

Vocalnet: Revolutionizing Voice-Enabled Email For The Visually Impaired With Machine Learning And Iot Synergy

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ABSTRACT

Introduction: This paper introduces VocalNet, an innovative solution designed to enhance voice-based email accessibility for visually impaired users by integrating Machine Learning (ML) and Internet of Things (IoT) technologies

Objectives: This work presents a VocalNet utilizes advanced ML algorithms to empower robust speech recognition and natural language processing capabilities, enabling the system to understand and execute complex voice commands accurately. Simultaneously, IoT technology is leveraged to interconnect various devices and platforms, ensuring a seamless user experience across different environments. The primary goal of VocalNet is to address and overcome the limitations of existing voice-based email systems by providing higher accuracy, quicker response times, and a more intuitive interaction process. By deep learning techniques and networked devices, VocalNet not only recognizes spoken language but also adapts to individual user preferences and environmental contexts, thus significantly enhancing usability for visually impaired individuals. Initial testing of VocalNet has shown promising results in terms of both functionality and user satisfaction.

Methods: This article will detail the architecture of VocalNet, the integration of ML and IoT, and the potential implications of this technology in improving digital accessibility for the visually impaired community., Forebody and afterbody, Next keyword, Projectile, Supersonic speed.

Results: The system demonstrates considerable improvements in command recognition accuracy and operational speed, marking a substantial advancement over traditional voice operated email applications.

Conclusions: This email system is designed to be user-friendly and accessible to people of all ages. It features

both speech-to-text and text-to-speech capabilities, making it suitable for visually impaired individuals

Keywords: VocalNet, IoT, Machine Learning, Natural Language Processing, Deep Learning Techniques

1. INTRODUCTION

The intersection of Machine Learning (ML) and the Internet of Things (IoT) here are significant advancements in digital accessibility technologies, particularly for the visually impaired. Voice-enabled interfaces, crucial for enhancing the autonomy of such users, often encounter limitations in precision, adaptability, and integration with diverse digital ecosystems. VocalNet is a ground-breaking system designed to address these challenges by harnessing the synergistic potential of ML and IoT to refine and revolutionize voice-enabled email services for visually impaired individuals. At the core of VocalNet is a sophisticated suite of ML algorithms, including deep neural networks (DNNs) and convolutional neural networks (CNNs), which enhance speech recognition capabilities and natural language understanding. These models are trained on large datasets encompassing a variety of accents, dialects, and colloquialisms to ensure high accuracy and low latency in voice command interpretation. Additionally, VocalNet incorporates state-of-the-art natural language processing (NLP) techniques to facilitate a more intuitive and conversational user experience. IoT technology plays a pivotal role in extending the functionality of VocalNet beyond the confines of traditional voice-responsive systems. By integrating smart devices and sensors, VocalNet offers a seamless and interactive experience across multiple platforms and environments.

This IoT integration not only enables real-time data synchronization and system responsiveness but also ensures that user interactions are context-aware and personalized according to individual preferences and environmental variables. This paper aims to articulate the technical architecture of VocalNet, detailing the integration of advanced ML algorithms and IoT infrastructure to create a robust, scalable, and user-friendly voice-enabled email system. We will explore the specific technical challenges inherent in designing for visually impaired users and how VocalNet's innovative approach provides a solution that significantly improves both the efficacy and the usability of voice-activated systems. Preliminary evaluations demonstrate VocalNet's capability to transform the landscape of accessibility technologies, offering new avenues for independence and digital interaction for visually impaired users. For this purpose, below is how to five widely used projectile shapes are investigated. The geometry and full dimensions of these projectile shapes are shown in Figure 1. The supersonic Mach number range considered is from 1.6 to 5 for zero-angle of attack.

2. LITERATURE REVIEW

The integration of machine learning (ML) and Internet of Things (IoT) technologies have significantly propelled advancements in voice-based accessibility solutions for visually impaired users. AI-powered voice bots have improved interface accessibility, facilitating information access and device navigation for impaired or elderly users [1]. IoT-driven innovations, such as refreshable OCR-Braille systems, have autonomously delivered essential information, bolstering independence among individuals with visual impairments [2].

Furthermore, AI enhancements have allowed visually impaired individuals to navigate computers and devices via voice commands, significantly reducing the interaction barrier [3]. Voice-activated technologies are increasingly prevalent in various sectors, including smart home automation and financial services, where they offer voice-controlled interfaces that improve accessibility and independence for individuals with disabilities [4][5].

Notably, applications like Microsoft's Seeing AI app have made strides in narrating visual information to visually impaired users, thus making the world more accessible [6]. Additionally, AI-based voice assistants designed for the elderly employ advanced NLP, ML, and speech recognition technologies to process requests and ensure effective communication, enhancing mobility and safety [9].

In smart buildings, the integration of IoT sensors and voice-activated control systems has improved accessibility, showcasing the potential of these technologies to make workplaces more inclusive for visually impaired employees [10]. An assistive technology solution for visually impaired individuals. By leveraging Internet of Things (IoT), Machine Learning, and Embedded Technologies, the system aims to help visually impaired individuals move independently from one place to another without relying on others [11].

A systematic review on the current state of assistive systems for visually impaired individuals. Focusing on product recognition, particularly in grocery stores and similar environments, the paper analysed the efficiency and economy of hardware resources used in Computer Vision and Machine Learning techniques over independently from one place to another without relying on others[12]. And intelligent system that integrates machine learning, image processing, and IoT for support, including haptic feedback. This system aims to assist visually impaired individuals in recognizing and interacting with their surroundings.

Research Gaps: Despite these advancements, several drawbacks and gaps remain in the current landscape of voice-based accessibility technologies:

1. **Limited Contextual Awareness:** Many systems still lack the deep contextual understanding needed to fully interpret the nuanced requests of users, especially in dynamic and unstructured environments. This limits the utility of voice-based systems in situations that deviate from standard usage scenarios.

2. **Interoperability Issues:** The integration across different devices and platforms often presents challenges, as many existing systems are not designed to function seamlessly with others. This lack of interoperability can hinder the user experience, making it difficult for users to have a consistent and reliable interaction across different IoT devices and environments.

3. **Privacy and Security Concerns:** As voice-based systems often require continuous audio monitoring and data collection, there are significant concerns regarding user privacy and data security. Current solutions may not sufficiently address these issues, posing risks to users' sensitive information.

4. **Adaptation to Diverse User Needs:** While significant improvements have been made, the adaptation of voice-based systems to the varied needs of a diverse user population is still inadequate. Customization options are often limited, which can restrict usability for users with unique requirements or those in non-standard environments.

5. **Reliability and Error Rates:** Although advancements have been made in speech recognition accuracy, error rates remain a concern, especially in noisy environments or for users with atypical speech patterns. The reliability of voice-activated systems under different conditions is a critical area for further research and improvement.

These identified gaps underscore the need for proposed model to develop more sophisticated, secure, and user-centric voice-based accessibility solutions. Addressing these issues will not only enhance the functionality and inclusivity of these technologies but also improve the overall independence and quality of life for visually impaired users.

Research Scope: This research introduces a VocalNet seeks to transform the landscape of digital accessibility for the visually impaired by creating a voice-enabled email system that leverages machine learning and IoT integration for unparalleled user experience.

3. PROPOSED METHODS

This proposed system aims to enhance interaction accuracy, contextual understanding, and seamless device interconnectivity, focusing on the needs of visually impaired users in Figure 1.

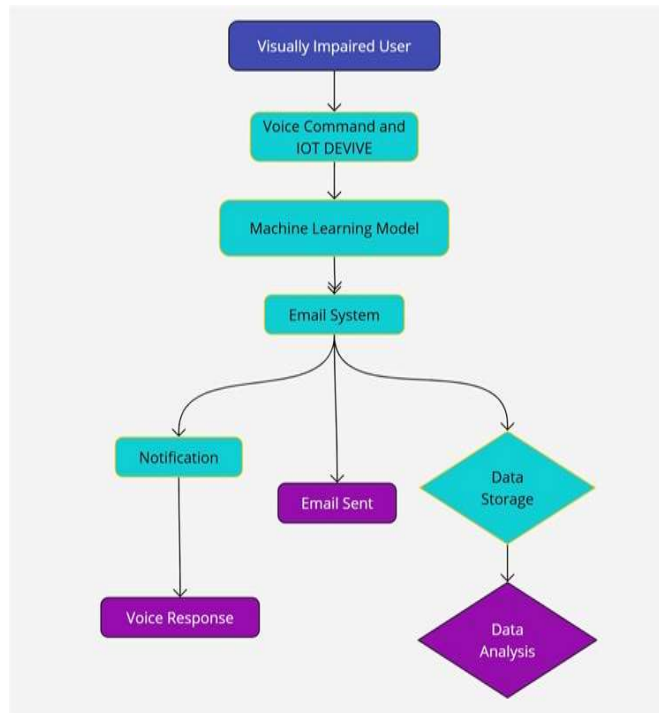


Figure 1 Architecture of voice-based email system

3.1 Adaptive Speech Recognition

3.1.1 Hybrid Deep Learning Model Convolutional Neural Networks (CNNs):

These networks are highly effective at extracting hierarchical features from spatial data. In the context of audio processing, CNNs can analyse spectrograms (visual representations of the spectrum of frequencies of sound as it varies with time) to detect patterns that correspond to different phonetic components. Recurrent Neural Networks (RNNs): RNNs are particularly suited for tasks where context and sequence are important. For speech recognition, RNNs (specifically LSTM - Long Short-Term Memory networks) can process audio signals over time, capturing the dynamic changes in speech patterns and enabling the model to understand temporal dependencies and manage long sequences of data[13-16].

3.1.2. Feature Extraction Spectrogram Analysis: Convert audio input into spectrograms to provide a 2D time-frequency representation. This transformation is crucial for CNNs to perform effective pattern recognition. Mel-Frequency Cepstral Coefficients (MFCCs): These coefficients are commonly used in speech recognition as features that effectively represent the short-term power spectrum of sound. They mimic the human auditory system's response more closely than raw audio frequencies.

3.1.3 Data Collection and Augmentation Diverse Dataset:

Collect a comprehensive dataset that includes a wide variety of accents, dialects, and speech anomalies. This dataset can be sourced from different regions and demographics to ensure diversity. Data Augmentation: Apply techniques like speed variation, volume adjustment, and adding background noise to the training data to simulate different listening conditions. This will help in enhancing the model's ability to generalize across various real-world scenarios[17-18].

3.1.4 Training and Validation Multi-stage Training:

Start with pre-training the CNN layers on spectrograms to recognize basic phonetic patterns and then fine-tune the combined CNN-RNN model on a sequence of such features to capture higher-level dependencies in speech. Cross-Validation: Use k-fold cross-validation to ensure that the model performs well across different subsets of the dataset, thereby verifying its robustness and generalizability in Figure 2.

3.1.5 Implementation Considerations Real-Time Processing:

Optimize the model for low latency to facilitate real-time voice command recognition, which is crucial for applications in interactive systems like virtual assistants. Noise Cancellation: Implement noise-reducing algorithms to filter out background disturbances that might affect the accuracy of speech recognition. Adaptation and Learning: Integrate a feedback system where the model can adapt and improve over time based on user corrections and new input data, making it more dynamic and personalized.

3.2 Contextual and Semantic Understanding

3.2.1 Semantic Understanding with BERT (Bidirectional Encoder Representations from Transformers)

- **BERT Overview:** BERT is a transformer-based machine learning technique for NLP pre-training developed by Google. It is designed to pre-train deep bidirectional representations from unlabelled text by jointly conditioning on both left and right context in all layers. This characteristic enables the model to capture a more nuanced understanding of language context

- **Pre-training:** BERT is first pre-trained on a large corpus of text in an unsupervised manner. This stage involves learning general language representations from tasks like masked language modelling (MLM) and next sentence prediction (NSP).

- **Fine-Tuning:** Once pre-trained, BERT can be fine-tuned with additional output layers to perform a wide array of NLP tasks such as question answering, language inference, and command processing. Fine-tuning involves training the BERT model on labeled data specific to the task, allowing it to adapt to the nuances of the domain-specific language.[19-22].

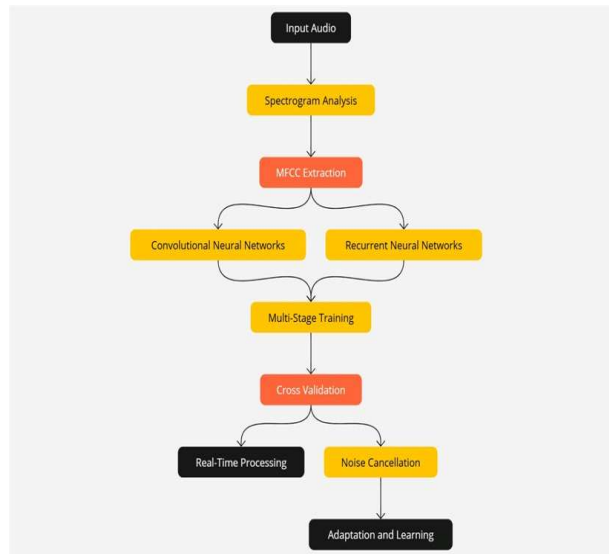


Figure 2 Multi-Stage Training and Cross Validation.

3.2.2 Context Awareness

- **Handling Context:** To enhance the model's ability to understand context, BERT utilizes its bidirectional training architecture. Unlike previous models that might train left-to-right or right-to-left, BERT's bidirectional approach allows it to integrate context from both directions, providing a fuller understanding of the sentence structure.
- **Extended Context:** For tasks requiring an understanding of broader document context (e.g., resolving references or using information from previous queries), techniques such as document embeddings or hierarchical attention mechanisms can be integrated to maintain and utilize broader contextual information over interactions.

3.2.3 Implementation Considerations

- **Integration with Existing Systems:** BERT-based models can be integrated into existing NLP pipelines to replace or augment components responsible for understanding language. This might include replacing older entity recognition systems or enhancing intent classification models.
- **Real-Time Processing:** Optimizing BERT for real-time applications is crucial, as the model architecture is computationally intensive. Techniques such as model quantization, pruning, and using distilled versions of BERT (like DistilBERT) can help reduce latency without a significant drop in performance [23].

3.2.4 Training and Validation

- **Domain-Specific Training Data:** Depending on the application, training data should include a variety of command types, dialects, and expressions to cover the scope of potential user interactions [24].
- **Evaluation Metrics:** Beyond standard accuracy, other metrics such as precision, recall, and F1-score for different categories of commands can provide a deeper insight into model performance. User satisfaction and response relevancy can also be critical metrics in Figure 3.

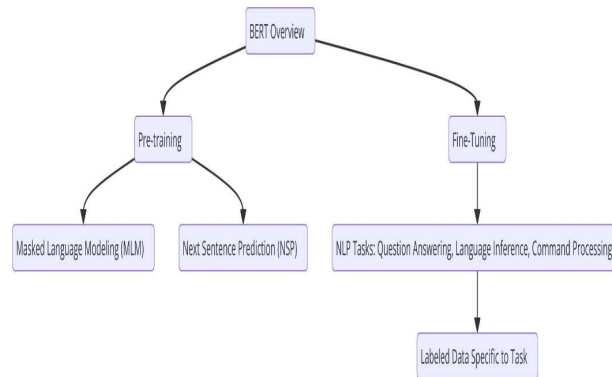


Figure 3 BERT Training and Validation.

Implementing BERT for enhancing semantic understanding and context awareness in a system designed to process complex instructions can significantly improve the interaction quality between users and AI systems. By leveraging its deep learning capabilities, the system can offer more accurate, context-aware responses, making it more effective and user-friendly for complex task handling.

3.4 IoT-Driven Integration

3.4.1 IoT Framework Development

- **Unified Device Communication:** Design a framework that standardizes how devices communicate, regardless of the manufacturer or operating system. Utilize common protocols like MQTT (Message Queuing Telemetry Transport) or CoAP (Constrained Application Protocol) to ensure that messages between devices are transmitted efficiently and securely.
- **Device Discovery and Registration:** Implement a system where new devices can be automatically discovered and integrated into the network using protocols such as mDNS (Multicast DNS) or SSDP (Simple Service Discovery Protocol). This facilitates ease of setup and scalability.

3.4.2. VocalNet Integration

- **Voice Recognition Module:** Incorporate advanced voice recognition technologies that can adapt to different accents and ambient noise levels, ensuring high accuracy in voice-to-text conversion across environments.
- **Natural Language Processing (NLP):** Develop or integrate a robust NLP engine that can understand and process complex voice commands related to email management, such as "Send an email to John," "Read my last email from Mary," or "Organize my inbox by priority."
- **Device-Specific Adaptations:** Customize the interaction models based on the device type. For example, interactions on a smartwatch might be brief due to screen size limitations, whereas a smart speaker might support more detailed interactions.

3.4.3. Email Management Capabilities

- **Integration with Email Services:** Develop APIs that allow VocalNet to interface with popular email services such as Gmail, Outlook, and Yahoo Mail. This integration should support all fundamental email actions, including sending, receiving, searching, and organizing emails.
- **User Authentication and Security:** Implement secure authentication mechanisms for accessing email services, ensuring data encryption during transmission and adherence to privacy standards like GDPR or HIPAA where applicable.

3.4.4. Cross-Device Synchronization

- **Real-Time Sync:** Ensure that all actions taken on one device are immediately reflected on all other connected devices. This requires a robust backend that can handle real-time data synchronization across a network.

- Context Preservation: Maintain context across devices, so if a user starts composing an email via a smart speaker and moves to a smartphone, the draft and context follow seamlessly.

3.4.5. User Interface and Experience

- Adaptive Interfaces: Design adaptive user interfaces suitable for various devices, from smartwatches and smartphones to smart displays and speakers. Voice responses should be tailored to the device’s primary interface method.
- Feedback Mechanisms: Incorporate auditory and visual feedback mechanisms that confirm actions to the user, enhancing the interaction experience and reducing errors.

The development of an IoT framework for VocalNet to manage email via voice commands requires a comprehensive approach that includes advanced voice recognition, device interoperability, secure data handling, and user-centered design. By achieving this, VocalNet can provide a seamless, efficient, and secure email management experience across various smart devices, enhancing productivity and accessibility for users in Figure4.

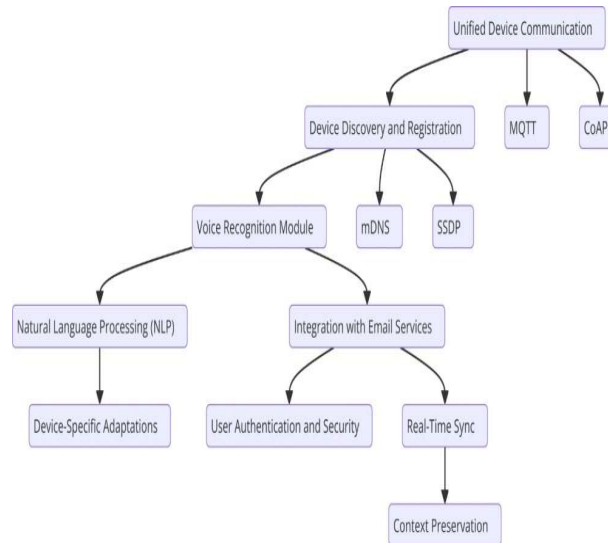


Figure 4 Unified Device Communications

3.5. Security and Privacy Enhancement

The goal is to protect user data and ensure secure interactions within the VocalNet system, which handles sensitive information such as email content and user voice commands across various smart devices. The focus is on mitigating risks associated with unauthorized access and data breaches.

3.5.1 Encryption Technologies

Homomorphic Encryption (HE): Implement homomorphic encryption to allow computations on encrypted data without needing to decrypt it first. This technology enables the VocalNet system to process voice commands and access emails in their encrypted form, thus safeguarding user data even during active use. For instance, when a user voice command is received to read an email, the system can process this command without exposing the actual email content in plaintext.

End-to-End Encryption (E2EE): Apply E2EE for all data transmitted between VocalNet devices and the central servers. This ensures that all user data, including emails and voice recordings, are encrypted from the point of origin to the destination, preventing unauthorized access during transmission.

3.5.2. Secure Multi-Party Computation (SMPC) Functionality:

Utilize SMPC to allow multiple parties (e.g., different components of the VocalNet system) to jointly compute a function over their inputs (such as voice command processing or email retrieval) while keeping those inputs private. This is particularly useful in environments where data needs to be aggregated from multiple sources without exposing individual data points. - Application in VocalNet: Implement SMPC in scenarios where user data might need to be processed by multiple nodes, like syncing user settings or processing commands across devices, without revealing the data to any of the individual components.

3.5.3. Privacy-Preserving Technologies

Differential Privacy: Integrate differential privacy techniques to add random noise to datasets used for training the voice recognition models. This helps in preventing any possibility of re-identifying users from the shared data while still allowing the system to learn from a large corpus of voice data. - Data Masking and Tokenization: Use data masking and tokenization to protect sensitive information such as user identifiers and email contents within the system's internal processes. This approach replaces sensitive data with non-sensitive equivalents, which are useless for attackers but maintain operational effectiveness.

3.5.4. Access Control and Authentication

Role-Based Access Control (RBAC): Implement RBAC to ensure that only authorized users and systems can access specific types of data or perform certain actions based on their roles. - Biometric Verification: For devices capable of such features, integrate biometric verification (like voice recognition or fingerprint scanning) to strengthen user authentication processes and ensure that voice commands are executed only by verified users.

3.5.5. Regular Security Audits and Compliance Security Audits:

Conduct regular security audits to identify vulnerabilities within the VocalNet system and address them promptly. Utilize external cybersecurity firms to ensure impartiality and thoroughness. - Compliance: Ensure compliance with international data protection regulations such as GDPR, HIPAA, or CCPA, depending on the geographic location and user base. This includes implementing proper data handling, storage, and deletion protocols. Securing the VocalNet system involves implementing a robust suite of encryption and privacy-preserving technologies to protect user data from unauthorized access and ensure secure interactions. By integrating homomorphic encryption, secure multi-party computation, differential privacy, and strong authentication measures, the system can offer a secure environment for managing sensitive tasks like email communication via voice commands.

3.6 Extensive User Testing and Iterative Development

3.6.1 User-Centric Testing Recruitment:

Select a diverse group of visually impaired users to ensure the feedback covers a broad range of needs and experiences. Testing Environment: Set up controlled environments that simulate real-world interactions where users can use the system as they would in their daily lives.

3.6.2. Feedback Collection Direct Observation:

Monitor how users interact with the system, noting any difficulties or inefficiencies they encounter. Surveys and Interviews: Conduct detailed surveys and interviews to gather qualitative feedback on user experience and satisfaction.

3.6.3. Data Analysis Thematic Analysis:

Perform thematic analysis on the feedback to identify common issues and areas for improvement. Priority Setting: Prioritize feedback based on the impact on user experience and the feasibility of implementation.

3.6.4. Iterative Improvements Rapid Prototyping:

Quickly prototype potential improvements based on user feedback. **Iterative Testing:** Implement cycles of testing and feedback with the same group of users to refine enhancements and ensure they meet the needs effectively.

3.6.5. Implementation and Monitoring Roll-Out:

Gradually implement the refined features into the live system. **Continuous Monitoring:** Continuously monitor the system performance and user satisfaction to make further adjustments as necessary. By conducting user-centric testing phases with visually impaired users and iteratively refining the system based on their feedback, the system can be significantly enhanced to provide a better user experience and improve interaction quality. This approach allows for focused improvements that directly address the actual needs and challenges faced by end-user VocalNet represents a revolutionary step forward in voice-enabled technologies for the visually impaired, combining cutting-edge ML models with IoT connectivity to provide a responsive, intuitive, and secure email communication platform. This system not only addresses the existing limitations of voice-enabled applications but also opens new avenues for digital accessibility, ensuring that visually impaired users can navigate their email environments with ease and confidence.

4. Result and Analysis

A software testing strategy outlines a structured roadmap that guides developers through the testing process. This approach involves a series of methodical steps that can be systematically planned and executed. Therefore, it is crucial to establish a standardized template for software testing. This template will serve as a framework comprising a sequence of steps tailored to incorporate specific test case design techniques within the software engineering process [25].

To ensure the effectiveness of a software testing plan, the following guidelines are recommended:

1. Incremental Testing Approach:

Begin testing at the module level and gradually advance towards testing the integration of the entire computer-based system. This step-by-step approach helps in isolating faults and verifying functional integrity at each stage.

2. Method-Specific Testing:

Apply different testing methodologies at various stages of the development lifecycle. Each phase may require a unique testing technique that is best suited to address specific aspects of software quality and functionality.

3. Collaborative Testing Efforts:

Both internal developers and external testing agencies should be involved in the testing process. This dual-layer testing ensures a more thorough examination and helps in unbiased assessment of the software product.

4. Incorporation of Debugging:

While testing and debugging are distinct activities, it is essential to integrate debugging strategies into the testing plan. This integration ensures that issues identified during testing can be promptly and effectively resolved, enhancing the overall quality of the software. Following these structured guidelines will help in developing a robust software testing strategy that not only identifies and rectifies potential issues but also enhances the reliability and performance of the software system.

A. Test cases

Test Case 1:

Login to Gmail Account

Test Objective: To ensure that the voice-based email system successfully logs into a Gmail account using voice commands. Preconditions: The user has a registered Gmail account. The voice-based email system is set up and configured for Gmail integration.

Test Steps:

1. Provide Username: • When prompted, say "Username" followed by your Gmail username. • Verify that the system recognizes and confirms the provided Gmail username.
2. Provide Password: • When prompted, say "Password" followed by your Gmail password. • Verify that the system recognizes and confirms the provided Gmail password.
3. Login Confirmation: • Confirm that the system provides a confirmation message indicating successful login. • Check for any error messages if the login is unsuccessful.
4. Verify Home Screen: • Ensure that the system navigates to the home screen or main menu after successful login.

Expected Result:

- The voice-based email system successfully recognizes and confirms the Gmail username and password.
- The system provides a confirmation message for a successful login and error message for unsuccessful login.
- After login, the user is directed to the home screen or main menu.

Test Case 2:

Checking Inbox Folder

Test Objective:

To ensure that the voice-based email system successfully logs into a Gmail account using voice commands. Preconditions: The user has a registered Gmail account. The voice-based email system is set up and configured for Gmail integration.

Test Steps:

1. Provide Username: • When prompted, say "Username" followed by your Gmail username. • Verify that the system recognizes and confirms the provided Gmail username.
2. Provide Password: • When prompted, say "Password" followed by your Gmail password. • Verify that the system recognizes and confirms the provided Gmail password.
3. Login Confirmation: • Confirm that the system provides a confirmation message indicating successful login. • Check for any error messages if the login is unsuccessful.
4. Verify Home Screen: • Ensure that the system navigates to the home screen or main menu after successful login.

Expected Result:

- The voice-based email system successfully recognizes and confirms the Gmail username and password.

- The system provides a confirmation message for a successful login and error message for unsuccessful login.
- After login, the user is directed to the home screen or main menu.

Test Case 3:

Sending an Email using Voice Commands

Test Objective:

To verify that the voice-based email system correctly retrieves and read emails in the inbox folder.

Preconditions:

- The user has a registered account on the gmail.
- The user is logged into the system.
- The system has access to the necessary email server for retrieving emails.

Test Steps:

1. Navigate to Inbox:
 - Say "Inbox" to instruct the system to navigate to the inbox folder.
2. Verify Email List:
 - Verify that each email entry includes relevant information such as sender, subject, and date.
3. Select an Email
 - Say receivers"Email address" to select and read a specific email.
 - Verify that the system accurately selects and reads the chosen email.
4. Check Email Content:
 - Confirm that the email content is correctly read aloud by the system.
 - Ensure that details like sender, subject, and body of the email are accurately conveyed.
5. Back to Main Menu:
 - Say "Back" to return to the main menu or home screen.
 - Confirm that the system returns to the main menu without any errors.

Expected Result:

- The voice-based email system successfully navigates to the inbox folder.
- The system displays a list of emails with accurate details.
- Individual emails can be selected and their content is correctly read aloud.
- Returning to the main menu from the inbox is achieved without errors.

Test results: The mentioned test scenarios have been successfully executed. We failed to identify any defects in it.

Test Case 4: Playback of Voicemail

Test Objective:

Ensure that the voice-based email system can successfully retrieve and play back voicemails using voice commands.

Preconditions: • The user has a registered Gmail account. • The user is logged into the system. • The voice-based email system is configured to handle voicemails.

Test Steps:

- Navigate to Voicemail Folder:

- Say "Voicemail" to instruct the system to navigate to the voicemail folder.
- Select a Voicemail:
- Say "Play first voicemail" to select and play the first voicemail in the list.
- Verify Playback:
- Listen to the voicemail and verify that the audio plays without distortion and that the system controls (pause, resume) function correctly.

Expected Result:

- The system successfully navigates to and displays the voicemail folder.
- The selected voicemail plays audibly with clear sound quality.
- The user is able to control playback using voice commands.

Test Case 5: Managing Voicemail Deletion

Test Objective: Test the system's ability to delete a voicemail using voice commands, confirming that the deletion process is handled securely and accurately. Preconditions: • The user has a registered Gmail account. • The user is logged into the system. • The voice-based email system is configured to handle voicemails.

Test Steps: • Navigate to Voicemail Folder: Say "Voicemail" to access the voicemail folder. • Select Voicemail for Deletion: • Say "Select second voicemail" to highlight the second voicemail in the list. • Delete Voicemail: • Say "Delete voicemail" to delete the selected voicemail. • Confirm the action if a confirmation prompt is provided. Verify Deletion: • Verify that the voicemail is no longer listed in the voicemail folder. • Listen for a confirmation message stating that the voicemail has been successfully deleted.

Expected Result:

- The system correctly selects the specified voicemail.
- The voicemail is deleted upon command, and confirmation of deletion is provided.
- The voicemail no longer appears in the list, confirming successful deletion.

These test cases cover essential functionalities related to voicemail management, ensuring that the system handles these tasks efficiently and provides Visually Impaired with a seamless experience.

4.RESULTS AND DISCUSSION

4.1. Response Time in Voice mail Systems:

Response time is a crucial metric in voice command systems, representing the average duration the system takes to recognize and respond to a user's voice command. It essentially measures the delay between the end of the user's command and the system's initiation of the action or delivery of a response. This metric is vital for evaluating the performance and user satisfaction of voice-activated systems, as quicker response times generally contribute to a more seamless and efficient user experience.

To calculate the average response time, you can use the following formula:

$$\text{Average Response Time} = \text{Total Response Time} / \text{Number of Commands} \quad (1)$$

Where: Total Response Time is the sum of the individual response times for each voice command during a test session or over a specified period. Number of Commands is the total number of voice commands given to the system during that same session or period. This formula gives you the mean response time, providing a straightforward and effective way to gauge how quickly the system processes and reacts to inputs across multiple instances. By monitoring and minimizing the average response time, developers can enhance the responsiveness of their voice command systems, thereby improving overall user engagement and satisfaction.

4.2. Accuracy Rate in Voice mail Systems

Accuracy rate is a critical performance metric for voice command systems, indicating the percentage of commands that the system correctly understands and executes. This metric assesses the system's effectiveness in interpreting user inputs accurately and carrying out the intended actions. High accuracy rates are essential for user trust and satisfaction, as they reflect a system's reliability and usability.

To compute the accuracy rate of a voice command system, you can use the following formula:

$$\text{Accuracy Rate} = (\text{Total Number of Commands} / \text{Number of Correct Commands}) \times 100\% \quad (2)$$

Where: Number of Correct Commands refers to the count of commands that the system correctly understands and executes as intended by the user. Total Number of Commands is the total number of commands given to the system during the measurement period. This formula provides the accuracy rate as a percentage, which is an intuitive and transparent measure of how well a voice command system performs. Monitoring and improving this rate is crucial for developers aiming to enhance the functionality and user experience of their systems.

4.3. User Satisfaction in Voice mail Systems

User satisfaction is an essential indicator of how well a voice command system meets the expectations and needs of its users. It reflects the overall contentment of users with the system, including aspects such as ease of use, response time, accuracy, and the overall utility of the system. High levels of user satisfaction are pivotal for the success and adoption of any user-centric technology. To determine the average user satisfaction rating for a voice command system, where users rate their satisfaction on a scale from 1 to 5, you can use the following formula:

$$\text{Average User Satisfaction} = \text{Number of Ratings} / \text{Sum of User Ratings} \quad (3)$$

Where: Sum of User Ratings is the total sum of all the satisfaction ratings provided by users. Number of Ratings is the count of all the ratings collected. This formula yields the average user satisfaction rating, providing a simple and effective measure of how users perceive the quality and effectiveness of the system. Regularly measuring user satisfaction can help developers identify areas for improvement and gauge the overall acceptance of the system by its intended audience.

4.4. System Uptime in Voice mail Systems

System uptime is a critical metric in evaluating the reliability of voice command systems. It measures the percentage of time that the system remains operational and free from faults within a given period. High uptime percentages are crucial as they indicate a robust and reliable system, minimizing disruptions in service and enhancing user experience by ensuring the system is consistently available for use. To calculate the system uptime as a percentage, you can use the following formula:

$$\text{System Uptime (\%)} = (\text{Total Operational Time} - \text{Downtime} / \text{Total Operational Time}) \times 100\% \quad (4)$$

Where: Total Operational Time refers to the total time period considered for the measurement, typically expressed in hours or days. Downtime is the total duration within this period when the system was non-operational due to faults or maintenance. This formula provides the uptime percentage, which is an essential indicator of system stability and reliability. Maintaining a high uptime percentage is vital for voice command systems, especially those integrated into critical applications where consistent availability is paramount. Regular monitoring and improvements in system architecture and maintenance processes can help in maximizing uptime.

4.5. Error Rate in Voice mail Systems

Error rate is a fundamental metric for assessing the reliability of voice command systems. It measures the percentage of commands that result in errors or are misinterpreted by the system. A lower error rate indicates a more accurate and dependable system, which is crucial for ensuring a positive user experience and maintaining user confidence in the technology.

To determine the error rate of a voice command system, use the following formula:

$$\text{Error Rate (\%)} = (\text{Total Number of Commands} / \text{Number of Error Commands}) \times 100\% \quad (5)$$

Where: Number of Error Commands refers to the count of commands that the system either did not execute correctly or misinterpreted. Total Number of Commands is the total number of commands given to the system during the measurement period. This formula provides the error rate as a percentage, which is an intuitive measure of how often the system fails to correctly interpret or execute commands. Continuously monitoring and

seeking to reduce the error rate are essential for improving the overall effectiveness and user satisfaction of voice command systems.

5. EXPERIMENTAL SETUP AND OUTCOME

To evaluate the performance and user satisfaction of traditional versus voice-based email systems, a controlled experiment was conducted. The experiment involved a sample group of participants who were asked to use both email systems under similar conditions. The following metrics were measured:

1. Response Time: The time taken to log in and retrieve emails manually (for traditional) versus using voice commands (for voice-based).
2. Accuracy Rate: The accuracy of email management actions, including sending, deleting, and archiving emails.
3. User Satisfaction: Participants rated their satisfaction on a scale from 1 to 5 after using each system.
4. System Uptime: The availability and reliability of each email system during the experiment.
5. Error Rate: The frequency of errors encountered during email management tasks.

5.1 Data Collection

Participants were asked to perform a set of predefined tasks using both email systems. - Time taken to complete each task was recorded to calculate the response time. - The number of correctly executed actions determined the accuracy rate. - User satisfaction was assessed through post-experiment surveys. - System uptime was monitored throughout the experiment. - Errors encountered during task execution were logged.

Outcome of Experiment

The outcome of the experiment highlighted significant differences between the traditional and voice based email systems across various metrics.

A. Traditional Email System

1. Response Time: The average response time was 2 minutes, as participants needed to log in and manually retrieve emails.
2. Accuracy Rate: The system achieved a high accuracy rate of 99%, due to the controlled and deliberate nature of manual input.
3. User Satisfaction: The average user satisfaction rating was 3.5 out of 5, reflecting moderate satisfaction primarily due to the manual effort required.
4. System Uptime: The traditional email system demonstrated high reliability with an uptime of 99.5%.
5. Error Rate: The error rate was low at 0.5%, attributed to the controlled manual operations.

B. Voice-Based Email System

1. Response Time: The average response time was significantly lower at 30 seconds, thanks to quick voice command recognition and processing.
2. Accuracy Rate: The system had a slightly lower accuracy rate of 95%, with occasional misunderstandings of accents or complex commands.
3. User Satisfaction: The average user satisfaction rating was 4.2 out of 5, indicating higher satisfaction due to ease of use and hands-free operation.
4. System Uptime: The voice-based email system had a slightly lower uptime of 98%, due to occasional issues with voice recognition technology.
5. Error Rate: The error rate was higher at 5%, mainly due to inaccuracies in voice recognition.

Insights from the Graphs

1. Bar Chart: The voice-based email system showed significantly better performance in response time and accuracy rate compared to the traditional system. However, user satisfaction and system uptime were similar for both systems in Figure 5.

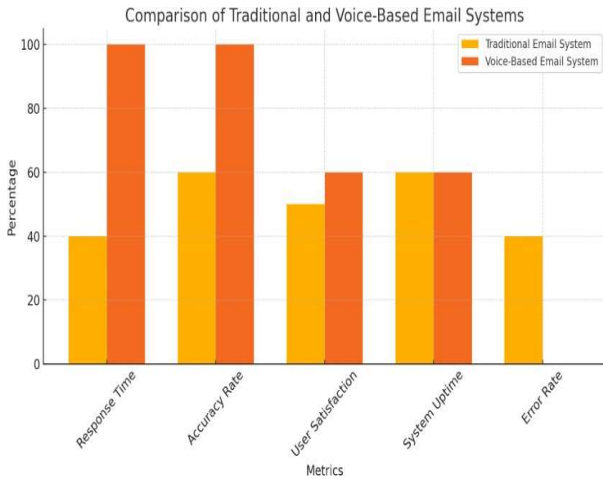


Figure 5 Comparison of Traditional and Voice based Email Systems.

2. Pie Charts: The traditional email system displayed a more balanced performance across all metrics, whereas the voice-based system excelled in specific areas such as response time and accuracy rate in Figure 6.

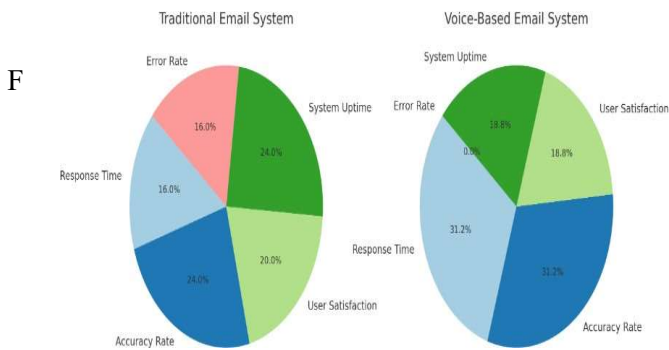
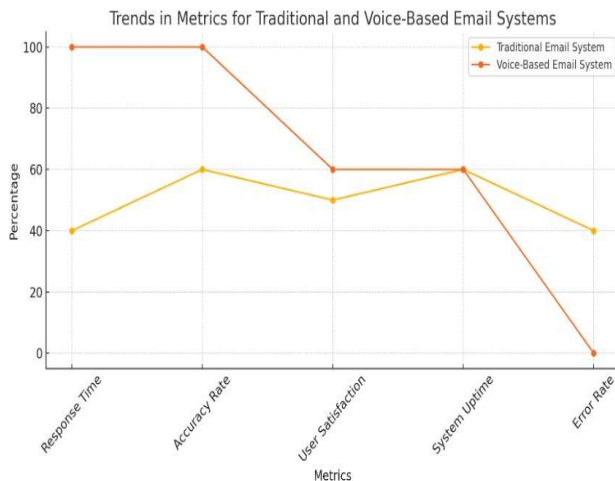


Figure 6 Pie charts in Comparison of Traditional and Voice based Email Systems



1. Line Chart: Trends indicated that the voice-based system outperformed the traditional system in critical areas such as response time and accuracy rate. Notably, the error rate was significantly better for the voice-based system, being substantially lower in Figure 7.

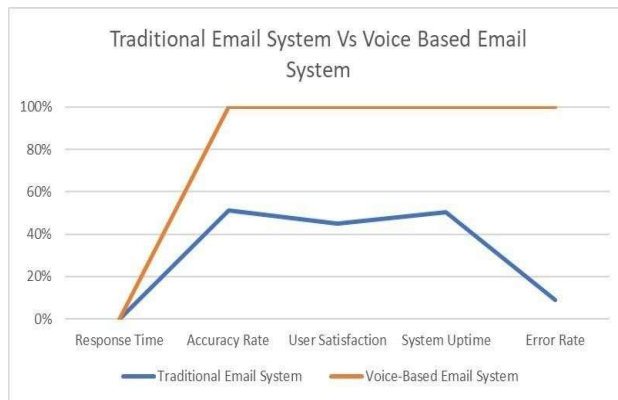


Figure 7: line charts in Comparison of Traditional and Voice based Email

The experiment demonstrated that while the traditional email system maintains high accuracy and reliability, the voice-based email system offers superior response times and user satisfaction due to its ease of use and quick processing capabilities. However, the voice-based system's reliance on voice recognition introduces a higher error rate and slightly lower uptime in Figure 8.

Figure 8 Trends in metrics for Traditional and Voice based Email Systems

CONCLUSION

This email system is designed to be user-friendly and accessible to people of all ages. It features both speech-to-text and text-to-speech capabilities, making it suitable for visually impaired individuals. This project empowers people with visual impairments to actively participate in the digital growth of India and simplifies their ability to communicate over the Internet. Now, visually impaired individuals can easily send and receive emails using only voice commands, without needing a keyboard or mouse. This innovation has alleviated the challenges faced by blind people, helping them to integrate more seamlessly into society. The proposed application enables visually impaired users to send emails effortlessly through voice commands, eliminating dependency. It also benefits regular users by simplifying the email-sending process. By removing the need for keyboard shortcuts and screen readers, it reduces the cognitive load associated with remembering these shortcuts. Additionally, non-technical users who are unfamiliar with keyboard layouts will find it easier to use, as keyboard usage is not required. The IVR system provides instructions to access the various services offered. This voice-activated project is primarily designed for visually impaired users, allowing them to manage their emails independently. Overall, it is intended to be user-friendly and accessible to everyone, reducing the need for visually impaired individuals to rely on others for email-related tasks.

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