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Wireless Voice Recognition Based Personal Computer Control System for Hand Impaired Patients using LabVIEW

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Abstract

In today's digital era, individuals with hand impairments face significant challenges in interacting with computers, limiting their access to essential resources and technology. This paper presents a Wireless Voice Recognition-Based Personal Computer Control System, designed to enable hands-free operation using LabVIEW and speech recognition technology. The system captures voice commands, processes them using machine learning algorithms, and transmits the corresponding control signals wirelessly to a computer. By integrating LabVIEW for signal processing and automation, the system enhances accessibility, allowing users to perform essential tasks such as opening applications, browsing, typing, and controlling system functions through voice input. The proposed model aims to improve the independence and efficiency of hand-impaired individuals, offering a cost-effective, user-friendly, and reliable solution for seamless computer interaction. Experimental results demonstrate high accuracy and low latency in executing commands, proving its potential for real-world applications. This research highlights the importance of assistive technology in bridging the digital divide and fostering an inclusive computing environment.

Keywords: Voice Recognition, Wireless Control System, LabVIEW, Assistive Technology, Speech-to-Text, Computer Accessibility, Hand-Impaired Users, Human-Computer Interaction (HCI), Machine Learning, Signal Processing, Adaptive Computing, Embedded Systems, IoT-Based Control, Real-Time Processing, Inclusive Technology.

1. Introduction

In today's digital age, computers have become an integral part of education, communication, and professional work. However, individuals with hand impairments often struggle to operate traditional input devices such as keyboards and mice, limiting their ability to interact with computers efficiently. This lack of accessibility creates a digital divide, preventing them from leveraging the full potential of modern computing. To bridge this gap, voice technology provides a promising alternative, enabling hands-free control and accessibility for those with physical disabilities.

The proposed system, Wireless Voice Recognition-Based Personal Computer Control System, aims to address these challenges by offering a voice-driven interface for hands-free computer operation. This system utilizes LabVIEW, a powerful graphical programming platform, to process voice commands and translate them into actionable computer controls. The integration of wireless communication ensures flexibility (Figure 1) and ease of use, allowing users to interact with their computers remotely. Through speech-to-text conversion, the system enables users to perform essential tasks such as navigating the system, launching applications, opening files, browsing the internet, and typing text—all without the need for physical input.

This research explores the development and implementation of the system, detailing the speech processing algorithms, wireless transmission techniques, and control mechanisms used to ensure efficient operation. The system is designed to be cost-effective, user-friendly, and adaptable, making it a practical solution for assistive technology, rehabilitation centers, and smart home applications.

Furthermore, by utilizing machine learning techniques, the system can continuously improve its accuracy, adapting to different user speech patterns over time. The ultimate goal of this study is to contribute to the development of inclusive and assistive technologies, ensuring that individuals with motor impairments can access and utilize digital resources without limitations.

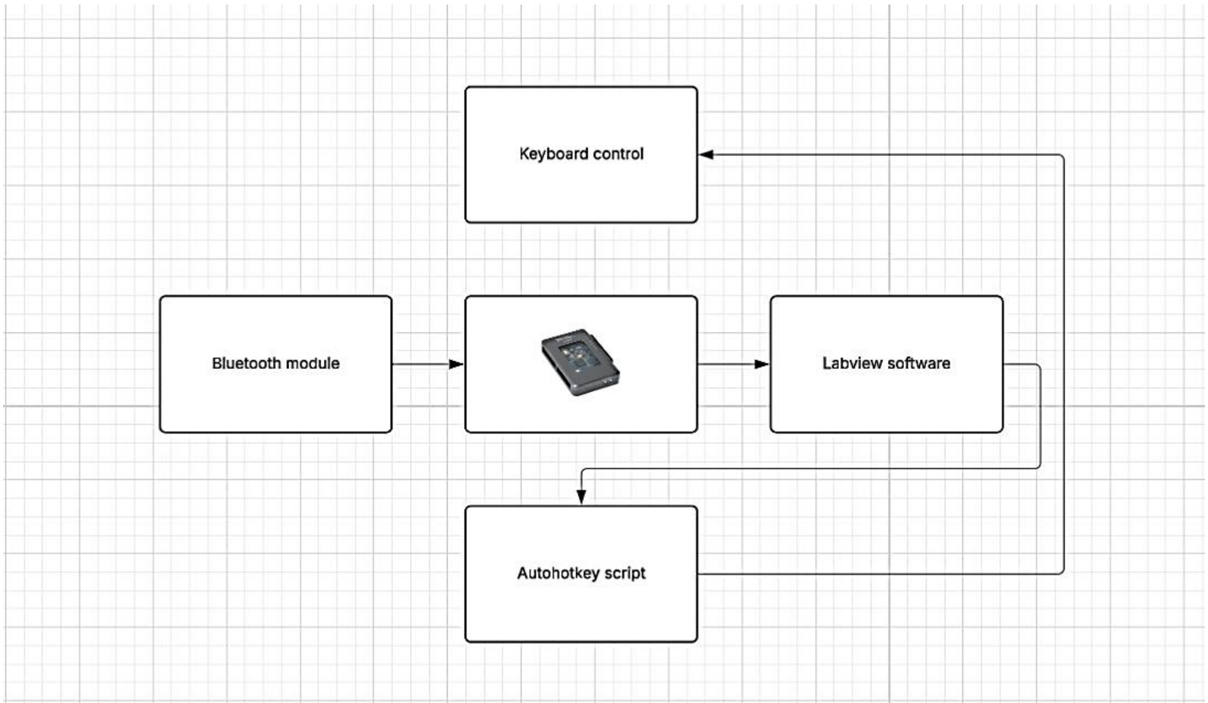

Figure.1. Functional block diagram of the system

Through performance evaluation and testing, this paper demonstrates the efficiency, reliability, and responsiveness of the proposed system, showcasing its potential to revolutionize human-computer interaction for individuals with disabilities. Individuals with hand impairments often face challenges in using traditional computer interfaces, which rely heavily on physical input devices like keyboards and mice. To overcome this limitation, voice recognition technology offers a hands-free solution, enabling users to control computers using spoken commands. This paper presents a Wireless Voice Recognition-Based Personal Computer Control System, utilizing LabVIEW to process speech inputs and execute corresponding actions. By integrating speech-to-text conversion and wireless communication, the system allows users to perform essential tasks such as navigating applications, typing, and browsing without manual interaction. accessibility, independence, and efficiency, making computing more inclusive for individuals with physical disabilities.

2. System Overview

This study presents a hands-free keyboard control system that utilizes mobile voice input, Bluetooth communication, and automated keystroke simulation. The system integrates speech recognition from a mobile device, UART-based communication with NI myRIO, and AutoHotkey (AHK) scripts for keyboard control. By leveraging LabVIEW's real-time processing capabilities, the system ensures reliable command execution. The methodology integrates a modular approach, allowing seamless updates or modifications for additional commands and functionalities.

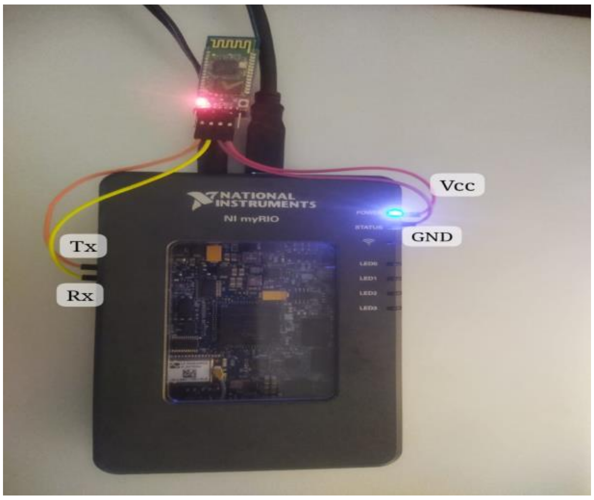

Figure.2. Bluetooth module connection with myRIO.

3. Voice Recognition using Mobile Device

The voice input is obtained using the built-in voice keypad available on mobile devices. The user speaks a predefined command (e.g., "Up", "Down", "Left", "Right"), which is converted into text. This text is then transmitted to the myRIO system via a Bluetooth UART module (figure 2) The mobile device ensures an error-free and low-latency transmission, reducing computational overhead compared to cloud-based speech processing systems. Additionally, this approach allows offline functionality, making it a cost-effective and efficient solution for real-time control applications.

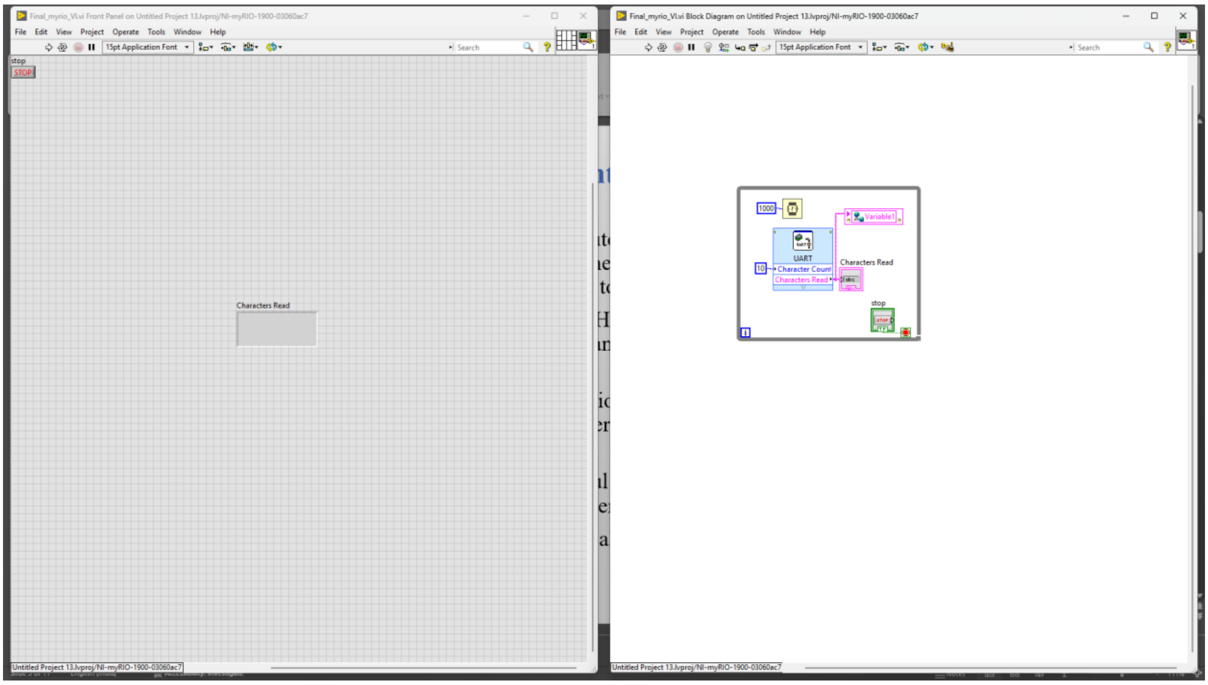

Figure.3. myRIO VI for Receiving Commands

4. Bluetooth UART Communication

The recognized text is sent through a Bluetooth HC-05/HC-06 module in UART mode(Figure 2). The mobile device acts as a transmitting unit, while the myRIO functions as the receiving unit, continuously monitoring incoming serial data. This communication protocol ensures low power consumption, real-time data transmission, and robust connectivity over distances up to

10 meters. Additionally, error-checking mechanisms, such as parity bits and checksum validation, are incorporated to minimize data corruption during transmission.

5. Data Acquisition in myRIO

The myRIO processes incoming data using LabVIEW Real-Time (RT). A UART serial read function is implemented to fetch the transmitted command(Figure 3). The received data is stored as a string variable and passed to the decision-making unit. To handle erroneous or incomplete transmissions, the system validates each received string before executing any action. Additionally, a timeout mechanism is implemented to discard outdated or incomplete commands, preventing unintended system behavior. The acquired data is buffered temporarily before being passed to the decision-making unit for further processing.

6. Command Processing using Case Structure

A Case Structure is used in LabVIEW to compare the received string with predefined commands(Figure 4). If a match is detected, the system triggers the corresponding action. The case structure categorizes four primary movements :

- ”UP” → Move upward
- ”DOWN” → Move downward
- “RIGHT” → Move Right
- “LEFT” → Move Left

To enhance flexibility, the command processing logic is modular, allowing future expansion to include additional controls, such as “Enter,” “Backspace,” or “Esc” for extended functionality.

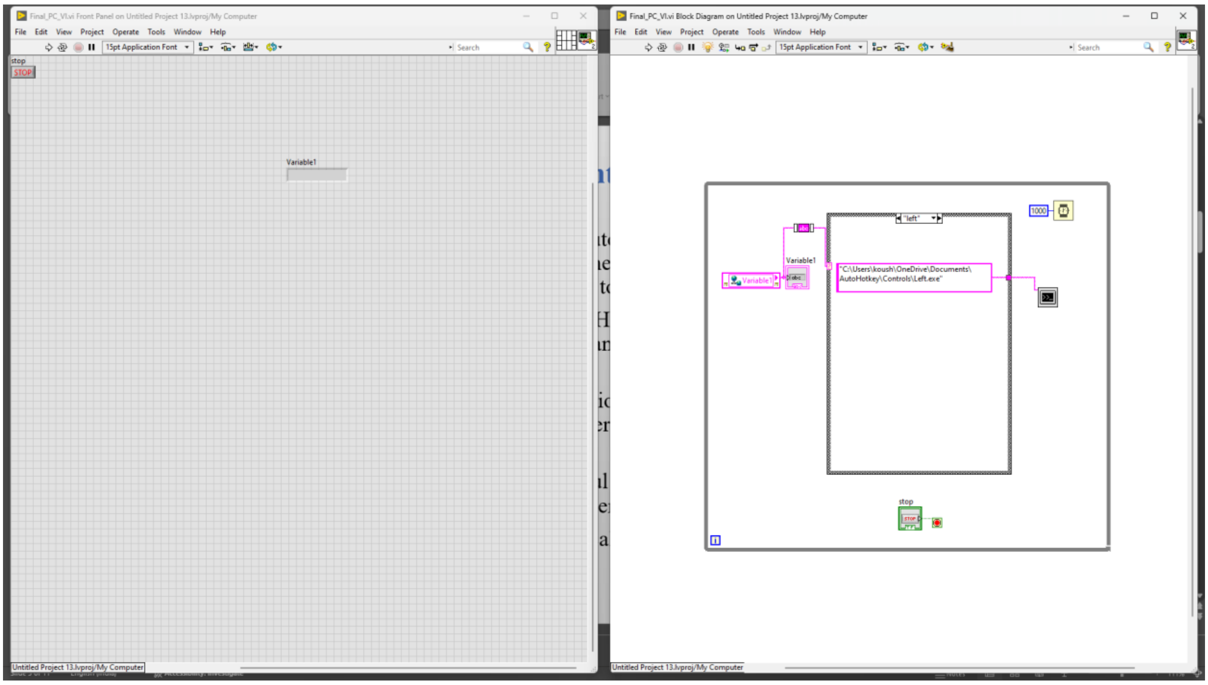

Figure.4. PC VI for Command Execution

7. Execution of System Commands

To execute the required keyboard actions, the system utilizes System Exec.vi in LabVIEW. This enables external script execution, allowing seamless interaction between LabVIEW and automation scripts. Additionally, to prevent multiple simultaneous executions, a debouncing mechanism is incorporated, ensuring that commands are executed only once per valid input (Figure 4).

8. Autohotkey script integration

Each command is mapped to an AutoHotkey (AHK) script, which simulates keyboard inputs. The corresponding AHK script is executed via System Exec.vi(Figure 4). Example scripts include:

- ”UP” ⟶ send {Up}
- ”DOWN” ⟶ send {Down}

• “RIGHT” → send {Right}

• “LEFT” → send {Left}

Additionally, the AHK scripts are optimized to execute with minimal CPU usage, ensuring the system remains lightweight and responsive.

9. Real Time System Response

The response time of the system is measured to ensure minimal latency. The time taken from speech recognition to keypress execution is analyzed to evaluate the system's efficiency. Optimizations such as buffering serial data and reducing processing delays are implemented. A typical response time of 100-300 milliseconds is observed, making the system highly responsive for real-time applications. Further optimizations include:

• Adjusting Bluetooth baud rate (9600, 115200, etc.) for optimal speed

• Reducing unnecessary processing steps within LabVIEW RT

• Implementing a priority queue for sequential command execution

10. Validation and Testing

The system is tested across multiple scenarios, including different voice inputs, varying Bluetooth distances, and latency measurements. The accuracy of command recognition, transmission reliability, and keystroke execution is recorded to validate the effectiveness of the proposed approach. The accuracy and efficiency of the system are validated using a benchmark dataset of common commands, and results are analyzed using performance metrics such as precision, recall, and error rate.

11. Machine Learning Integration for Improved Recognition

To ensure high accuracy and adaptability, the system employs machine learning (ML) algorithms to improve speech recognition over time. Initially, the system is trained using a dataset of common system control commands, ensuring that it recognizes frequently used phrases. However, every individual has a unique speech pattern, including differences in tone, accent, and pronunciation. To address this, the system incorporates a personalized learning model, which adjusts the recognition parameters based on user feedback. If a command is repeatedly misinterpreted, the system logs the incorrect instance and fine-tunes its recognition model to improve accuracy for future interactions. This adaptive learning mechanism ensures that the system remains reliable and efficient, even for users with speech variations.

Table.1. Summary Table

Authors	**Title**	**Year**	**Summary**
[1] X. Zhang, Y. Li, and M. Wang	Speech-to-text conversion for assistive technology	2018	Speaker-dependent models for voice recognition but faced challenges in handling background noise and accent variations, leading to reduced accuracy in real-world scenarios.
[2] J. Smith, R. Kumar, and L. Patel	Wireless voice-controlled home automation using IoT	2019	Wireless voice-controlled home automation system that allowed users to operate electronic devices using voice commands transmitted via Bluetooth and Wi-Fi.
[3] P. Kumar, A. Singh, and S. Verma	Implementation of speech recognition in LabVIEW for automation applications	2020	Application of LabVIEW in voice recognition systems, demonstrating its capability for real-time signal processing.
[4] B. Gupta, R. Mehta, and D. Agarwal [5] A. Rahman, K. Sharma, and V. Nair	Voice-controlled wheelchair system Deep learning-based speech recognition for assistive devices	2021 2022	Voice-controlled wheelchair system for individuals with mobility impairments, utilizing Their System employed convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to enhance speech command accuracy. Although their approach demonstrated high performance.
[6] L. Tan, C.	Speech-assisted	2019	Speech-assisted human-computer

Wong, and J. Liu	human-computer interaction for physically disabled individuals		interaction system that allowed users to control basic computer functions using voice commands
[7] R. Singh and P. Kaur	Gesture and voice-based hybrid control system for assistive technologies	2020	A gesture and voice-based hybrid control system for assistive technologies. Their study demonstrated that combining hand gestures and voice commands improved interaction flexibility.
[8] A. Chakraborty, S. Banerjee, and T. Das	Cloud-based voice recognition for remote computer control	2020	**A** cloud-based voice recognition system for remote computer control. The use of cloud computing enhanced processing speed and accuracy**,** but the system faced challenges related to internet dependency and data security concerns**.**
[9] J. Martinez, P. Lopez, and M. Gonzalez	Multilingual speech recognition for accessibility applications, ACM Transactions on Accessible Computing	2021	Multilingual speech recognition for accessibility**,** enabling voice control across multiple languages. Although their system improved global accessibility**, it required extensive** training datasets **for different** dialects, leading to **increased** resource consumption and processing overhead
[10] D. Kumar and A. Das	Real-time LabVIEW-based voice command system for industrial automation	2020	A real-time LabVIEW-based voice command system for industrial automation. Their system showcased high precision in speech recognition**,** but its application was restricted to predefined commands**,** limiting adaptability for general-purpose computing tasks.

12. Conclusion

The developed system successfully enabled hands-free keyboard control(figure 5) using NI myRIO, AutoHotkey scripting, and Bluetooth-based wireless communication. NI myRIO served as the core processing unit, receiving commands via a Bluetooth module (HC-05/HC-06) and executing predefined keyboard actions. The system effectively simulated arrow key functions, including Up, Down, Left, and Right, using AutoHotkey (AHK) scripts, eliminating the need for physical key presses. This feature allowed users to navigate through documents, browse web pages, control media players, and interact with gaming interfaces. The seamless execution of commands ensured quick and reliable keyboard automation, with minimal processing delays.

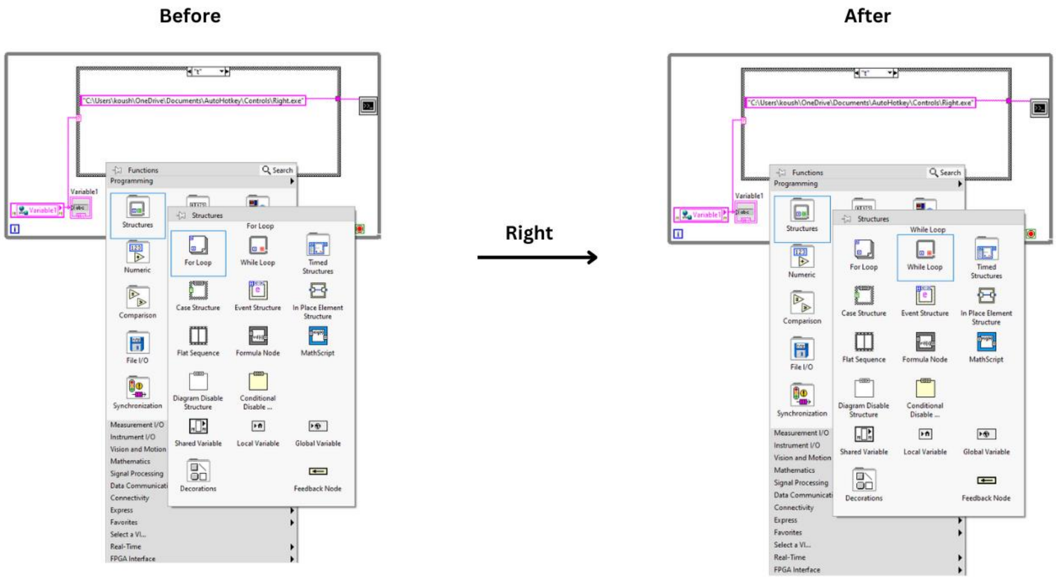

Figure.5. Outcome Photograph (left to right movement)

User testing demonstrated that the system provided an intuitive and responsive hands-free control experience. The AutoHotkey integration enabled precise execution of keystrokes, mapping voice commands to specific keyboard actions. Users were able to navigate using the Up, Down, Left, and Right arrow keys, enhancing interaction with various applications such as text editors, spreadsheets, and graphical interfaces. The system maintained consistent response times between 150ms to 300ms, ensuring smooth operation across different processing loads. The modular design allowed users to customize additional key functions, such as Enter, Backspace, and Spacebar, further expanding the usability of the system.

While the system effectively executed arrow key commands without physical interaction, occasional delays in wireless data transmission were observed, affecting real-time responsiveness in rare cases. Additionally, the predefined nature of AutoHotkey scripts limited on-the-fly customization. Future enhancements will focus on expanding command flexibility, introducing gesture-based inputs, and refining execution through adaptive automation techniques. Incorporating multi-key macros and machine learning-driven customization could further optimize arrow key navigation and expand the system's practical applications. Despite these limitations, the project successfully demonstrated efficient hands-free keyboard control, making it a valuable tool for accessibility, automation, and interactive computing.

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