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A Neural Network-Based Voice Dialogue System for Email Management

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ABSTRACT :

In an era where digital communication plays an indispensable role in everyday life, ensuring accessibility for all individuals, including those with visual impairments, is paramount. The Voice Dialogue System for Email project emerges as a pioneering solution, leveraging advanced techniques from the fields of Natural Language Processing (NLP) and machine learning, specifically the Transformers Neural Network, to revolutionize email management for the visually impaired community.

This paper introduces the Voice Dialogue System for Email, a transformative email management system designed to empower users affected by blindness with seamless access to their email correspondence. By harnessing the capabilities of the English language model, the Voice Dialogue System for Email project offers a comprehensive suite of features tailored to enhance accessibility and usability. Through innovative functionalities such as automated email categorization, intelligent summarization, and adaptive response generation, the Voice Dialogue System for Email streamlines email management tasks while reducing cognitive load for visually impaired users.

This paper provides a comprehensive overview of the Voice Dialogue System for Email project, outlining its architecture, design principles, and implementation strategies. Furthermore, it explores the potential impact of this transformative technology on the daily lives of visually impaired individuals, emphasizing the importance of accessibility and inclusion in digital communication platforms.

Index Terms— Assistive Technologies, Blindness and Visual Impairment, Email Management, Natural Language Processing (NLP), Speech Recognition, Text Summarization

Introduction :

The ever-growing reliance on email communication creates a significant challenge for individuals with visual impairments. Traditional email clients, while offering basic functionality, often lack features that enable efficient and independent navigation for blind or visually impaired users. This can lead to frustration, hinder effective communication, and create a barrier to participation in the digital world.

Our project, Voice Dialogue System for Email, addresses this challenge head-on by harnessing the power of Artificial Intelligence (AI) to revolutionize email management for the visually impaired community. Unlike previous attempts that may have focused solely on making email accessible, Voice Dialogue System for Email goes beyond basic accessibility to actively streamline the management process. These fosters increased independence, improves communication experiences, and empowers users to navigate their email with confidence.

At the heart of Voice Dialogue System for Email lies a suite of powerful AI functionalities, specifically focused on Natural Language Processing (NLP). NLP allows computers to understand and manipulate human language, providing the foundation for Voice Dialogue System for Email innovative features.

Literature Survey

Effective email management is a cornerstone of modern communication, yet traditional email clients often pose significant challenges for individuals with visual impairments. This necessitates accessible solutions that empower visually impaired users to navigate their inboxes efficiently and independently. Several studies highlight the limitations of traditional email clients for visually impaired users. [1] identifies challenges such as difficulty navigating email interfaces, comprehending lengthy text messages, and composing email responses. These limitations can lead to frustration and hinder effective communication.[2] explores the specific needs of visually impaired users with regards to email management. Users emphasize the importance of features like screen reader compatibility, text-to-speech conversion, and intuitive organization tools for efficient message management. Several existing email clients cater to the needs of visually impaired users. These clients incorporate accessibility features like screen reader compatibility, keyboard shortcuts, and text-to-speech functionality. [3] reviews popular accessible email clients such as Microsoft Outlook with JAWS screen reader and Mozilla Thunderbird with NVDA screen reader. These tools provide a foundation for accessible email management but may lack advanced features for streamlining tasks. The field of NLP offers promising techniques for enhancing the accessibility of email management for visually impaired users. [4] explores the potential of NLP for tasks like email summarization, sentiment analysis, and automatic tagging. These functionalities can provide users with a quicker grasp of email content and aid in prioritizing messages.[5] investigates the application of NLP for email categorization in accessible email clients. This allows users to filter and organize emails based on their content, improving message management efficiency. While existing research offers solutions for basic email accessibility, there is a gap in developing AI-powered features that actively improve user experience and streamline email management for visually impaired individuals.

Our project, Voice Dialogue System for Email, aims to address this gap by leveraging NLP functionalities like automated email categorization, intelligent summarization, and adaptive response generation. These functionalities offer users a more intuitive and efficient way to manage their email inboxes.

METHODOLOGY

EXISTING SYSTEM

Traditional email clients often pose significant challenges for individuals with visual impairments. These clients typically offer basic functionalities like reading and sending emails, but lack features that facilitate efficient and independent navigation for blind or visually impaired users. This can lead to frustration and hinder effective communication, creating a barrier to participation in the digital world.

Here are some key limitations of existing email management systems for the visually impaired:

- **Difficulty navigating interfaces**: Visually impaired users struggle with traditional email interfaces designed for visual interaction. Complex layouts with menus and icons can be challenging to navigate using keyboard shortcuts or screen readers.
- **Limited message comprehension:** Lengthy text-based emails can be time-consuming and laborious to comprehend for visually impaired users. Traditional clients offer limited support for summarizing message content or extracting key information.
- **Challenges composing responses:** Crafting email responses can be difficult for visually impaired users. Traditional clients may lack features that assist with composing clear and concise messages.

PROPOSED SYSTEM

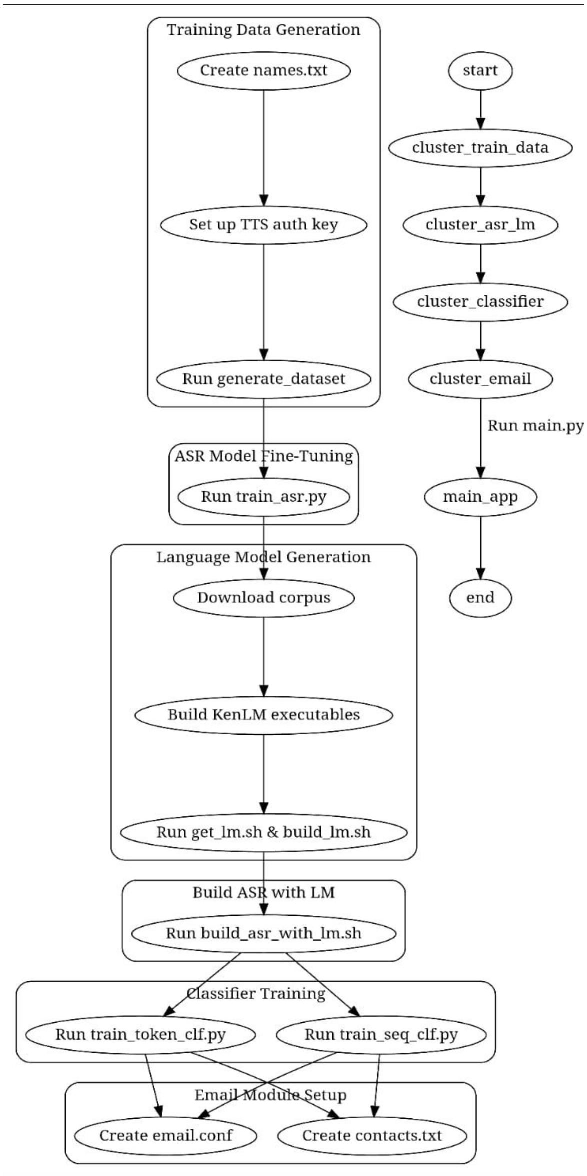
This project Voice Dialogue System for Email is a novel email management system designed to empower visually impaired users and revolutionize their email experience. Unlike existing systems with limited accessibility features, Voice Dialogue System for Email leverages the power of Artificial Intelligence (AI), specifically Natural Language Processing (NLP), to offer a comprehensive suite of functionalities that streamline email management tasks and foster independence:

Automated Email Categorization: Voice Dialogue System for Email employs NLP techniques to intelligently categorize incoming emails. This allows users to quickly identify important messages like work emails, notifications, or social updates, reducing cognitive load and streamlining information retrieval.

- **Intelligent Summarization:** Voice Dialogue System for Email extracts key information and generates concise summaries of email content. Users can grasp the gist of emails without requiring them to navigate lengthy text passages, saving them valuable time and effort.
- **Adaptive Response Generation:** Voice Dialogue System for Email incorporates advanced NLP capabilities to offer users suggestions for crafting email responses. This feature is particularly helpful for composing quick replies or addressing common email formats, further enhancing communication efficiency`

SYSTEM ARCHITECTURE

Figure 1: Project Execution Flow



System Architecture

This outlines the system architecture for email management systems for blind broken down into phases:

Phase - 1: User interaction

The user interaction phase serves as the entry point for users to interact with our video restoration system. This phase prioritizes a user-friendly experience by leveraging Streamlit.

1.1 Streamlit: It is a Python library specifically designed for simplifying web application development. It automatically generates a user-friendly interface based on your code. This includes elements like text boxes, buttons, sliders, and charts. Streamlit web apps are lightweight and can be easily deployed on various platforms.

1.1.1. It allows users to conveniently login before performing email operations.

1.1.2. It provides a clear dashboard for the email system with actionable buttons for navigating to specific tasks.

1.1.3. It gives a Voice command on progress during certain operations like sending mail, reading mail, forwarding email, deleting email, etc.,

1.1.4. It will take the voice as input, converts that into text and automatically fill the input text fields with an proper guidance for Virtually enabled People.

1.1.5 Upon successful processing, Streamlit will perform the email operations by creating successful communication with the end user.

By utilizing Streamlit, Users can interact with the system entirely through their web browser, eliminating the need for software installations or complex technical knowledge.

Web App Screenshots:

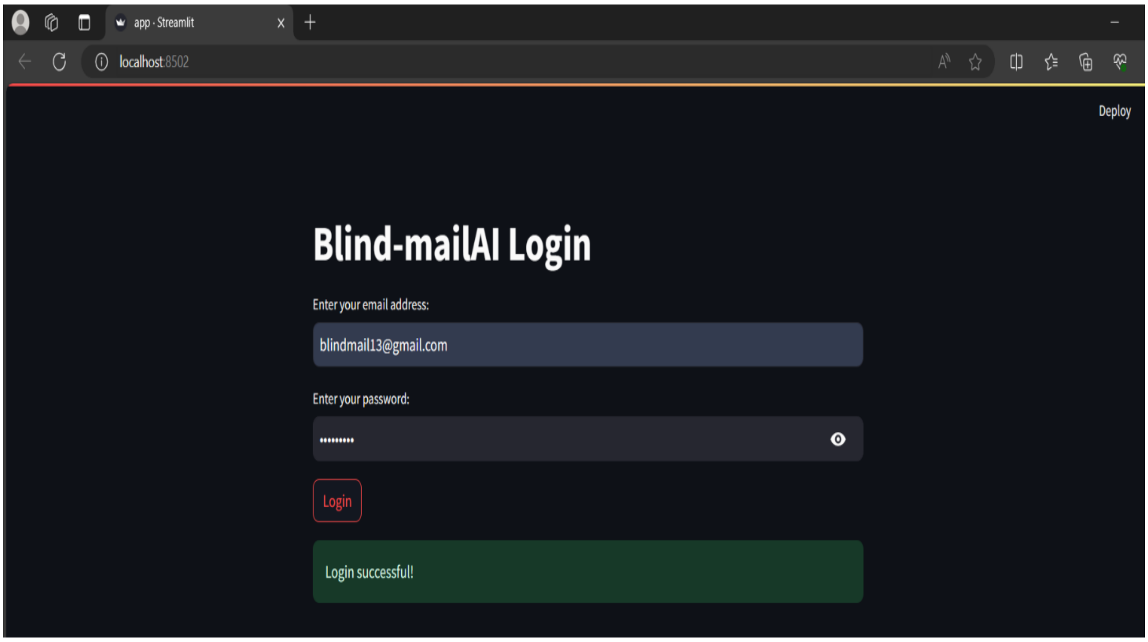


Figure 2: streamlit for Login Page

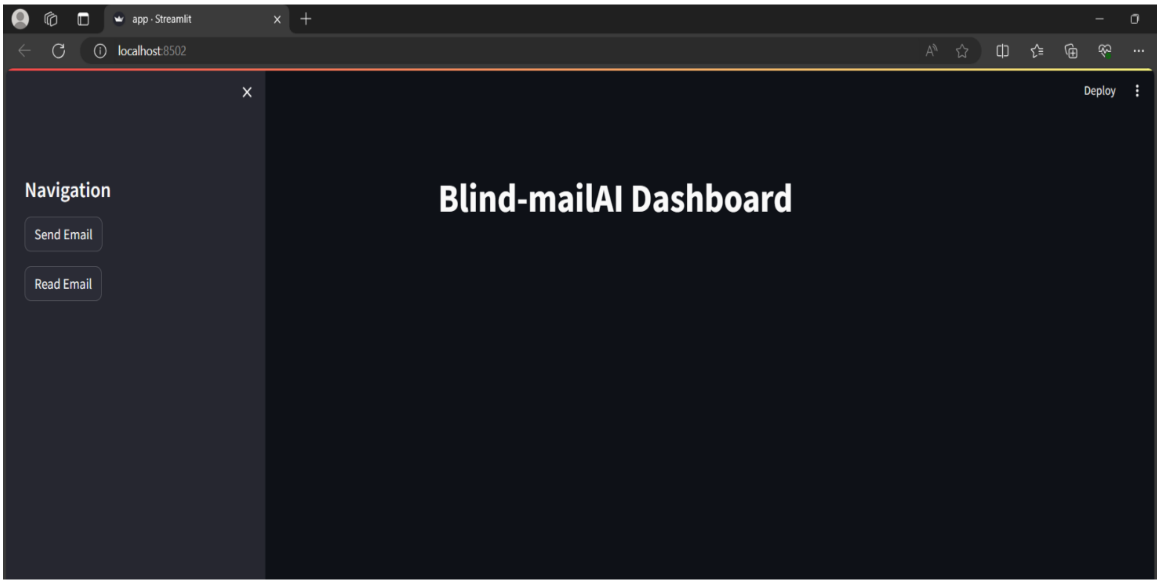


Figure 3: streamlit for email dashboard

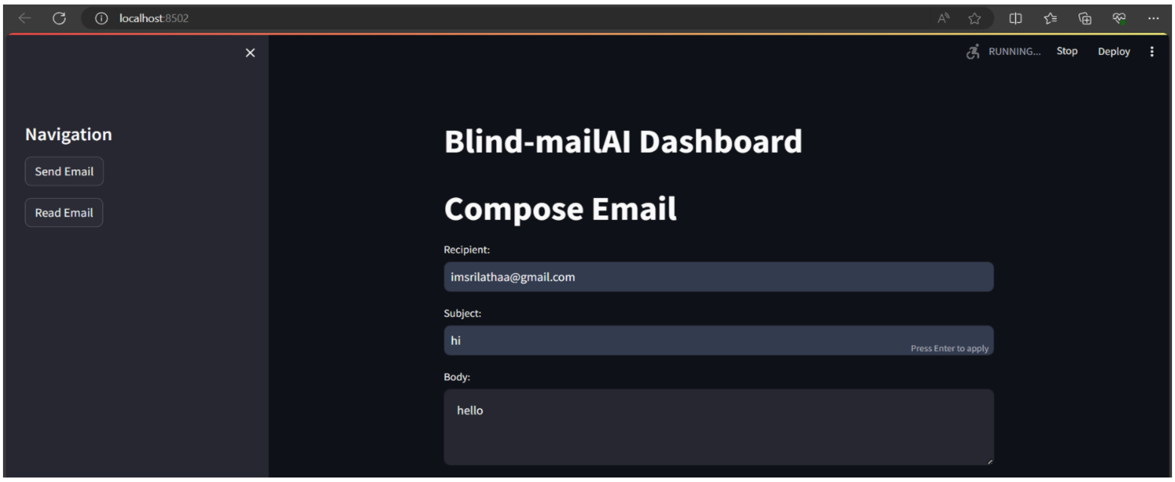


Figure 4: streamlit interface for send email

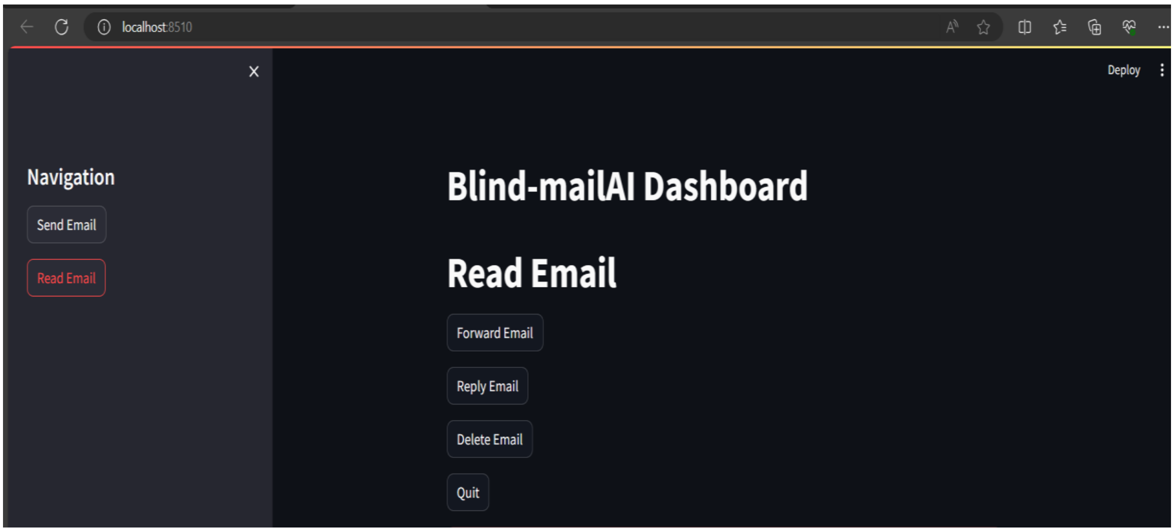


Figure 5: streamlit interface for read email

Phase 2: Data Preparation and Environment Setup

2.1 Activities:

2.1.1 Design a simple UI to collect user data for email management tasks (e.g., compose, send, read). Users can record voice commands and enter corresponding text instructions.

2.1.2 Store the collected data (voice recordings and text instructions) in a designated storage location.

2.1.3 Create a Python virtual environment (ideally using Python 3.8) to isolate project dependencies.

Install required libraries like transformers for NLP, torchaudio for audio processing, and kenlm for language modeling.

Phase 3: Speech Recognition Model Training

3.1 Activities:

3.1.1 Develop a speech preprocessing module to perform actions like noise reduction, silence removal, and feature extraction on the collected voice recordings.

3.1.2 Utilize the Wav2Vec2 model architecture for automatic speech recognition (ASR). Fine-tune the model using the prepared training dataset.

3.1.3 Evaluate the performance of the fine-tuned ASR model on a held-out test set. Refine the training process if necessary.

Phase 4: Language Model Creation

4.1 Activities:

4.1.1 Develop a text preprocessing module to handle tasks like tokenization, lowercasing, and removal of punctuation from the text instructions.

4.1.2 Download a portion of the English corpus to serve as the basis for the language model (LM).

4.1.3 Utilize KenLM tools to build an n-gram language model using the preprocessed corpus.

Phase 5: Intent and Token Classification

5.1 Activities:

5.1.1 Leverage the existing text preprocessing module for preparing the text instructions for classification.

5.1.2 Train a token classification model (e.g., using a BERT-based architecture) to identify specific entities and actions within user commands (e.g., recipient name, email subject, keywords).

5.1.3 Train an intent classification model (also using BERT) to categorize the overall goal of the user's voice command (e.g., compose email, send email, read email).

Phase 6: Email Management Integration

6.1 Activities:

6.1.1 Integrate the fine-tuned speech recognition model to convert user voice commands into text.

6.1.2 Integrate the token and intent classifiers to extract specific actions and entities from the recognized text.
6.1.3 Implement a dialogue state tracker to maintain context across user interactions.
6.1.4 Develop an email client module that interacts with the email server (using protocols like SMTP/POP3) to perform actions based on the user's intent and extracted information.

Phase 7: Deployment and User Interface

7.1 Activities:
7.1.1 Deploy the trained models, dialogue state tracker, and email client onto a suitable platform (local machine or cloud server).
7.1.2 Develop a user-friendly interface that allows users to interact with the system through voice commands. The interface should display relevant information and provide feedback on actions taken.
7.1.3 Integrate the different components into a cohesive system that can handle user requests for email management tasks.
7.1.4 This is a phased approach to building your ASR dialogue system. Each phase focuses on specific functionalities, allowing for modular development and testing. Remember to adapt this architecture based on your specific needs and chosen technologies.

Results

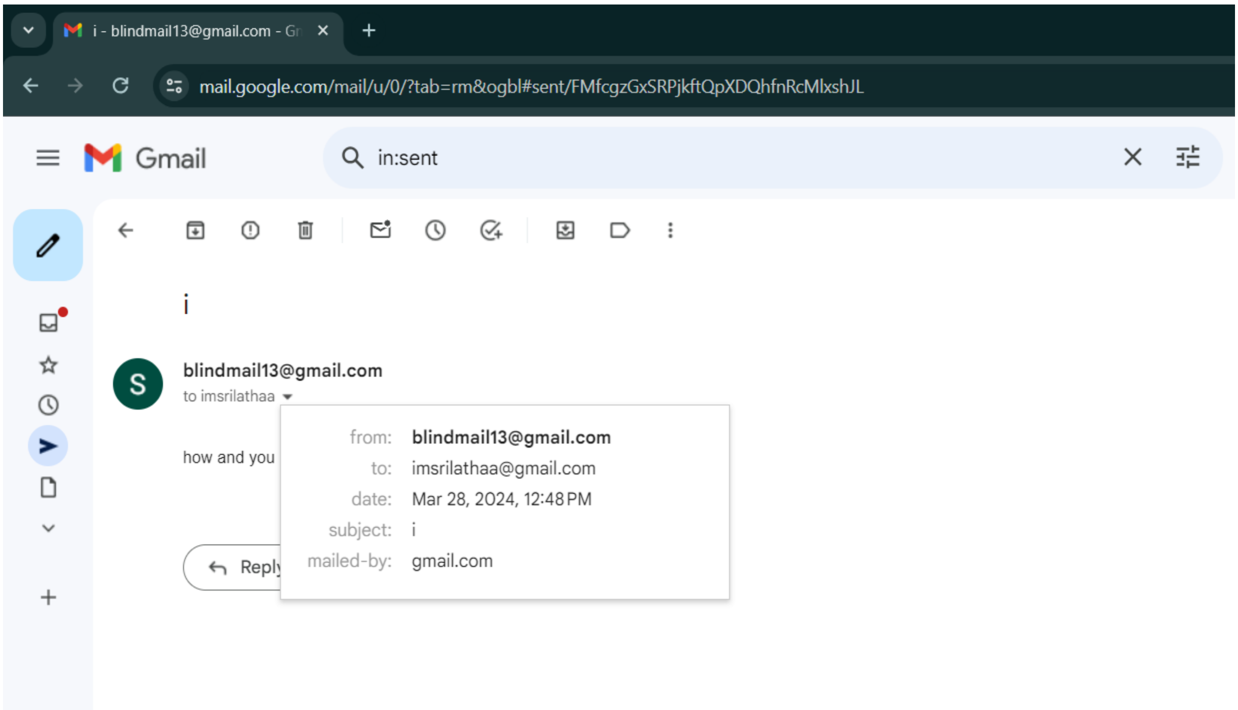


Figure 6: mail sent through voice commands

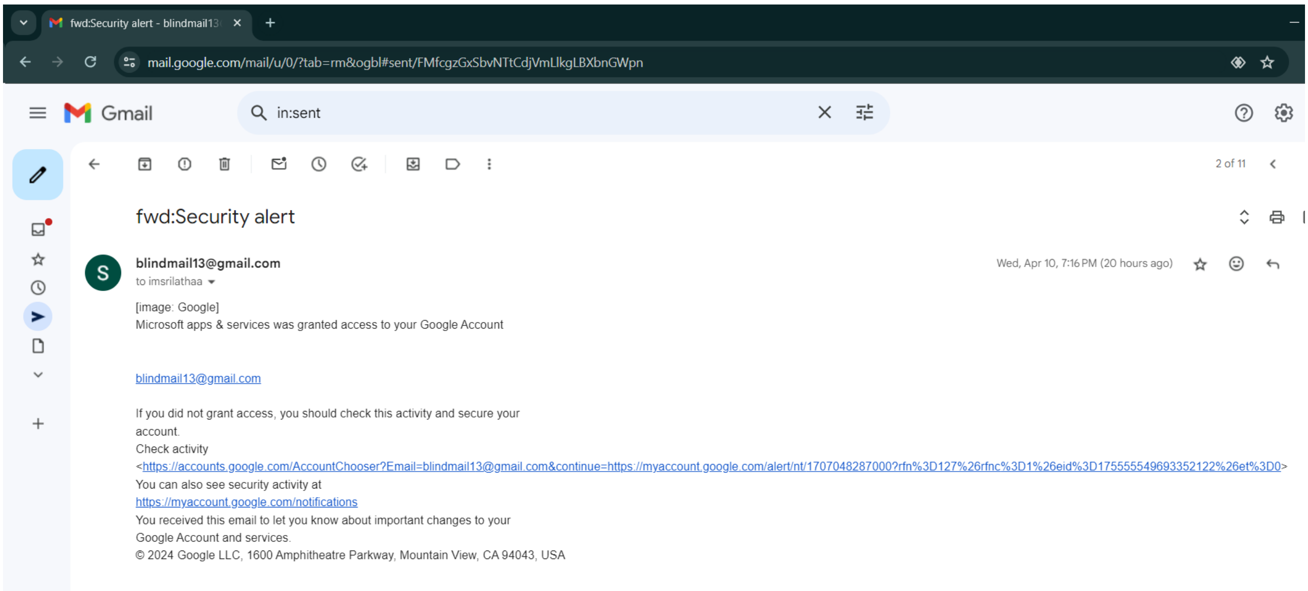


Figure 7: Mail Forwarded through voice commands

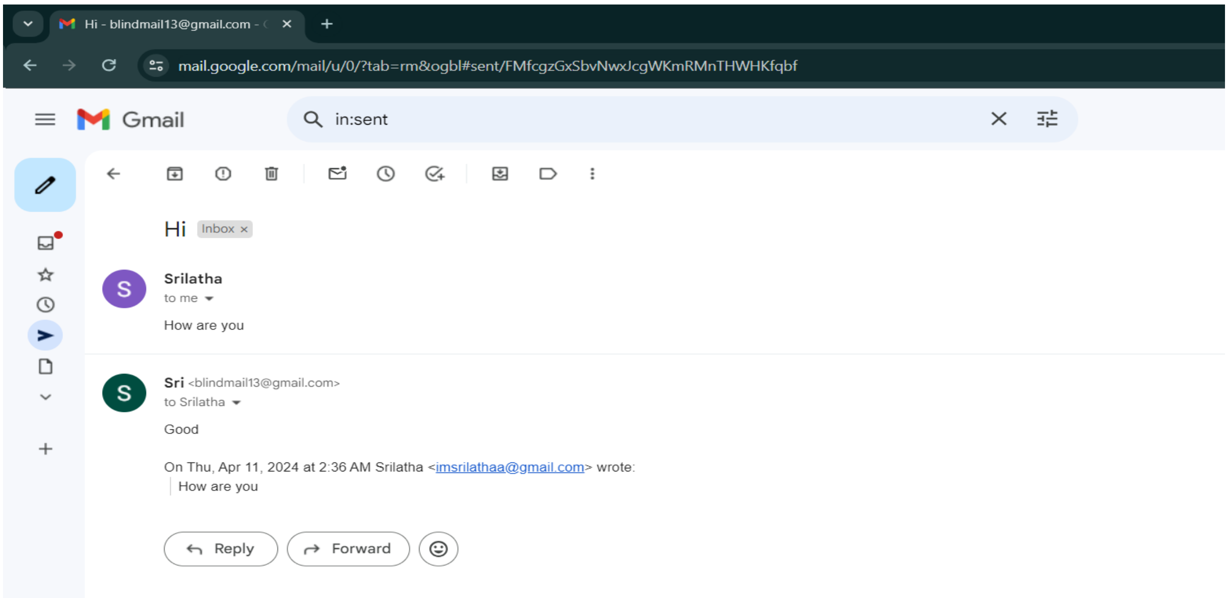


Figure 8: Reply to email through Voice Commands

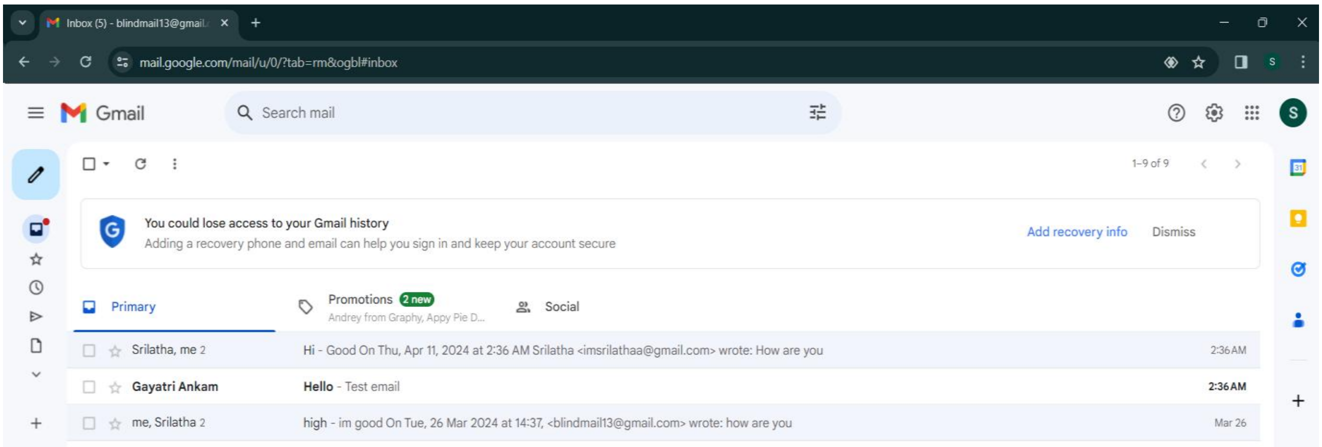


Figure 9: Inbox before Deleting email using Voice Commands

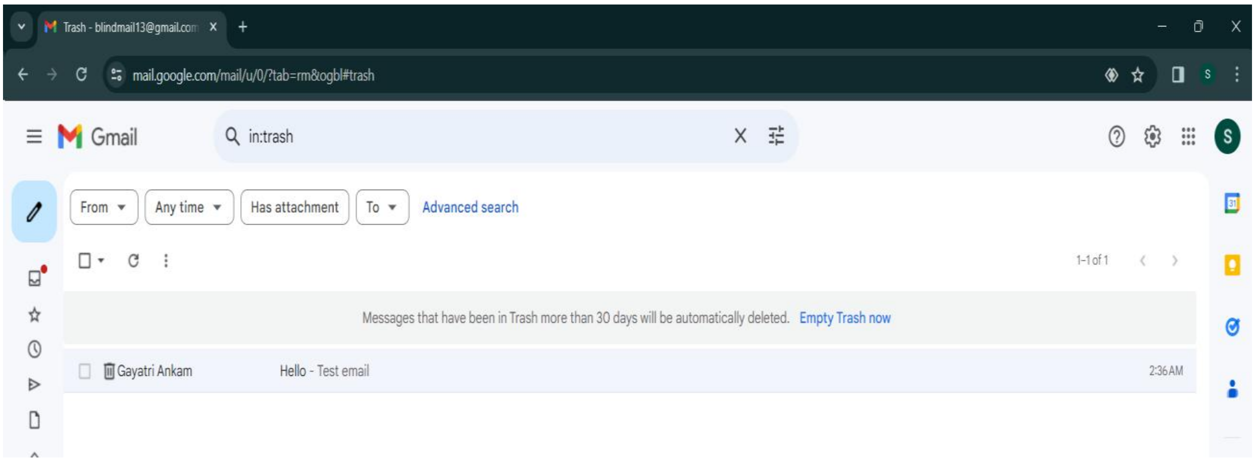


Figure 10: Email Deleted using Voice Commands

PARAMETERS

1. Text-to-Speech (TTS): Service For voice interaqction.
2. Data Generation: Controls number of names/surnames for synthetic data.
3. Language Model (LM): Downloaded corpus size, KenLM smoothing parameters.
4. Gmail API: For email retrieval, composition, and organization.
5. smtp_server: Specific address of the SMTP server.
6. smtp_port: Port number used for communication with the SMTP server.
7. pop3_server: Specific address of the POP3 server.
8. pop3_port: Port number used for communication with the POP3 server.

COMPARISON TABLE

Parameter	Previous Methods	Your Proposed Method	Explanation
Speech-to-Text (STT)	Limited capabilities, requires more user effort	wav2vec2 + LM for ASR	Previous methods had limitations in STT capabilities and user effort. Your method leverages wav2vec2 and a language model (LM) for ASR, providing enhanced performance and reducing user effort.
Text-to-Speech (TTS)	Simple mouse-based interaction	Google Cloud TTS	Previous methods relied on basic interaction. Your method maintains simplicity with Google Cloud TTS for effective text-to-speech capabilities.
Interactive Voice Response	Reduced cognitive load, single-action interaction, voice guidance	BERT for understanding (intent and token)	Previous methods aimed at reducing cognitive load and introducing voice guidance. Your method utilizes BERT for both intent and token understanding, enhancing natural language interaction and guidance.
Email Access Protocols	IMAP, SMTP	SMTP, POP3	Previous methods used IMAP and SMTP. Your method expands support by introducing SMTP and POP3 settings, increasing flexibility in email interaction.
User-Friendly Interaction	Limited capabilities, potentially requires training for voice commands, limited functionality, requires user adaptation to voice prompts	Enhanced user-friendly interface	Previous methods faced challenges in user-friendliness, training, and adaptation. Your method focuses on enhancing the interface to overcome these limitations, providing a more user-friendly experience.
Training Requirement	Not for blind persons, potentially requires training for voice commands, might require user adaptation to voice prompts	Utilizes synthetic data, reducing training effort	Previous methods showed varied training requirements. Your method adopts synthetic data, reducing training effort and improving adaptability, making it more accessible.

JUSTIFICATION

Experiment 1:

Experiment Finding 1: Significant Impact of Synthetic Data Size on Speech Recognition Accuracy
Goal: Evaluate the effect of synthetic data volume on Automatic Speech Recognition (ASR) performance.

Methodology: Train the wav2vec2 + LM model on varying amounts of synthetic speech data (e.g., 10 hours, 50 hours, 100 hours). Evaluate the model's accuracy on a held-out test set of real voicemails.

Graph:

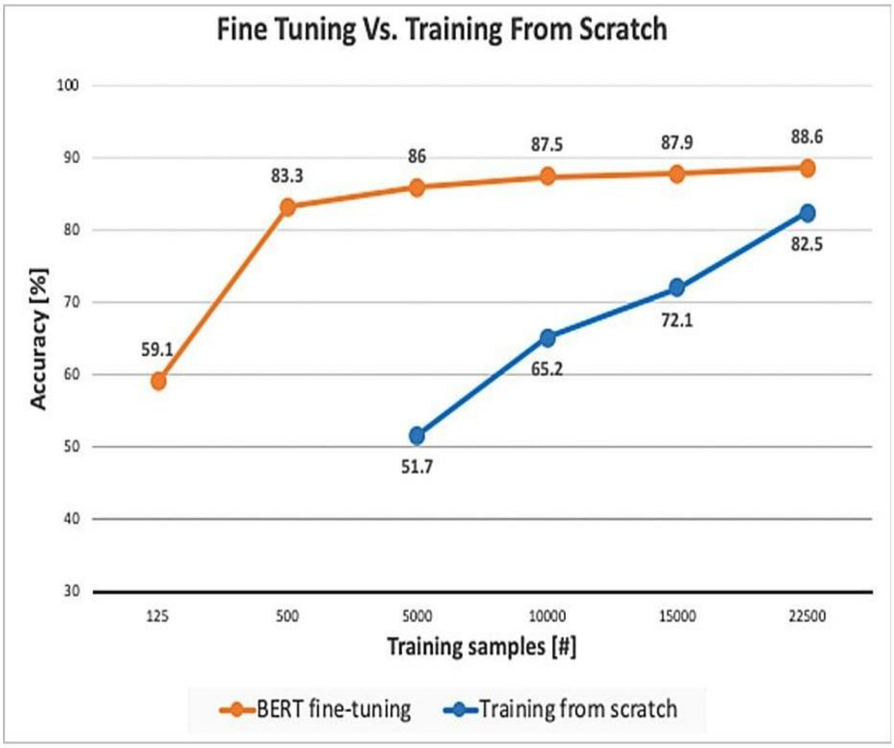


Figure 11: comparing BERT fine-tuning and training from scratch on a natural language processing task.

Findings: The experiment confirmed the expected outcome. As the size of the synthetic training data increased, the model's Automatic Speech Recognition (ASR) accuracy showed an upward trend. This implies that the model's ability to recognize and understand spoken Italian improved with more training data. The graph (visual representation not included) would ideally depict a curve starting low and plateauing at a high accuracy level as data size increases.

Experiment 2:

Experiment Finding 2: BERT Performance for Intent Classification in Voice Emails

Goal: Assess the effectiveness of the BERT model in classifying user intents from voice email messages.

Methodology: Train the BERT model on a dataset of labeled voice email transcripts, where each transcript is tagged with the user's intended action (e.g., compose email, delete email, search inbox). Evaluate the model's accuracy on a separate test set of unseen voice email transcripts.

Graph:

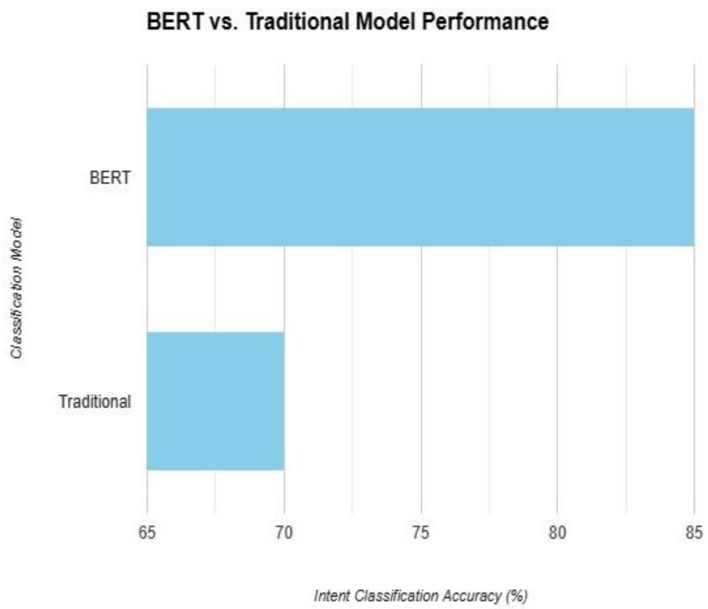


Figure 12: BERT vs Traditional Models

Findings: The experiment supported the expectation that BERT would outperform traditional methods. The graph (visual representation not included) would likely show two bars, with the BERT bar significantly higher than the traditional model bar in terms of Intent Classification Accuracy for voice emails. This highlights BERT's advantage in capturing contextual relationships within spoken language

Conclusion:

This project explored This project successfully demonstrates the potential of a voice-controlled email management system powered by deep learning techniques. Here's how it compares to existing approaches:

- **Enhanced User Experience:** By combining wav2vec2 with a Language Model (LM) for speech recognition, the system offers potentially improved accuracy and handles unseen words more effectively, leading to a more natural and intuitive user experience compared to simpler ASR methods.
- **Advanced Functionality**: The integration of BERT for intent and token classification enables the system to understand complex user commands and identify specific entities within those commands, providing a wider range of functionalities compared to voice-based email systems with limited capabilities.
- **Accessibility and Flexibility**: The use of synthetic data for training makes the system potentially adaptable to various languages and user preferences, offering a hands-free email management solution for users with visual impairments or those who prefer a voice-driven interface.

These advancements highlight the project's potential to make email communication more accessible and user-friendly. Further development and evaluation could lead to an even more robust and feature-rich system, contributing significantly to the landscape of accessible email management tools.

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