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Braille Enabled Smart Gloves for the Deaf-Blind People

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***Abstract*— This paper introduces a novel approach employing Smart Gloves to enhance communication abilities among deaf and blind individuals, thereby mitigating the communication barrier they often encounter. The system is designed around the fundamental principles of Braille patterns, facilitating both remote and in-person communication. The Smart Gloves, worn on the left hand, integrate a wireless communication module controlled by an Arduino coding framework. Positioned strategically on the dorsal and palmar sides of the gloves are six push buttons and six vibration motors, respectively, representing the six dots of the Braille code. Users utilize these components to compose and transmit messages. Incoming messages from mobile devices or other users wearing similar gloves are conveyed through vibrations corresponding to Braille codes on the user's fingers. Additionally, the system incorporates mechanisms to identify the sender and ensure structured message delivery through predefined time intervals. The proposed device is user-friendly, cost-effective, and tailored to appeal to Braille users, thus offering a promising solution to enrich communication and dismantle existing barriers.**

***Index Terms*— smart gloves, braille, deaf-blind, tactile feedback, communication barrier, wireless module.**

I. Introduction

The World Health Organization (WHO) estimates that 285 million people worldwide are visually impaired and 39 million individuals are blind. 90% of the blind people live in the developing world. Out of India's population of 120 crore, 8.90 crore people are visually impaired and 90% of people cannot independently travel. Many individuals with severe visual impairments including blindness write and read using the braille method. There is a communication barrier between normal and blind people and although some people can read and write in braille, most normal people cannot. They may feel isolated or excluded from social activities and interactions, especially if they do not have adequate support or communication devices. They may encounter stigma or discrimination from people who do not understand their condition or respect their needs. Deaf and blind people have the right to communicate and participate in society as fully as possible. They need more awareness, recognition, and inclusion from the public and the authorities. Because of their sensory impairments, people who are deaf-blind have a distinct set of obstacles in their everyday lives. Therefore, some navigation system is required to guide them. There has been an effort to enhance the communication techniques for the deaf and visually impaired. Techniques usually tactile perception, such as manual alphabets, finger braille, and several other electric devices are the most commonly used techniques. Disability and technology are viewed as symbiotic: leveraging advancements in bioengineering technology, innovative solutions have been suggested to mitigate their effects. To address these

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challenges, Smart Gloves has been developed as an assistive device for individuals who are deaf-blind, aiding in reducing communication barriers and providing assistance. The braille pattern served as the basis for the development of the smart gloves.

A. Braille Language

The braille alphabet is a system of raised dots that can be read with finger sensation by blind and vision-impaired people all over the world in their native languages. The braille pattern is used by visually impaired individuals including people who are blind, deaf-blind, or people who have low vision. It is a universal language. It is a tactile alphabet system that consists of 6 raised dots as shown in Fig.1. It is a 6-cell ordered matrix in a 3 x 2 configuration. The combination of these cells denotes 26 basic alphabet letters and punctuation as shown in Fig.1. The primary goal of this initiative is to facilitate interpersonal communication for deaf-blind individuals. With the help of smart gloves, the glove user can send and receive messages. The smart gloves developed can convert text to braille and vice versa. The main aim of this project is to design and implement a system that (i) Enables the user to easily learn and operate the system. (ii) Without having to learn new techniques, blind users can compose and receive braille messages with ease, and the system will not cause them any inconvenience. (iii) Make it very comfortable so that it will be small and easy to carry. (iv) Providing them security with the help of technology that protects user privacy by limiting who can access messages. (v) Provide them with a low-cost, affordable device. With this glove, it is possible to ease the communication barrier between the able and the disabled.

II. Materials And Methodology

Generally, deaf-blind individuals barely rely on tactile communication due to their limitations in auditory and visual interactions with people. Over the past decades, numerous technologies have emerged that incorporate tactile sensors and actuators, utilizing sensory substitution for many beneficial applications. One of the commonly used tactile communication methods which is used especially for deaf-blind individuals is BRAILLE. The braille code is attached in Fig 1. Braille functions as a cornerstone tool for communication for both deaf and blind people, the incorporation of advanced technologies using braille as a tool enhances their communication capabilities and overall accessibility. This smart glove is based on the concept of the Braille system. In this device, a grade 1 braille coding pattern is featured. This device is mainly designed to help deaf-blind people communicate with other people without any communication barrier. They can easily communicate with hearing and sighted people and also other deaf-blind people. The concept of the smart gloves is shown in Fig.2. It is made up of woolen smart gloves that communicate with a mobile app via a wireless communication module using Arduino coding. The smart gloves user can send and receive messages from and to the mobile user and also another smart gloves user.

A. Materials

It mainly consists of TTGO T CALL V1.4 ESP32 SIM800L a wireless communication module that has an inbuilt SIM CARD, GSM MODULE, and ARDUINO CONTROLLER which enables the glove's user to send and receive messages. These gloves mainly comprise six-coin type VIBRATION MOTORS and six PUSH BUTTONS which represent the six dots of the braille. The six vibration motors are placed on the palmar side of the gloves, five motors are placed in five fingers and 6th motor is placed in the center of the palm. The six push buttons are placed on the dorsal side of the gloves, five buttons on the knuckles of the fingers, and one on the center part of the dorsal side of the gloves. This smart glove is a WOOLLEN GLOVES, chosen due to its inherent properties and comfort. For deaf-blind individuals who barely rely on the touch as the primary source of communication, integrated technology within the woolen gloves provides them seamless and familiar interface. Also, a LITHIUM RECHARGEABLE BATTERY is used. Messages are received by the glove user from another person by the haptic feedback in the form of vibration motors. The glove user can reply by tapping on the push buttons corresponding to the braille code which works by tactile feedback. Deaf-blind people can either use this glove to communicate with a nearby or remote mobile phone user as well as a smart-glove user.

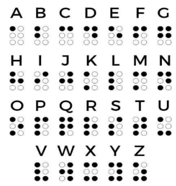

Figure.1.Braille Cell

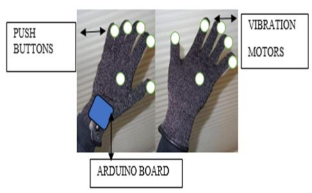

Figure.2. Concept of Smart Gloves

B. Input and Output Unit

The crucial element that facilitates message transmission and reception is the SIM800L GSM MODULE. The board features a USB C port. It comprises an ESP32 module along with the SIM800L GSM/GPRS module, which transmits the power of 22dBm. This also contains a battery of 3.7v lithium. This device also features six mini coin-type vibration motors of size 10x 2.5mm which have a nominal speed of 12000 RPM. This motor is a compact circular motor with low power consumption and small size. These motors will provide an effective way to alert us or provide haptic sensations. The 4-pin push button is used which is compact in size, comfortable and waterproof, and has a protection standard of IP65. The lithium battery is of 3.7v and 2000mAh rechargeable battery. This battery is known for its reliability and durability. All the specifications are mentioned in the table 1. The woolen gloves provide warmth, softness, and flexibility. The natural flexibility of the wool provides the incorporation of smart technology components. The wool maintains a consistent temperature for the hands which has beneficial insulating properties. This glove facilitates easy customization and facilitation.

C. Methodology

1. Receiving System

The block diagram of how the system works using the vibration motor is shown in Fig.3. The SIM card is integrated into the SIM800L within the TTGO T CALL wireless communication module. This module can read the messages sent by the mobile user using the GSM MODULE. Arduino 2.2.1 is the software used in this device. The Arduino microcontroller then decodes the alphabet and converts the alphabet to braille code using customized coding, as smart gloves only know braille language.

Vibration Motors

The interpreted alphabet is presented to the user as a vibrotactile feedback pattern. The converted braille message is then transmitted to six vibration motors placed on the palmar side of the gloves. These motors vibrate corresponding to the braille pattern. Through this the gloves wearers can receive messages. Initially, they will be alerted by the vibration of all six motors to indicate that they are receiving a message. Between the notification alert and the sender's name, there will be a gap of 6 secs. Then the sender's first three letters will vibrate and after a gap of 6 seconds the message will get received. Each letter has a gap of 3 secs and each word has a gap of 6 secs. Each motor will vibrate for a duration of 3 seconds.

TABLE I. SPECIFICATION

HARDWARE COMPONENTS	WORKING VOLTAGE	WORKING CURRENT
TTGO T CALL V1.4-ESP32 SIM800L MODULE	2.7v – 3.6v	70mA
COIN-TYPE VIBRATION MOTORS	2.0v – 3.5v	85mA
LITHIUM ION BATTERY	3.7v	2000mAh
PUSH BUTTON	12v	50mA

2. Sending System

Push Button

The block diagram of how the system works using the push buttons is shown in Fig.4. After receiving the message, the glove's user can now reply to the mobile user. The glove user should press the 6th button so that the device switches from receiving mode to messaging mode. The user then inputs their message using braille letters corresponding to the push button. To create a space the user can press the 5th push button. After a 5secs interval, a gap will be generated between words, allowing them to input another word. The contact number of the glove's user will be preinstalled with a logical code number. Once the user composes the message, they need to press the push button corresponding to the logic number of the person they wish to contact which will navigate to the page of that particular person. After a 3-second delay, they should press the 4th button to transmit the message to the intended recipient. The micro-controller will then translate the braille code to regular text which is then transmitted to the receiver. The entire setup will be in the PCB BOARD. The Arduino board, battery, and connecting wires from the vibration motors will be placed in the PCB board. And further, we have implemented this project in a real-time application for the individual who is deaf-blind and refined it based on the feedback on their needs.

D. Software implementation

1.Arduino IDE 2.2.1

To program this device ARDUINO SOFTWARE (IDE) or the Arduino integrated development environment is used. This software commonly consists of a message area (serial monitor), a text console, a toolbar, and a text editor for writing the code. At first, ESP32 wrover module, tiny GSM, and one wire should be installed to proceed with the coding. The braille pattern corresponding to the English alphabet is pre-installed in this Arduino IDE 2.2.1 version. The contact numbers and the first three letters of their name should be entered in the coding. The Arduino hardware is connected to the software. Once the code is completed it should be uploaded to the Arduino hardware using a USB C port which enables communication.

2.Writing Sketches

Programs written using the Arduino software (IDE) are called sketches. These sketches are written in a text editor. These are saved with the file extension. no. The text editor has some features like cutting and pasting the text and replacing and searching the text. The message area (serial monitor) is the major part where all the errors are displayed and also gives feedback while saving and exporting the file. The console is the area where the output will be displayed including other messages.

3.IDE Verify File

Verify and check the code for errors before compiling it.

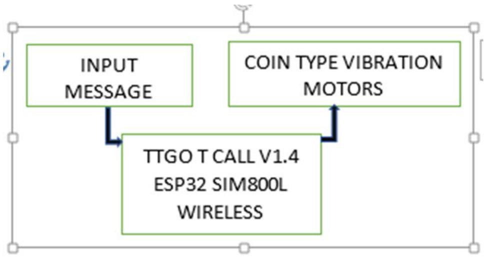

Figure.3. Block Diagram- Receiving System

Figure.4. Block Diagram- Sending System

III. RESULTS AND DISCUSSION

By the end of implementation, smart gloves are successfully designed and developed. Now, a deaf-blind individual has a method to send and receive messages. Upon receiving process, when the mobile user sends messages to the wearer of the glove, the message reaches the user promptly, facilitated by the integration of a high-speed SIM card, which ensures that the message is received within 5 seconds. To fully process and display the message from initial notification alert to complete reception it takes approximately 2 to 3 minutes. In the receiving process, upon arrival of a word, the Smart Gloves reacts by initiating a series of tactile feedback responses to convey the incoming messages to the glove's user. Once the incoming message is detected, the system generates a notification alert, signaling the user to the impending communication. Subsequently, the braille pattern encoded vibrations corresponding to the individual characters of the word are decoded with the help of gloves technology. Each vibration motor translates the word into a tactile pattern that the user can discern through touch. This process is explained with an example 1. If a mobile user sends a message "hi how r u", the active and inactive motors of this message is shown in Table 2. The palmar side of the prototype of the Smart Gloves is shown in Fig.6. Upon sending process, after a 3-second time interval, the user can switch their mode from receiving mode to messaging mode (sending mode) by pressing the 6th push button. The entire sequence of pressing the requisite buttons for message composition and all the requirements usually takes 2 to 3 minutes to complete. Within just 1 minute, the recipient (mobile user) will receive the message sent by the glove's user.
In the sending process, for a word, the Smart Gloves system responds by translating the user's input into a braille text for transmission. As the user selects the desired letters or characters through braille-coded push buttons on the gloves, the embedded technology processes these inputs and transmits them via the wireless communication module, facilitated by the fast SIM card. This rapid transmission ensures that the message is delivered accurately to the intended recipient, typically within a matter of seconds. Thus, the system reacts by efficiently encoding and

dispatching the user's composed word, facilitating seamless communication for individuals with visual and auditory impairments. This process is explained with example 2: "hi mam". The mobile user received the message and the screenshot of it is shown in Fig.8. The contact list stored in the code is shown in Fig.9. The dorsal side of the prototype of the Smart Gloves is shown in Fig.7.

TABLE II. DETAILS ABOUT THE VIBRATION MOTOR ACTIVATION WITH A SAMPLE MESSAGE.

ALPHABET	ACTIVE MOTORS	INACTIVE MOTORS
H	M1, M2 & M5	M3, M4 & M6
I	M2 & M4	M1, M3, M5 & M6
H	M1, M2 & M5	M3, M4 & M6
O	M1, M3 & M5	M2, M4 & M6
W	M2, M4, M5 & M6	M1 & M3
R	M1, M2, M3 &M5	M4 & M6
U	M1, M3 & M6	M2, M4 &M5

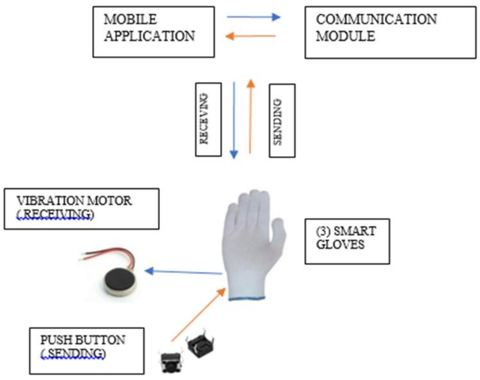

Figure.5. Smart Gloves Design- Methodology

The figure shown here describes that when some person uses mobile application (1) to send message to gloves user, it is first received to the micro-controller (2), then reaches the gloves user (3). Finally, it reaches the vibration motor and if the gloves want to reply they can use the push button (4), and this process is reversed back to the mobile application.

A. Discussions

In contrast to previous projects and papers, this project addressed the issue of glove thickness by decreasing it. To alleviate the challenge of carrying bulky gloves, we minimized the number of components used. Additionally, reduced the size of wire placement within the gloves to prevent their collapse on the user. A significant benefit of this project is its affordability, as these smart gloves are cost-effective. Took battery life as concern by enhancing it through the adoption of lithium-ion batteries, thus improving durability. Furthermore, soldering onto a PCB board and installing it into the gloves is made simple with this smart glove design. Compared to existing projects this device consists of both receiving and sending parts in one smart glove. Through this device, the user can identify the sender's name. A notification will alert you with six vibrations indicating incoming messages. Furthermore, this project incorporated specific time delays into the code to indicate the intervals between each letter and the spaces between each word, ensuring a clear and structured message delivery. The code has been customized on behalf of the sender, enabling them to send messages to any individual in their contact list. During message composition, to ensure the accuracy of the button pressed, the corresponding vibration motor will activate to confirm that the correct push button has been selected. Also, communication is unrestricted, allowing anyone to send customized messages to the user.

Figure.6. Palmar Side of Gloves

Figure.7. Dorsal Side of Gloves

TABLE III. REFERENCE TABLE OF ALL VIBRATIONAL MOTORS

MOTORS / ALPHABETS	M1	M2	M3	M4	M5	M6
A	1	-	-	-	-	-
B	1	1	-	-	-	-
C	1	-	-	1	-	-
D	1	-	-	1	1	-
E	1	-	-	-	1	-
F	1	1	-	1	-	-
G	1	1	-	1	1	-
H	1	1	-	-	1	-
I	-	1	-	1	-	-
J	-	1	-	1	1	-
K	1	-	1	-	-	-
L	1	1	1	-	-	-
M	1	-	1	1	-	-
N	1	-	1	1	1	-
O	1	-	1	-	1	-
P	1	1	1	1	-	-
Q	1	1	1	1	1	-
R	1	1	1	-	1	-
S	-	1	1	1	-	-
T	-	1	1	1	1	-
U	1	-	1	-	-	1
V	1	1	1	-	-	1
W	-	1	-	1	1	1
X	1	-	1	1	-	1
Y	1	-	1	1	1	1
Z	1	-	1	-	1	1

B. *Implementation Issues*

A few problems that arose during implementation were: (i) the coin-type vibration motors were too small to handle when connecting these wires, and they were also extremely thin, necessitating precise handling. (ii) encountered some difficulties selecting the gloves' materials. (iii) encountered some difficulties when putting the Arduino board, batteries, vibration motors, and all the push buttons in the same gloves.

IV. CONCLUSION

This project focuses on the development of Smart Gloves aimed at enhancing communication for individuals who are deaf-blind. With this device, the glove user can be able to communicate with any person who are not familiar with braille. This can be achieved by integrating mobile with smart glove technology. The mobile user can send and receive messages from the smart gloves user and the smart gloves user can send and receive messages from the mobile user. This braille-enabled smart gloves are cheap, affordable, easy to carry and use, light in weight, and also have no risk. After the project, it is a valuable and highly beneficial tool for blind individuals to communicate with others. It proves particularly advantageous for deaf-blind individuals, especially if they are proficient in Braille, enabling effective communication.

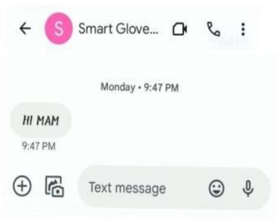

Figure.8. Message Received

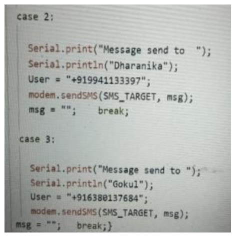

Figure.9. Contacts in Arduino Coding

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