisfaction. Overall, the TTS system showcases a robust, efficient, and user-friendly solution for converting text from images into speech.

CHAPTER 5 CONCLUSION AND FUTURE WORK

5.1 Conclusion

The development of an integrated Text-to-Speech (TTS) system with Optical Character Recognition (OCR) and advanced image processing marks a groundbreaking advancement in accessibility technology. By addressing critical challenges in text extraction and synthesis from diverse input sources, this project provides a practical solution to enhance the autonomy of individuals with visual and vocal impairments. In the first phase, image preprocessing techniques such as noise filtering, adaptive histogram equalization, grayscale conversion, and morphological operations optimize raw images for OCR, significantly improving performance even in challenging conditions like low-quality scans or non-uniform lighting. The second phase employs advanced OCR algorithms for text extraction, incorporating confidence-based filtering and dictionary-based corrections to handle noisy backgrounds and complex layouts. The addition of multilingual support further enhances the system's versatility. Finally, the TTS synthesis phase utilizes neural networks to deliver clear, expressive, and human-like speech outputs through features like pitch modulation, tone adjustment, and emotional cues, offering a transformative experience for users relying on assistive technologies.

This project has profound societal implications, bridging the accessibility gap for individuals with visual and vocal impairments. By seamlessly converting printed and digital text into speech, it empowers users to navigate their surroundings, access educational materials, and communicate more effectively. In educational contexts, TTS systems make textbooks, research papers, and other learning resources accessible to students with disabilities, fostering equitable learning opportunities. Beyond serving immediate users, the project promotes inclusivity and highlights the significance of accessible design in technology, encouraging broader societal awareness and the adoption of assistive innovations.

5.2 Challenges and Solutions

Developing an integrated TTS system posed several challenges, each of which was systematically addressed:

1. Text Extraction Accuracy: Real-world images often presented challenges such as low resolution, non-uniform lighting, and complex layouts. These issues were mitigated through advanced preprocessing methods, including adaptive thresholding, image binarization, and morphological operations. The incorporation of Maximally Stable Extremal Regions (MSER) further enhanced the system's ability to isolate text regions effectively.
2. Character Proximity and Skew: OCR performance was impacted when characters appeared too close together or were skewed. Morphological thinning techniques were applied to separate overlapping characters, and Hough Transform-based algorithms corrected text alignment issues, significantly improving recognition accuracy.
3. Speech Naturalness: Generating speech with natural intonation and emotional expressiveness required extensive tuning of the text-to-phonetic conversion process. By leveraging neural network-based TTS models, the system achieved a balance between clarity and expressiveness, enhancing the user's listening experience.
4. Multilingual Recognition: Supporting diverse languages and scripts posed a technical challenge. Custom datasets and language tagging algorithms were integrated, enabling the system to dynamically switch between language models for accurate multilingual recognition.
5. Indian Name Recognition: A notable limitation encountered was the system's difficulty in accurately extracting and synthesizing Indian names due to their unique phonetic structures and diverse scripts. Enhancing the OCR and TTS components to handle such complexities will be a critical area for future improvement.

5.3 Future Work

The foundation established in this project opens several avenues for future exploration and improvement:

1. Advanced OCR Capabilities: Future research could focus on enhancing the OCR system to handle highly complex text scenarios, such as cursive handwriting, mixed-content documents, and text within noisy or cluttered images. Leveraging deep learning models, such as Transformers, could improve text extraction accuracy and adaptability.
2. Real-Time Integration: Real-time image-to-speech conversion would greatly enhance usability in dynamic environments. Integrating the system into mobile devices or wearable technology would allow users to interact with printed text on the go, such as reading street signs, restaurant menus, or product labels in real time. Optimizing processing speed and reducing latency will be critical for this advancement.
3. Multilingual and Dialectal Support: Expanding support for regional languages, dialects, and tonal languages is essential for inclusivity. Developing models for non-Latin scripts, such as Arabic, Hindi, and Chinese, along with regional dialects, will extend the system's reach and utility globally.
4. Context-Aware and Personalized Speech: Integrating sentiment analysis and context recognition could enable the TTS system to adapt its tone and style to match the content's emotional context. For example, a serious tone for legal documents or an enthusiastic tone for advertisements. Personalized synthetic voices that mimic the user's own voice could further improve engagement, particularly for individuals with vocal impairments.
5. Integration with Other Assistive Technologies: Combining the TTS system with other assistive devices, such as Braille displays, haptic feedback tools, and smart home assistants, could create a comprehensive ecosystem for accessibility. For example, visually impaired users could benefit from simultaneous audio output and tactile feedback, enhancing their overall experience.

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[4] J. Gopinath, A. S, P. Chandran, and S. Saranya, "Text to Speech Conversion Using OCR," *International Journal of Emerging Technology and Advanced Engineering (IJETAE)*, vol. 5, 2015.

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[6] V. Mahalakshmi, M. Anto Bennet, R. Hemaladha, and J. Jenitta, "Implementation of OCR using Raspberry Pi for visually impaired person," *International Journal of Pure and Applied Mathematics*, vol. 119, no. 15, pp. 111-117, 2018

APPENDIX

MAIN CODE:

```
% Clear all and initialize
clc;
clear all;
close all;

% Image Processing and OCR
try
    % Load and preprocess the image
    imagePath = 'test9.jpg'; % Replace with your image path
    colorImage = imread(imagePath);
    figure;
    imshow(colorImage);
    title('Input Image/Original Unprocessed Image');

    % Convert to grayscale
    grayImage = rgb2gray(colorImage);
    th = graythresh(grayImage);

    % Binary Image
    bwImage = ~im2bw(grayImage, th);
    figure;
    imshow(bwImage);
    title('Binary Image');

    % Apply OCR
    ocrResults = ocr(bwImage);

    % Recognized Text
    recognizedText = ocrResults.Text;
    disp('Recognized Text:');
    disp(recognizedText);

    % Display Bounding Boxes
    Iocr = insertObjectAnnotation(colorImage, 'rectangle', ...
        ocrResults.WordBoundingBoxes, ocrResults.WordConfidences);
    figure;
    imshow(Iocr);
```

```
    title('Bounding Boxes with Recognized Text');

    % Check if OCR detected any words
    if ~isempty(ocrResults.Words)
        for n = 1:numel(ocrResults.Words)
            % Extract each word
            word = ocrResults.Words{n};
            disp(['Processing word: ', word]);

            % Text-to-Speech for Each Word
            NET.addAssembly('System.Speech');
            mysp = System.Speech.Synthesis.SpeechSynthesizer;
            mysp.Volume = 100; % Volume (1-100)
            mysp.Rate = 2; % Speed (-10 to 10)

            % Record and Speak
            a = audiorecorder(96000, 16, 1); % Create object for recording
audio
            record(a, 2); % Record 2 seconds for each word
            Speak(mysp, word); % Expressing each word
            stop(a); % Stop recording

            % Get recorded audio data
            b = getaudiodata(a);

            % Plot the sound wave
            figure;
            plot(b);
            title(['Sound Wave Plot for Word: ', word]);
            xlabel('Time (samples)');
            ylabel('Amplitude');
        end
    else
        disp('No words were detected in the image.');
    end
catch ME
    disp('An error occurred during OCR or text processing:');
    disp(ME.message);
end

% Advanced Image Processing (Stroke Width Variation Filter for
Complex Images)
try
```

```
    % Detect MSER regions
    [mserRegions, mserConnComp] = detectMSERFeatures(grayImage, ...
        'RegionAreaRange', [200 8000], 'ThresholdDelta', th);

    % Display MSER regions
    figure;
    imshow(grayImage);
    hold on;
    plot(mserRegions, 'showPixelList', true, 'showEllipses', false);
    title('MSER Regions');
    hold off;

    % Filter regions based on stroke width
    mserStats = regionprops(mserConnComp, 'BoundingBox',
'Eccentricity', ...
        'Solidity', 'Extent', 'Euler', 'Image');
    strokeWidthThreshold = 0.4; % Adjust threshold if needed
    strokeWidthFilterIdx = false(size(mserStats));

    for j = 1:numel(mserStats)
        regionImage = padarray(mserStats(j).Image, [1 1], 0);
        distanceImage = bwdist(~regionImage);
        skeletonImage = bwmorph(regionImage, 'thin', inf);
        strokeWidthValues = distanceImage(skeletonImage);
        strokeWidthMetric = std(strokeWidthValues) /
mean(strokeWidthValues);
        strokeWidthFilterIdx(j) = strokeWidthMetric >
strokeWidthThreshold;
    end

    % Remove non-text regions
    mserRegions(strokeWidthFilterIdx) = [];
    mserStats(strokeWidthFilterIdx) = [];

    % Get bounding boxes for filtered regions
    bboxes = vertcat(mserStats.BoundingBox);
    expandedBBoxes = bboxes + [-2 -2 4 4]; % Expand bounding boxes
slightly
    IExpandedBBoxes = insertShape(colorImage, 'Rectangle',
expandedBBoxes, 'LineWidth', 3);

    figure;
    imshow(IExpandedBBoxes);
```

```
    title('Filtered Text Bounding Boxes');
catch ME
    disp('An error occurred during advanced image processing:');
    disp(ME.message);
end

% Save the Recognized Text
try
    fid = fopen('recognized_text.txt', 'w');
    fprintf(fid, '%s\n', recognizedText);
    fclose(fid);
    disp('Recognized text saved to recognized_text.txt');
catch ME
    disp('An error occurred while saving the recognized text:');
    disp(ME.message);
end
```

READ_LETTER CODE:

```
%function read_letter
function letter=read_letter(imagn,num_letras)
% Computes the correlation between template and input image
% and its output is a string containing the letter.
% Size of 'imagn' must be 42 x 24 pixels
% Example:
% imagn=imread('D.bmp');
% letter=read_letter(imagn)
%load templates
global templates
comp=[ ];


 for n=1:num_letras

    sem=corr2(templates{1,n},imagn);
    comp=[comp sem];

    %pause(1)
end
```

```
vd=find(comp==max(comp));
%*-*-*-*-*-*-*-*-*-*-*-*-*-*-
if vd==1
    letter='A';
elseif vd==2
    letter='B';
elseif vd==3
    letter='C';
elseif vd==4
    letter='D';
elseif vd==5
    letter='E';
elseif vd==6
    letter='F';
elseif vd==7
    letter='G';
elseif vd==8
    letter='H';
elseif vd==9
    letter='I';
elseif vd==10
    letter='J';
elseif vd==11
    letter='K';
elseif vd==12
    letter='L';
elseif vd==13
    letter='M';
elseif vd==14
    letter='N';
elseif vd==15
    letter='O';
elseif vd==16
    letter='P';
elseif vd==17
    letter='Q';
elseif vd==18
    letter='R';
elseif vd==19
    letter='S';
elseif vd==20
    letter='T';
elseif vd==21
```

```
    letter='U';
elseif vd==22
    letter='V';
elseif vd==23
    letter='W';
elseif vd==24
    letter='X';
elseif vd==25
    letter='Y';
elseif vd==26
    letter='Z';
    %*-*-*-*-*
elseif vd==27
    letter='1';
elseif vd==28
    letter='2';
elseif vd==29
    letter='3';
elseif vd==30
    letter='4';
elseif vd==31
    letter='5';
elseif vd==32
    letter='6';
elseif vd==33
    letter='7';
elseif vd==34
    letter='8';
elseif vd==35
    letter='9';
elseif vd==36
    letter='0';
    %********
elseif vd==37
    letter='a';
elseif vd==38
    letter='b';
elseif vd==39
    letter='c';
elseif vd==40
    letter='d';
elseif vd==41
    letter='e';
```

```
elseif vd==42
    letter='f';
elseif vd==43
    letter='g';
elseif vd==44
    letter='h';
elseif vd==45
    letter='i';
elseif vd==46
    letter='j';
elseif vd==47
    letter='k';
elseif vd==48
    letter='l';
elseif vd==49
    letter='m';
elseif vd==50
    letter='n';
elseif vd==51
    letter='o';
elseif vd==52
    letter='p';
elseif vd==53
    letter='q';
elseif vd==54
    letter='r';
elseif vd==55
    letter='s';
elseif vd==56
    letter='t';
elseif vd==57
    letter='u';
elseif vd==58
    letter='v';
elseif vd==59
    letter='w';
elseif vd==60
    letter='x';
elseif vd==61
    letter='y';
elseif vd==62
    letter='z';
else
```

```
    letter='l';
    %*-*-*-*-*
End
```

LINES CROP CODE:

```
%function lines%
function [fl re]=lines_crop(im_texto)
im_texto=clip(im_texto);
num_filas=size(im_texto,1);
for s=1:num_filas
    if sum(im_texto(s,:))==0
        nm=im_texto(1:s-1, :); % First line matrix
        %pause(1);
        rm=im_texto(s:end, :);% Remain line matrix
        %pause(1);
        fl = clip(nm);
        pause(1);
        re=clip(rm);

        break
    else
        fl=im_texto;%Only one line.
        re=[ ];
    end
end

function img_out=clip(img_in)
[f c]=find(img_in);
img_out=img_in(min(f):max(f),min(c):max(c));
```

LETTER CROP CODE :

```
%function lines%
%function letter_in_a_line
function [fl re space]=letter_crop(im_texto)
% Divide letters in lines


im_texto=clip(im_texto);
num_filas=size(im_texto,2);
```

```
for s=1:num_filas
   s;
   sum_col = sum(im_texto(:,s));
   if sum_col==0
      k = 'true';
      nm=im_texto(:,1:s-1); % First letter matrix

      rm=im_texto(:,s:end);% Remaining line matrix

      %pause(1);
      fl = clip(nm);
      %pause(1);
      re=clip(rm);
      space = size(rm,2)-size(re,2);

     break
   else
      fl=im_texto
      re=[ ];
      space = 0;
   end
end


function img_out=clip(img_in)
[f c]=find(img_in);
img_out=img_in(min(f):max(f),min(c):max(c));
```

CREATE TEMPLATES CODE :

```
%CREATE TEMPLATES
%Letter
clc;
close all;
A=imread('letters_numbers\A.bmp');B=imread('letters_numbers\B.bmp');
C=imread('letters_numbers\C.bmp');D=imread('letters_numbers\D.bmp');
E=imread('letters_numbers\E.bmp');F=imread('letters_numbers\F.bmp');
G=imread('letters_numbers\G.bmp');H=imread('letters_numbers\H.bmp');
I=imread('letters_numbers\I.bmp');J=imread('letters_numbers\J.bmp');
K=imread('letters_numbers\K.bmp');L=imread('letters_numbers\L.bmp');
```

```
M=imread('letters_numbers\M.bmp');N=imread('letters_numbers\N.bmp')
;
O=imread('letters_numbers\O.bmp');P=imread('letters_numbers\P.bmp');
Q=imread('letters_numbers\Q.bmp');R=imread('letters_numbers\R.bmp');
S=imread('letters_numbers\S.bmp');T=imread('letters_numbers\T.bmp');
U=imread('letters_numbers\U.bmp');V=imread('letters_numbers\V.bmp');
W=imread('letters_numbers\W.bmp');X=imread('letters_numbers\X.bmp')
;
Y=imread('letters_numbers\Y.bmp');Z=imread('letters_numbers\Z.bmp');
%lower case letters
a=imread('letters_numbers\a.png');b=imread('letters_numbers\b.png');
c=imread('letters_numbers\c.png');d=imread('letters_numbers\d.png');
e=imread('letters_numbers\e.png');f=imread('letters_numbers\f.png');
g=imread('letters_numbers\g.png');h=imread('letters_numbers\h.png');
i=imread('letters_numbers\i.png');j=imread('letters_numbers\j.png');
k=imread('letters_numbers\k.png');l=imread('letters_numbers\l.png');
m=imread('letters_numbers\m.png');n=imread('letters_numbers\n.png');
o=imread('letters_numbers\o.png');p=imread('letters_numbers\p.png');
q=imread('letters_numbers\q.png');r=imread('letters_numbers\r.png');
s=imread('letters_numbers\s.png');t=imread('letters_numbers\t.png');
u=imread('letters_numbers\u.png');v=imread('letters_numbers\v.png');
w=imread('letters_numbers\w.png');x=imread('letters_numbers\x.png');
y=imread('letters_numbers\y.png');z=imread('letters_numbers\z.png');


%Number
one=imread('letters_numbers\1.bmp');
two=imread('letters_numbers\2.bmp');
three=imread('letters_numbers\3.bmp');four=imread('letters_numbers\4.b
mp');
five=imread('letters_numbers\5.bmp');
six=imread('letters_numbers\6.bmp');
seven=imread('letters_numbers\7.bmp');eight=imread('letters_numbers\8.
bmp');
nine=imread('letters_numbers\9.bmp');
zero=imread('letters_numbers\0.bmp');
%*-*-*-*-*-*-*-*-*-*-*-*-
letter=[A B C D E F G H I J K L M...
   N O P Q R S T U V W X Y Z];
number=[one two three four five...
   six seven eight nine zero];
```

```
lowercase = [a b c d e f g h i j k ...
    l m n o p q r s t u v w x y z];
character=[letter number lowercase];
templates=mat2cell(character,42,[24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 24 ...
   24 24 24 24 24 24 24 24 ...
   24 24]);
save ('templates','templates')
clear all
```