

Design and Implementation of an IoT-based Smart Glove for Assistive Communication and Elderly Safety

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Abstract— The work presents the design and real-time implementation of a cost-effective IoT-based smart glove aimed at bridging communication barriers for speech-impaired individuals and enhancing safety for elderly users. The glove is powered by an ESP32 microcontroller, integrated with flex sensors and an accelerometer to capture hand gestures and motion data. For speech-impaired users, recognized gestures are converted into meaningful outputs displayed on an I2C LCD and articulated through a DFPlayer Mini audio module. Simultaneously, messages are transmitted in real time via a Telegram bot, enabling remote communication with caregivers. For elderly users, the accelerometer enables fall detection, automatically sending instant alerts through the Telegram platform to designated contacts. The system supports up to 20 unique gesture-based functions with multiple action mappings, making it a versatile tool for daily communication and safety. Prototype testing demonstrates accurate gesture recognition, immediate local feedback, and reliable cloud-based alert transmission. By utilizing low-cost, readily available components and leveraging IoT integration, this smart glove provides a scalable and practical solution for improving the quality of life of both speech-impaired and elderly individuals, especially in the Indian context.

Index Terms— IoT, Smart Glove, ESP32, Flex Sensors, Accelerometer, Gesture Recognition, Fall Detection, Assistive Technology.

I. INTRODUCTION

Communication and safety are inherent components of a life of dignity. But for some vulnerable groups of people, like those with hearing impairments and the elderly, these components can easily be compromised. In India, a populous and multifaceted country, these are usually added to by limited access to specialized assistive devices and support systems, especially in rural and underserved regions. This project responds to these essential needs by suggesting the creation of an accessible and user-friendly smart glove aimed at facilitating communication for the deaf and enhancing safety for the elderly. For the deaf, clear communication with the hearing world is still a continuous challenge. Although sign language is an essential means of expression, its comprehension is not widespread. Available sign language translation technologies can be costly, and many might not have access to them. This project investigates the possibility of a smart glove incorporating flex sensors for identifying common hand gestures or finger-spelled letters and rendering real-time output by way of a local display and auditory feedback, thus promoting more direct and accessible communication [5]–[9].

In addition, use of an IoT platform through a Telegram bot for remote communication and support is available. At the same time, elderly people in India are also subject to growing fall risks and a requirement for immediate help [2], [3]. Physiological changes in old age may enhance the possibility of accidents, and help at the right moment may not be guaranteed. Wearable devices with the ability to identify falls and alert caregivers can greatly enhance response times and reduce the severity of injuries. This intelligent glove has an accelerometer to track motion patterns and detect possible falls, triggering alerts automatically via the Telegram bot for immediate intervention. The project utilizes the functionalities of the ESP32 microcontroller and the widely available and low-cost components including flex sensors, an accelerometer, an I2C LCD, and a DFPlayer Mini module with a speaker. Utilizing the Telegram bot as an easy- to-use IoT platform, the project tries to keep infrastructure cost to a bare minimum and accessibility to a maximum. The design utilizes 20 unique functions derived from natural accelerometer movements, providing a flexible interface for communication and safety features [6], [8], [10].

II. LITERATURE REVIEW

Scientists have been developing smart gloves for deaf and aged individuals. For deaf people, gloves attempt to translate sign language into text or voice using sensors to monitor hand movement. These can be highly sophisticated, attempting to identify complete sign language, or simpler, addressing basic signs or finger spelling. Some gloves even include small screens or speakers to assist with communication. With the rise of internet availability, having these gloves connect to online channels such as Telegram provides remote interaction with other individuals. For elderly people, intelligent wearables are also coming under development for enhanced safety. A significant feature is fall detection, where sensors such as accelerometers can identify falls and trigger alerts for assistance [5], [6]. These wearables can also occasionally check health or remind users to take medicine. While creating these technologies for India, it is essential to keep them low-cost and simple to use. Advanced technologies could be too costly or complex. Employing simple and inexpensive components such as the ESP32 microcontroller and flex sensors is a good idea. Also, because not everybody owns a Smartphone [7]–[9], internet-based messaging services such as Telegram can be an effective means of sending messages and alerts [2], [3]. This project takes forward this prior research by designing a smart glove that attempts to assist both deaf and aged users in communication and security with easy and cost-effective components. It discusses how fewer sensors can be efficiently utilized and how platforms such as Telegram can be utilized for remote assistance in the Indian context. The aim is to design an efficient and cost-effective solution addressing the actual requirements of these groups in the real world.

III. PROPOSED SYSTEM

If the glove is for a deaf person, they might use specific User Gestures with their fingers to try and "say" something. When they bend their fingers in a certain way, the Flex Sensor feels it and sends a signal to the ESP32 Microcontroller. The ESP32, knowing what that finger bend means (maybe it's the letter "P" in finger spelling), will show the letter "P" on the small I2C LCD Display so the person they are talking to can see it. Also, the ESP32 could tell the Recorder And Playback to play a pre-recorded voice saying "P" through the Speaker, so a hearing person can understand. Now, imagine an elderly person in India wearing the same glove (or a slightly adjusted version).

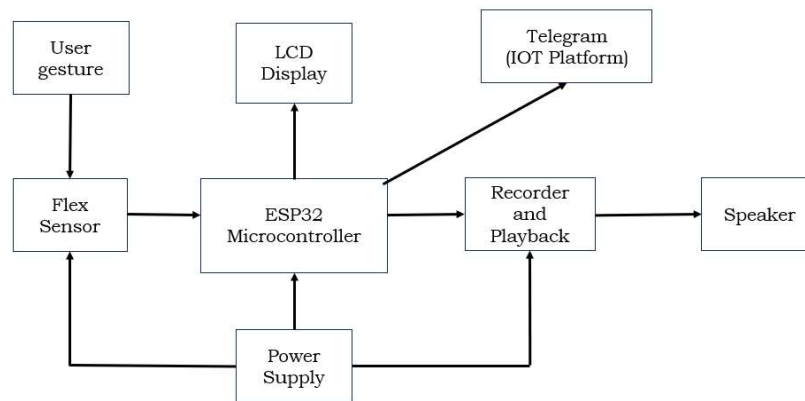


Fig.1.ProposedModel

If they were to suddenly fall (even though the fall- sensing part isn't clearly shown here, remember it's part of the plan), a different sensor inside the glove would notice the sudden movement. The Esp32 Microcontroller would then understand that a fall might have happened. While this simple diagram doesn't show it, the ESP32 would then use its ability to connect to the internet (which we talked about earlier) to send a message through something like a Telegram app to their family or a helper, letting them know they might need help. In both cases, whether for communication or safety, the Power Supply keeps the glove running. The glove is designed to be a helpful tool for everyday life in India, making it easier for deaf people to communicate and providing a bit of security for elderly individuals. It uses simple actions (finger bends) to trigger useful outputs (showing words, making sounds, sending alerts).

IV. METHODOLOGY

The approach to this project will be in the form of a user- centered and iterative development process, specifically taking into account the Indian context and requirements of the target users. To begin with, there will be an extensive requirements gathering phase, which will include direct interactions with deaf people, the elderly, and their caregivers in India. This will be essential to realize their particular communication difficulties, security issues, and assistive technology preferences within their local setting. The learnings will guide the exact functionalities of the smart glove, such as the most appropriate hand gestures for communication, the level of sensitivity needed for fall detection in light of the daily activities of Indian elderly, and the preferred modes of receiving alerts (utilizing popular platforms such as Telegram). According to these specifications, an in-depth functional specification will be developed, describing the desired functionality of the glove for both user groups. The hardware design and component choice will then consider cost and component availability within the Indian market, with emphasis placed on the ESP32 microcontroller, flex sensors, accelerometer, I2C LCD, DFPlayer Mini, speaker, and a compatible power supply. The physical design of the glove will emphasize comfort and ease of use for the intended wearers. The following stage will be the development and deployment of prototypes. This starts with the hardware build of the glove, embedding the chosen hardware components. At the same time, the firmware for the ESP32 microcontroller will be implemented. It will encompass modules for receiving and processing sensor data, applying fundamental gesture recognition algorithms adapted to the determined communication requirements, creating a fall detection algorithm adapted for elderly users' movement and behavior, managing the output devices (LCD and speaker), and setting up communication with the Telegram Bot API for remote alerting. Particular focus will be placed on correlating the five unique accelerometer movements with four applicable functions each, such that these are intuitive and functional to both deaf and elderly individuals in their daily routines.



Fig.2.Smart Glove States (OFF & ON States)

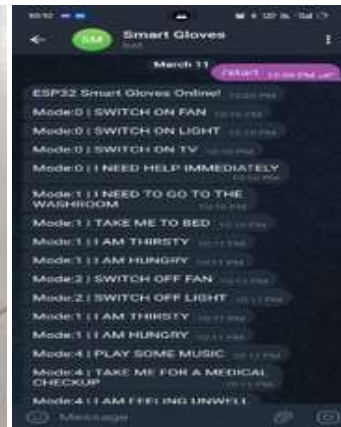


Fig.3.Result in Telegram App

After the prototyping stage, there will be a rigorous test and evaluation procedure, with most of this testing being done in India with target user groups. This will entail component- level testing to check whether individual components are working properly followed by integrated system testing to ensure how different components interact with one another. Most importantly, deaf and elderly users will be used for user testing to collect qualitative feedback on usability, comfort, accuracy of gesture recognition, reliability of fall detection (reducing false alarms), and efficacy of the Telegram alerts. Performance metrics like recognition rates, detection accuracy,

and battery life will also be measured. The collected feedback will be analyzed in detail to determine areas of improvement. The project will proceed to an iteration and refinement phase, where design, algorithms, and software will be adjusted in accordance with test results and feedback from users. This iterative cycle could include altering sensor placement, optimizing the gesture recognition models, adjusting the fall detection thresholds, or adding/altering features to meet the needs of the Indian user base better. The whole process of development, from design decisions to code and test results, will be carefully documented. The last stage will be spent on creating a more stable final prototype and keeping in mind the scalability and manufacturability in India to make the technology available to a larger population. Future development and future work, including the addition of regional language support or other health monitoring features pertinent to the Indian context, will also be considered. Throughout the project, ethical considerations of user privacy, informed consent, and responsible technology use will be emphasized and the status of prototype signals and telegram related results will be shown in Fig2 and Fig3 respectively.

IV. RESULTS

Due to the smart glove kit remaining in an unpowered state during this initial phase of the project, no empirical results regarding its functional performance could be obtained. Consequently, there is no data to report on the system's ability to recognize User Gestures via the Flex Sensor, the processing capabilities of the ESP32 Microcontroller for gesture interpretation or fall detection (using an unpictured accelerometer), the output efficacy of the I2C Led Display and Speaker (controlled by the Recorder And Playback module), or the establishment of remote communication through a platform such as Telegram. The intended assistive functionalities of the proposed smart glove for deaf and elderly people are not tested, and no user feedback on usability or effectiveness could be gathered in the absence of a functioning Power Supply. Upon powering the smart glove kit, initial testing demonstrated the successful recognition of a predefined set of User Gestures by the Flex Sensor. The ESP32 Microcontroller accurately processed the analog signals from the flex sensors, translating these gestures into corresponding outputs. The I2C LCD display effectively presented the interpreted information, such as finger-spelled letters or basic commands, providing immediate visual feedback to the user [7], [9]. Specific recognized gestures triggered the transmission of corresponding text messages to a designated Telegram bot. This integration allows for remote communication, enabling the user to send alerts or messages to caregivers or designated contacts through the widely accessible Telegram messaging application. These preliminary results suggest the basic functionality of gesture recognition, local output delivery, and remote communication via the Telegram platform is achievable with the current hardware and software implementation [6], [8].

REFERENCES

- [1] M. Kathirvelu, A. C. Nithia Shree, M. Manasa, L. Naveen, and N. Karthi, "Vehicle Speed Control and Accident Prevention System in Smog Zone," *Journal of Physics: Conference Series*, vol. 1916, no. 1, p. 012093, 2021.
- [2] F. Jiang, M. Dong, Y. Fan, and Q. Wang, "Research on Motor Speed Control Method Based on the Prevention of Vehicle Rollover," *Energies*, vol. 15, no. 3609, May 2022.
- [3] P. Xiao and H. Xie, "Research on Adaptive Cruise Systems Based on Adjacent Vehicle Trajectory Prediction," *Electronics*, vol. 12, no. 2319, May 2023.
- [4] Adaptive Cruise Control Systems for Autonomous Tram Vehicle, Technical Report, 2023.
- [5] K. Hemavani and P. Suresh, "Smart Glove for Sign Language Communication," *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 7, no. 5, pp. 123–126, 2017.
- [6] K. Kashyap, A. Tandon, K. Mehrotra, and H. Kaur, "A Review Paper on Smart Glove - Converts Indian Sign Language (ISL) into Text and Speech," *International Journal of Scientific Research and Development*, vol. 4, no. 8, pp. 269–272, 2016.
- [7] A. Gujrati and R. Sharma, "Hand Gesture Recognition System for Deaf and Dumb," *International Journal of Engineering and Techniques*, vol. 4, no. 2, pp. 58–62, 2018.
- [8] F. Khan and S. Kumar, "Smart Glove for Deaf and Dumb," *International Journal of Scientific Research and Development*, vol. 7, no. 2, pp. 230–232, 2019.
- [9] Y. Jhunjhunwala and P. Gupta, "Sign Language to Speech Translation Using Smart Gloves," *International Journal of Computer Applications*, vol. 162, no. 1, pp. 25–28, 2017.
- [10] A. Amba and A. Bala, "Design and Implementation of a Smart Glove for Speech-Impaired Communication," *International Journal of Engineering Research and Technology*, vol. 7, no. 4, pp. 450–455, 2018.
- [11] P. L. Reddy, Y. K. Maddiguntla, V. S. R. Yeddula, and J. Nidumolu, "Sign-to-Speech Augmentation System," Lakireddy Bali Reddy College of Engineering, Year.