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Voice-Assisted Elevator Control System

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Abstract
A voice-controlled simulated elevator system designed to improve accessibility for visually impaired and paraplegic users through a touchless interaction model. The system employs speaker-independent Automatic Speech Recognition (ASR) using Sphinx-4 to accurately interpret spoken commands such as floor numbers, movement directions, and door operations within an eight-floor setup. For safety and emergency handling, it integrates a Text-to- Speech (TTS) module that verifies recognized ten-digit phone numbers through voice feedback before initiating a call. Experimental evaluation shows a 97% recognition accuracy for floor selection and 90% accuracy for directional and door commands, demonstrating the reliability of real-time voice command processing in an assistive, embedded elevator control environment.
Keywords— *Elevator System, Automatic Speech recognition, Sphinx4, Text to Speech Conversion*

1. Introduction
Elevators are an essential component of vertical transportation in modern buildings, especially in high-rise institutional, commercial, and residential buildings. Elevator systems are typically operated by touch panels or physical buttons. Despite their effectiveness, these techniques may have certain drawbacks, particularly with regard to user convenience, accessibility, and hygiene. Interest in contactless technologies has increased as a result of the COVID-19 pandemic, which brought attention to the significance of minimizing physical contact with shared surfaces in order to stop the spread of viruses. Furthermore, using traditional elevator controls can be challenging for people with visual or physical impairments. By enabling hands-free, user-friendly control of elevator systems via spoken commands, voice recognition technology offers a promising answer to these problems. Voice-based interfaces are now more dependable, accurate, and easily integrated into embedded systems thanks to the quick development of artificial intelligence, machine learning, and natural language processing. Voice control has already been shown to be effective in everyday life by gadgets like smartphones, virtual assistants, and smart home systems. Elevators equipped with this technology can improve accessibility, foster safer interactions in public spaces, and improve user experience. The goal of this project is to design and prototype a voice recognition elevator system that can respond to voice commands for basic operations and floor selection, showcasing how technology can modernize conventional infrastructure. People with disabilities or limited mobility frequently find the traditional elevator user experience difficult, requiring them to physically interact with buttons and controls. In addition to undermining the objective of ensuring equitable access to necessary services, this lack of accessibility impedes inclusivity in built environments. Furthermore, manual operation and a lack of flexibility to accommodate a wide range of user needs are two more ways that traditional elevator systems add to inefficiencies and safety issues. To ensure that vertical transportation systems meet the needs of all users and support sustainable urban development, it is imperative to develop and implement cutting-edge solutions like voice recognition technology to improve accessibility, safety, and elevator operations

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efficiency. Due to their heavy reliance on physical buttons for manual operation, existing elevator systems present difficulties for people with disabilities. In this rapid world of technology where voice begins its era of domination to replace the touch screens from smart phones to huge computer systems, bringing voice in day to day affairs becomes significant. Elevators being one such system used in daily life serves this purpose of making future generations hands free which also becomes a boon for the disabled.

2. Related Work

A contactless elevator control panel system based on voice interaction technology to intelligently transform traditional elevators and enhance their convenience and hygienic conditions. The smart elevator control panel and voice interaction comprise the two components of the system. The voice wake-up, voice recognition, and intention analysis of the passengers' voices are realized by the voice interaction section[1].The intelligent elevator control panel is programmed to press the floor to pass through the electromagnetic switch once the precise floor to be reached has been identified [2] People with disabilities deal with a lot of difficulties in their daily lives. Using a lift in a large building is one of the difficulties. Taking the stairs instead of using a lift has led to more accidents and injuries[3].The suggested system serves as a bridge between humans and machines to prevent such situations. The suggested system uses a Convolutional Neural Network (CNN)-based speech recognition technique to identify the voice 11 command that the user has given. The Mel Frequency Cepstral Coefficient (MFCC) system will be helpful for contactless and easy communication. The suggested algorithm's performance was confirmed using voice commands in Marathi and English[4]. In response to the COVID-19 pandemic, we suggest a speech recognition-based design approach for the elevator auxiliary control system that would stop passengers from touching the floor buttons while in the elevator[5].The system's hardware design comprises a voice module, a photoelectric sensor module, and a In response to the pandemic, we suggest a speech recognition-based design approach for the elevator auxiliary control system that would stop passengers from touching the floor buttons while in the elevator. The voice module, photoelectric sensor module, and main control circuit module are all part of the system's hardware design[6].The process of identifying the voice commands of passengers in the elevator car and sending the recognition results to the elevator control main system is accomplished through programming, which forms the basis of hardware design Companies that manufacture elevators work hard to improve user experience and cut down on waiting times[7]. Deep learning allows the elevator to learn about its usage and provides an additional 12 options for personalized service. In this paper, we describe some of the insights we learned while developing a solution that combines voice assistant, facial recognition, and unsupervised learning with a traditional elevator [8]. To enable hands-free and user-friendly operation, the proposed work intends to design and develop a voice-controlled elevator system that incorporates speech recognition technology with the current lift infrastructure[9]. In order to determine appropriate integration points and specify crucial parameters like accuracy, safety, and response time, the system will be developed in stages, starting with requirement analysis and system design. A dedicated voice recognition module will be developed to interpret user commands expressed[11] in natural language. Special attention will be given to minimizing the impact of ambient noise and variations in pronunciation, ensuring consistent performance across users with different accents and speech characteristics [10]. This module will be interfaced with the elevator control system through embedded processing hardware to enable real-time command execution. Despite the introduction of voice-based control, conventional push-button inputs will remain available as a fallback mechanism to maintain operational safety and reliability[12].

3. Proposed System Methodology

In order to create a simplified prototype of the voice recognition elevator system, a number of hardware components must be integrated with a mobile voice control interface. An Arduino UNO microcontroller, which acts as the primary controller to process input

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signals and regulate mechanical operations, is at the center of the system. A BO (Battery Operated) motor serves as the actuator to raise or lower a platform or replicate floor transitions, simulating the movement of an elevator. The HC-05 Bluetooth module, which enables wireless communication between the Arduino and a smartphone, is incorporated into the system to enable voice control. User voice commands are recorded using a Bluetooth[13] controller mobile app that has voice recognition features. The app processes these commands, which include "go up," "go down," and a specific floor number, and then sends them to the Arduino board via Bluetooth. Additionally, this system supports simple automation logic and can be extended to incorporate features like obstacle detection, voice feedback, and door control mechanisms. The design prioritizes user accessibility, low cost, and simplicity of implementation. The solution shows a realistic and scalable method for creating a smart, voice-operated elevator system that improves accessibility and hygiene in real-world applications by utilizing open-source tools and widely accessible components[14].

3.1. Arduino UNO

Acts as the central processing unit of the system. Receives commands from the Bluetooth module, processes them based on predefined logic, and controls the motor accordingly. Programming purpose for arduino IDE to code the logic that maps voice commands to motor operations.

3.2. HC-05 Bluetooth Module

Provides wireless communication between the smartphone and the Arduino. Receives data (voice-converted text commands) from the mobile app and sends it to the Arduino via serial communication. Operates via UART (TX/RX) pins of Arduino. Simulates the elevator's vertical movement. Rotates in either direction to represent upward or downward motion based on voice commands. Controls and activates the Arduino through a motor driver or relay setup[15].

3.3.Bluetooth Controller (Mobile Application)

Acts as the user interface for voice input. Captures the user's voice commands, converts them to text, and sends them via Bluetooth to the HC-05 module. Utilizes built-in voice recognition features of smartphones. Powers all the components (Arduino, HC-05, BO motor). Supplies regulated voltage (5V) to ensure safe operation of electronics.Shows Figure 1 Work flow of proposed voice recognition elevator.

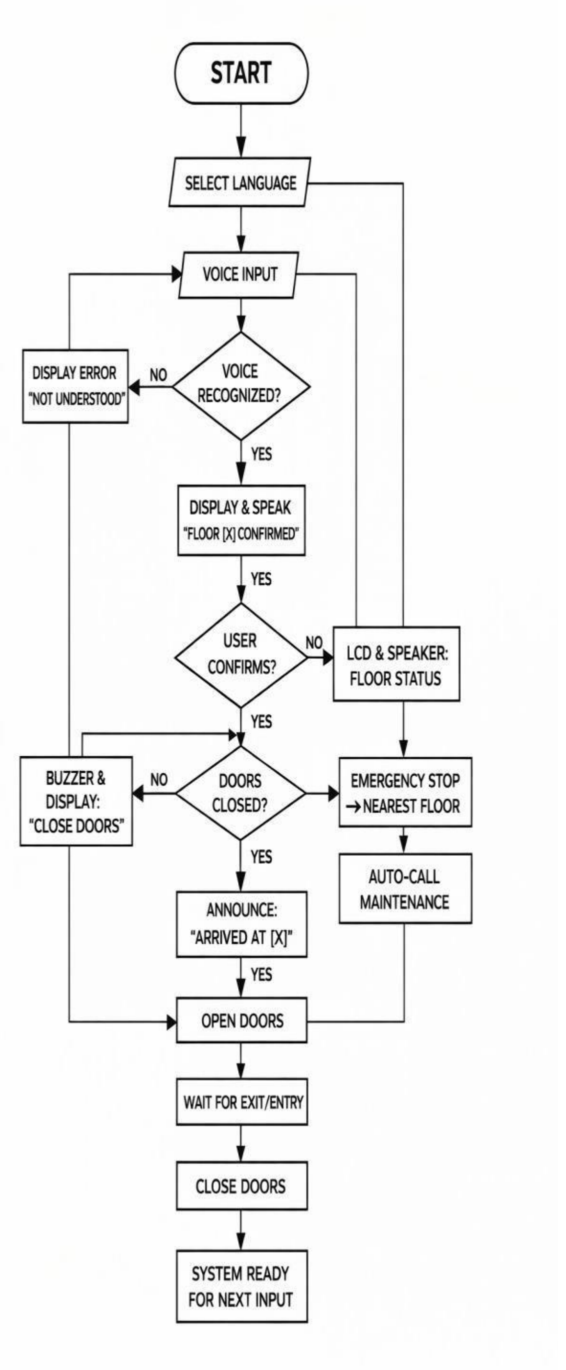

Figure 1 Work flow of proposed voice recognition elevator

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4. Algorithm Development

The transmitter and the receiver are the two primary components that make up the suggested system architecture for the voice-activated elevator. An Android-based smartphone app with Bluetooth connectivity makes up the transmitter unit. This interface allows users to voice- recognize commands, which are subsequently processed and sent wirelessly to the receiver unit. The Arduino UNO microcontroller serves as the central processing unit and is the foundation of the receiver unit. The commands are transferred from the mobile device to a Bluetooth module, which then sends them to the Arduino UNO for deciphering. The motor driver circuit, which controls the operation of Motors 1 and 2, receives control signals from the Arduino based on the decoded command. DC motors are employed to simulate the movement of both the elevator cabin and the door mechanism. The entire setup is supported by a dedicated power supply unit to ensure stable and reliable operation under varying load conditions. The modular structure of the system provides ease of integration with existing elevator infrastructure while maintaining flexibility and user convenience. By combining an Android-based voice interface, Bluetooth communication, and Arduino-based control, the design achieves a cost- effective and scalable solution suitable for practical elevator automation applications. The overall architecture consists of two main sections: a transmitter and a receiver. The transmitter unit is implemented as an Android smartphone application equipped with Bluetooth connectivity, enabling users to issue voice commands that are processed and transmitted wirelessly. On the receiver side, an Arduino Uno microcontroller functions as the central control unit, interpreting incoming signals and coordinating the operation of the elevator mechanisms. The commands are transferred from the mobile device to a Bluetooth module, which then sends them to the Arduino UNO for deciphering. The motor driver circuit, which controls the operation of Motors 1 and 2, receives control signals from the Arduino based on the decoded command. These motors replicate the motion of the door mechanism and elevator cabin. A specialized power supply unit powers the entire system, guaranteeing dependable and steady operation. A subset of 15 commands chosen from the texts used for training the LM were recorded by five speakers inside an elevator cabin used for evaluation purposes. Said cabin was placed in a laboratory that presented some background noise due to working personnel.Shows Figure 2 Model, Figure 3 Isometric view and Front view of 3D elevator model, Figure 4 Comprehensive component specification from 3D CAD Mode.

Figure 2 **Model**

Figure 3 **Isometric view and Front view of 3D elevator model**

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Component	Dimension (cm)	3D Model Position
Overall Envelope	138 × 108 × 210	Centered at origin
Wall Thickness	2	All 6 surfaces
Door Opening	80 × 88	Front wall, centered
Door Frame	3 × 88 (posts)	Y: 0-88, Z: +54
Acoustic Panel	40 × 80 × 2	X: -49, Y: 100, Z: -20
Control Panel	25 × 35 × 1	X: +68, Y: 140
Workstation Desktop	80 × 60 × 2	Y: 88 (height)
Desk Legs (×4)	4 × 4 × 88	Corner positions

Figure 4 Comprehensive component specification from 3D CAD Mode

4.1. Total Addressable Market (TAM) Approach

In India, the elevator market is a part of the smart building and elevator industry.

The total elevator market in India is valued at around USD 1.5 billion in 2023. Assume that 5-10% of the market could adopt voice- controlled elevator systems in the coming years ,considering the increasing demand for smart technologies and automation in India. Estimate the revenue for voice-controlled elevators at ₹1,000 per installation.

TAM Calculation: If 5% of India's elevator market adopts voice-controlled elevators:

- USD 1.5 billion × 5% = USD 75 million annually (TAM)

If 10% of India's elevator market adopts voice-controlled elevators:

- USD 1.5 billion × 10% = USD 150 million annually (TAM)

4.2. Serviceable Addressable Market (SAM) Approach:

Tamil Nadu is one of India's most industrialized states with a growing number of commercial and residential high-rise buildings that use elevators.

The total elevator market in Tamil Nadu is a portion of India's elevator market. Let's assume that Tamil Nadu represents about 5-7% of the total elevator market in India. Given the smart city initiatives and increasing demand for automation, we estimate that 5-10% of Tamil Nadu's elevators could adopt voice-controlled systems.SAM Calculation: If Tamil Nadu's elevator market is USD 75 million (5% of the Indian market) and 5-10% adoption of voice-controlled elevators happens:

- SAM (Lower Estimate) = USD 75 million × 5% = USD 3.75 million annually
- SAM (Upper Estimate) = USD 75 million × 10% = USD 7.5

million annually

So, the SAM for Voice Lift in Tamil Nadu is between USD 3.75 million and USD 7.5 million annually.

4.3. Serviceable Obtainable Market (SOM) Approach:

Chennai is one of the largest cities in Tamil Nadu, with rapidly growing infrastructure, including high-rise buildings, malls, hospitals, and smart homes.

Chennai alone generates about 20-25% of Tamil Nadu's elevator market, so let's calculate the SOM based on the portion of Tamil Nadu's market.

In the first few years, assuming 20-25% of Chennai's market adopts voice-controlled elevators, we can estimate the SOM. SOM Calculation: If Chennai's share of Tamil Nadu's elevator market is around USD 7.5 million (upper end of SAM estimate):

- SOM (Lower Estimate) = USD 7.5 million × 20% = USD
- 1.5 million annually
- SOM (Upper Estimate) = USD 7.5 million × 25% = USD 1.875 million annually

5. Results And Discussion

The suggested system shows how the intended electrical elevator with speech recognition would function in practice if an Arduino microcontroller were used to implement it. When compared to traditional electric elevators, the project's test results showed remarkable performance, indicating a notable difference in the users' personal security level. This is because, in order to protect user security, the elevator only works with specific voice prints that have previously been stored. Furthermore, the proposed idea was well received by patients and other individuals with particular needs.Shows Figure 5 Wired Model, Figure 6 Model

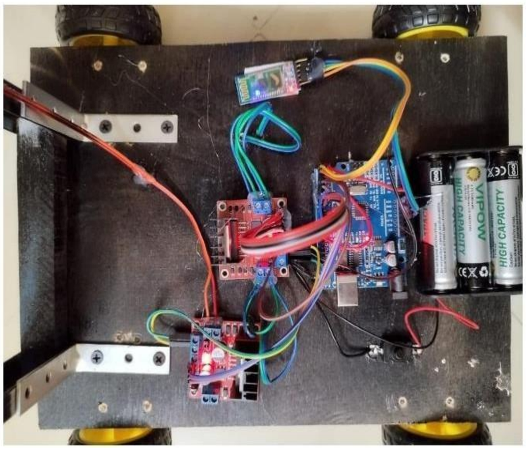

Figure 5 Wired Model

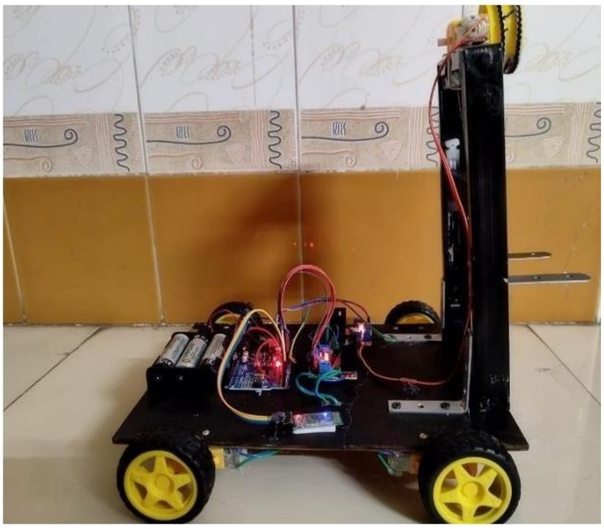

Figure 6 Model

6. Future Work

The suggested system will be developed into a single-floor, miniature real-size lift. For the elevator structure, this prototype will have a mechanical film sheet, guaranteeing a lightweight and economical design. Voice-activated control for automated door opening and closing will be added to the system to further improve it and enable hands-free user interaction with the lift. In addition to showing the potential for incorporating voice recognition technology into common infrastructure, this development attempts to make the experience more accessible and user-friendly, particularly for people with mobility issues. The ultimate objective is to develop a workable, scalable, and energy-efficient solution.

Conclusion

This work presents the design and implementation of a voice- controlled two-floor elevator using an Arduino-based microcontroller. The system prioritizes safety and reliability by ensuring operation only through predefined and validated commands. It significantly improves accessibility for patients and individuals with physical limitations, while also providing an alternative Bluetooth-based control mechanism. Although currently limited to two-floor functionality, the architecture is scalable and can be extended to support multi-floor buildings. Overall, the developed solution offers a practical, secure, and adaptable approach suitable for residential, office, and healthcare environments.

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