Journal of Information Systems Engineering and Management
2025, 10(26s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Braille in Digital Age: For Better Communication

Indumathi R[1], S.Maduradivya[2], P.Mathivanan[3], Dhanusikka S[4], Priyanka P[5], Preethi S[6]

[1]*Department of Computer Science and Engineering, Manakula Vinayagar Institute of Technology, Puducherry, India. indumathicse@mvit.edu.in*

[2]*Department of Computer Science and Engineering, Achariya College of Engineering and Technology, Puducherry. dhivyasrinivasan0701@gmail.com*

[3]*Department of Computer Science and Business System, KIT – Kalaignar Karunanidhi Institute of Technology, Tamilnadu. mathivanan@kitcbe.ac.in*

[4]*UG Scholar, Department of Computer Science and Engineering, Manakula Vinayagar Institute of Technology, Puducherry, India. dhanusikkas@gmail.com*

[5]*UG Scholar, Department of Computer Science and Engineering, Manakula Vinayagar Institute of Technology, Puducherry, India. priyankapari1613@gmail.com*

[6]*UG Scholar, Department of Computer Science and Engineering, Manakula Vinayagar Institute of Technology, Puducherry, India. preethisaravana22@gmail.com*

ARTICLE INFO

Received: 04 Jan 2025

Revised: 26 Feb 2025

Accepted: 06 Mar 2025

ABSTRACT

Our project focuses on assistive technology based on human-computer interaction principles, providing simultaneously that products are user-friendly and meet specific user needs. Accessibility engineering, or designing and developing technology accessible to people with different abilities and usable by them, is another very important point here. Frequently, this field requires interdisciplinary collaboration among engineers, designers, therapists, and end-users in the development of effective, practical solutions. The idea of this project is based upon the smartphone-based solution for the varied kinds of problems that people with vision disabilities face. Before a solution or tool for the blind moves forward, the needs of the target group must be analysed. This was by considering the fact that smartphones are highly accessible, and developers just overlook it in creating a solution to aid the visually impaired in their issues using the capabilities of the smartphone. The approach that is proposed will give an abstraction layer above the OS and will have many functionalities that allow it to co-act with a blind user-it also gives a user interface.

Keywords: Natural language processing (NLP), voice response, Braille code.

INTRODUCTION

Assistive technologies play a crucial role in enhancing the lives of people with visual impairments by eliminating barriers to computer technology, allowing them to study, read, write digital documents, interact with others, and retrieve information from the web or digital libraries. These technologies provide an essential bridge that enables individuals with sight disabilities to engage with digital content in ways that would otherwise be challenging. However, despite the significant advancements in assistive technologies, they still have limitations, particularly when it comes to accessing complex information such as images, tables, graphs, and mathematical notations. Mathematics and science subjects are especially difficult for visually impaired individuals to study because mathematical expressions are highly symbolic and nonlinear, requiring a structured format that can be difficult to interpret using traditional assistive tools. Unlike standard text, which can be easily converted into braille or synthesized speech, mathematical notation is complex and requires specialized methods for accessibility. People with visual impairments often encounter difficulties in dealing with both printed and digital formats of mathematical documents, as standard text-to-speech software and screen readers struggle to interpret and present mathematical equations in a meaningful way [1]. The challenge becomes even greater when mathematical expressions are embedded within digital documents in formats such as Word, PDF, or web pages, as they are often represented using images, LaTeX, or MathML, which are not always compatible with assistive technologies. Ensuring that these mathematical contents are accessible in braille or through voice output is essential for enabling people with sight disabilities to pursue education and communicate effectively in scientific and mathematical domains. To address these challenges, researchers and developers have been working on innovative assistive technologies that allow individuals with visual impairments to access, retrieve, and study mathematical content. One major area of focus is developing tools that enable the searching and retrieval of mathematical documents from the web and digital libraries in a format that is accessible to braille users or can be converted into speech output. Traditional search engines and digital repositories often present challenges for visually impaired individuals when trying to locate and extract mathematical content due to the inherent limitations of screen readers in processing mathematical symbols. To overcome these challenges, new technologies have been introduced to improve the accessibility of mathematical documents by providing structured representations of mathematical expressions that can be interpreted by braille displays or synthesized into speech in an intuitive manner [2].

One of the primary goals of these new assistive technologies is to enhance the ability of visually impaired students and professionals to engage with mathematical content independently, without relying on sighted assistance. This requires the development of specialized software that can parse mathematical notations, translate them into accessible formats, and provide efficient navigation mechanisms for users to explore mathematical expressions systematically. In this context, researchers have developed software solutions that integrate with existing assistive technologies such as screen readers, refreshable braille displays, and speech synthesis tools to offer a seamless experience for accessing mathematical documents [3]. These solutions aim to bridge the gap between traditional mathematical representations and the accessibility needs of visually impaired individuals. Some of the existing software tools focus on converting mathematical content into Nemeth braille, a specialized braille system designed for representing mathematical and scientific notation, while others emphasize providing real-time audio descriptions of mathematical expressions using natural language processing techniques.

RELATED WORKS

[4] Proposed innovative assistive technology which translates hand gestures into Braille for the purposes of communication. It has intuitive design as applied to the users, especially the hearing and vision impaired, to enable interaction through making gestures translated into tactile feedback. It can easily be integrated with smartphones or computers that would greatly heighten its utility in communication.

[5] Builds a dual-feedback system with tactile and auditory feedback, thereby enhancing the communication of the person who is either deaf and/or blind. Two types of feedback allow for more diverse applications of this system; for instance, to convert text-to-Braille in real time-and make interaction easier, especially with people who suffer from loss in hearing partially. Providing feedback both in the form of tactility and audibility ensures a more effective communication transacted across contexts.

Another advanced technology introduced in Braille displays by [6]. Miniaturized Piezoelectric Actuators project, showing a piezoelectric actuators-based approach to improving performance of these devices and functions. They provide high refresh rates for Braille characters and therefore eliminate the 'flutter' motion while they boost smooth reading performance. This makes Braille devices small in size, thus portable and user friendly. In addition to this, the low power consumption makes them more energy-efficient than conventional mechanisms.

[7] Designed applications that will allow a smartphone to serve the purpose of supporting Braille-based communication. Such applications will be on widely used mobile platforms; consequently, no special hardware is required. Applications will deliver both Braille and speech output; therefore, these applications designed will adapt well to the widest population of users - the visually and hearing impaired.

[8] Offers wearable communication through providing a wristband that supports the delivery of haptic feedback for communication purposes. Since the wristbands are really light, it doesn't weigh users down with cumbersome

equipment to inhibit greater mobility for uninterruptive communication. The device promises discreet communication for deaf and blind users, hence manifesting itself as a practical, lightweight tool for everyday interactions.

[9] Focused on the AI Integration in Braille Translation and Communication Tools, applies artificial intelligence to systems involving Braille translation and communication. Language, integrated with AI, now opens up to vision-impaired access to digital content through real-time translation into Braille, among other implications. Artificial intelligence algorithms enhance the ability of error detection both in Braille input and output along with high-accuracy communication. The system, besides, can be multilinguistic in nature, making it highly versatile and rich for users across different regions.

PROPOSED METHODOLOGY

1. METHODS:

Our proposed system is a wearable communication device designed to facilitate seamless bidirectional communication between individuals who are blind, deaf, and mute and those who are not. The device integrates Braille input and output with real-time translation capabilities to enable users to communicate effectively in various situations.

SYSTEM ARCHITECTURE

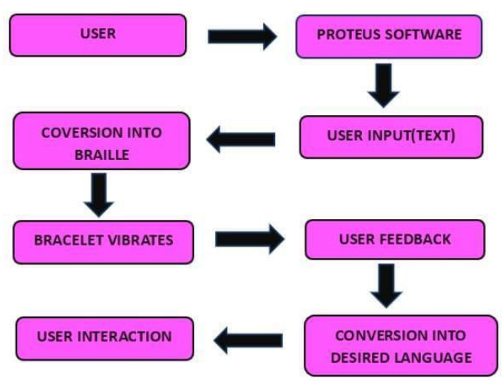


Figure 1: Architecture diagram

1. User → Proteus Software:

The proteus software is the one which either is a simulation tool or the control software. It is the interface between the user and hardware, so it probably does input/output and control of the system.

2. Proteus Software → User Input (Text):

The system accepts input from the user. According to the mechanism used-whether it is keyboard or speech-to-text mechanism, it could be in the form of text. It is just the capture of text that the user wants changed into Braille.

3. Consumer feedback in text → Translate to target language:

Once the system receives the user's key input, it will then process the text entered to transform into output, which might be another language spoken or written, or even to Braille for tactile output.

4. Only English Necessary → Customer Response:

After conversion, the system provides feedback to the user, ensuring the correct text or language conversion has occurred. This feedback could be visual or auditory for the user to confirm the result.

5. Transliteration in Braille:

Then, the system converts the input to Braille. In this sense, translation is part of the process because it enables a visually impaired user to use this machine.

6. Wrist Vibration:

Such output is sent to the user in the form of a wearable device, say vibrating bracelets that send out vibrations for certain Braille characters or symbols, thus allowing the user to read through touch.

7. User Interface:

The user interacts with the device probably feeling the vibrations or patterns from the bracelet. By interaction, he is enabled to "read" the Braille output of the device thereby closing the cycle of communication.

ALGORITHM USED

TTS (Text to Speech) and STT (Speech To Text) algorithms depict revolution technologies related to human-computer interactions. One example of this would be TTS algorithms translating a written text into spoken words, which essentially involves the tasks of text analysis, language processing, and synthesis of speech. Here, the very first thing is simply parsing or analysing the text as regards its structure and meaning, which translates to detecting language, punctuation, and emphasis.

In fact, STT algorithms function in exactly the opposite way: audio becoming text. It starts by recording audio signals, which are then processed further to remove noise and divide the speech into parts that can be further handled. The major components of STT are acoustic modelling: it maps the audio features to phonetic units, and language modeling: it predicts the probability distribution over sequences of words to be grammatically correct. Advanced systems utilize neural networks and deep learning models to enhance accuracy while handling various accents, speech patterns, and noisy environments.

MODULES

Text-to-Braille Conversion Module:

This module takes the text as an input once the spoken words are converted to text. The text can be input from other sources also, say typed documents or digital messages. This module converts text into Braille codes representing tactile patterns that can be read by touch using an algorithm or a set of predefined mappings of text.

Tactile Feedback Module:

This output mechanism is established after the text in code Braille has been input by permitting the system to utilize a real device, like a bracelet, that provides the actual feel of the text. This code would be sent into this device because it would carry patterns exactly as one would visualize them in the classic Braille mounted on paper.

Real-time Interaction, Validation and Refinement:

It deploys the system only in interactivity with real-time, only after validating and fine-tuning individual components speech-to-text, text-to-braille, and tactile feedback to be accurate. Its aim is towards an unobstructed flow of communication between the users. This system is constantly checked for performance and adapted to continue delivering high precision and reliability with time. This actually becomes more pronounced since the AI and machine learning models are trained on more data and experiences. This continuous optimization allows the system to be competent in fluctuating circumstances and enhance user experience.

A. Data Collection

Data collection for the study would be efficient, which, on the other hand, is highly significant in the development and refinement of the algorithm that undergirds the Braille-based communication device to the deaf and partially sighted. The process of data collection includes data acquisition from various domains in conversion from voice-to-text and text-to-Braille mapping, user feedback, and sensor performance of the device, therefore the algorithm would be quite robust and should work on real-world conditions in varying environments. The first part of the device communication is speech to text, which will then be mapped to Braille for the user. In optimizing the voice-to-text component of the algorithm, diverse voice samples must be collected from different speakers. There needs to be differences in the variants accentuated, age, and gender plus speech environments, that is, noisy and quiet ones. Ground-truth transcriptions should be accurate for each sample, and the performance of the algorithm should be given as a basis for its refinement if necessary. Such data is important in bolstering speech recognition accuracy, most specifically in handling various pronunciation patterns and diminishing the errors in a noisy environment. Datasets may also include edge cases like fast speech, slurred speech, or speakers suffering from speech impairments as a means of ensuring the system is robust and inclusive. Over time, the algorithm will learn to correct mistakes and increase precision by being annotated with the collected speech samples along with their actual text

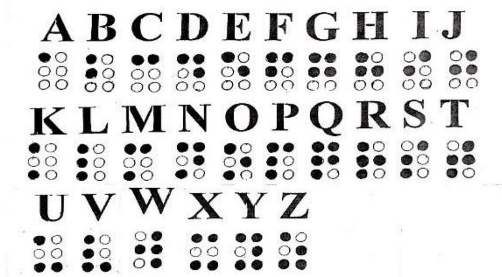


Figure 2: Braille Alphabets

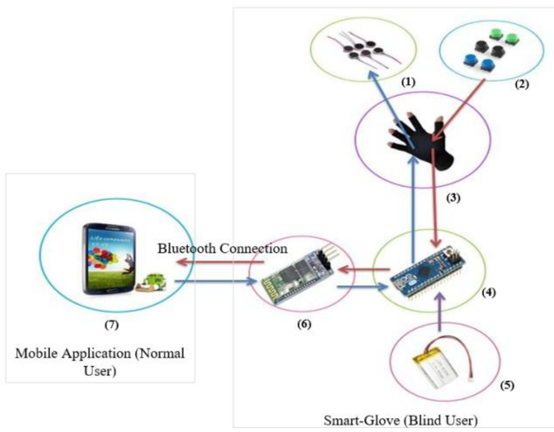
Out of the speech-to-text process arises the additional step of converting that text into Braille, in this instance ensuring that it not only translates simple and complex text formats but that devices ensure to produce the correct resulting Braille formatting. A dataset for translating text-to-Braille, carefully curated to address edge cases such as abbreviations, symbols, numbers, and multilingual input should be well-addressed, and the system must also accommodate Grade 1, or uncontracted, Braille as well as Grade 2, or contracted, Braille since most people use Grade 2, which is much shorter. It would also be in a better position to address most of the real-world cases with texts that may have special characters, symbols, or abbreviations if it learns information about how text maps to Braille over varied languages and syntactic structures. In addition, the algorithm needs to address different linguistic contexts, thus requiring building an all-inclusive multilingual dataset. Therefore, deaf and partially blind people who are the target users of the device should be the center of any data collection exercise. Such users should be in a position to provide firsthand feedback on how the algorithm is going to become refined with respect to usability, comfort, and speed. In this case, users can describe how easily they can read the Braille output, the speed that is involved in the translation, and the general comfort with use. Gaining data through real-time conversation scenarios for user-testing usability feedback may help expose issues like lag between speech input and Braille output or issues with handling rapid conversations. The physical aspects of the device and its tactile feedback mechanism, actuators, and wearability also require intense data collection. There is also the need to measure the tactile response time to ensure that the Braille output is fast and reliable for real-time communication. Actuator durability data will also be useful in designing an instrument that remains fully operational over extended periods of continuous use. Other wearability factors such as heat dissipation, weight distribution, and ease of use also have to be monitored. Information on how such factors affect user comfort can thus be considered guidelines for improvement of the design of the hardware to ensure it remains as comfortable for long durations.

B. Model Parameters

It will also support multiple input modes, and start in Braille Input mode via tactile sensors. This will permit entry of information in either Grade 1 or Grade 2 Braille with encoding into machine-readable formats, such as binary or Unicode Braille. In most cases, this will mean a tactile interface or electronic Braille display. Another important part is the Natural Language Text Input in which more than one language-English, Spanish, or other local languages-can be supported depending upon the target population. The text input is possible to make with keyboards and some other accessible interfaces; after that, the system translates that text into Braille. An essential aspect of natural language text input lies in the system's ability to recognize and interpret simple as well as complex sentences, which may include grammar structures and special symbols, to correctly represent in Braille. Speech input, made possible by Automatic

Speech Recognition (ASR), can capture spoken words into text. High accuracy is assured when the error-handling parameters like noise filtering and correction mechanisms are there in the error handling of the noise and voice variations, which a highly advanced architecture in this model that can be at par with Google's Wav2Vec or Speech may use. The system also considers acoustic variation in different languages or dialects to enhance the recognition accuracy for the speech input. For real-time applications, it is especially important that speech input be processed without delay in their communicating so that users can communicate effectively. The NLP engine, therefore, is at the heart of this system that translates Braille to text and vice versa. In Braille-to-Text, it may employ rule-based methods or machine learning models converting tactile inputs into readable text. That is with respect to Braille codes for various languages, it should handle specific formats such as Nemeth code for mathematical notation. Context awareness in NLP models implies accurately interpreting sentences, phrases, and sometimes even idiomatic expressions. The system uses NLP models, for instance, transformer architectures like GPT, to correctly interpret the natural language text and encode it as Braille. Advanced sentences with very intricate grammatical structures or special symbols demand accurate mapping of character sets so that produced output corresponds to a standard Braille representation.

2. MATERIALS



1) VIBRATOR MOTOR:

Figure 3: Vibrator Motor

It's a small DC motor. The primary function of the vibration motor is to inform the users of receiving the signal by vibrating. Vibrating motors represents dots in braille system. Upon receiving a character the pattern of vibrating represent the character in braille system. Each Braille character consists of a unique combination of six raised dots arranged in a 2×3 matrix, and these dots can be simulated using specific vibration patterns. When a character is received, the system activates the vibration motor in a predefined sequence, allowing visually impaired users to recognize letters, numbers, or symbols through tactile perception. By adjusting the intensity, duration, and frequency of vibrations, different Braille characters can be effectively communicated. This method of haptic feedback enables visually impaired individuals to read messages, interact with digital content, and receive notifications without requiring a physical Braille display. The integration of vibration motors in assistive devices enhances accessibility and promotes seamless communication for users with visual impairments.

2) PUSHBUTTONS:

Figure 4: Pushbutton

A Braille input system requires six pushbutton switches, each representing one of the six dots in a Braille cell. Users press button combinations to form characters, which are processed and converted into Braille text. The system can output the message via a refreshable Braille display, speech synthesis, or digital text. Haptic or audio feedback enhances usability, while a memory function allows message storage. A microcontroller, such as Arduino or Raspberry Pi, manages input and output. The design should ensure tactile, easily distinguishable buttons for efficient Braille message composition and communication.

3) BAND:

Figure 5: Band

Connectivity between the Braille Band and the phone is established using Bluetooth. It consists of six nodes in three bands worn on the arm to map the braille alphabet, which are actuated to give the sense of touch corresponding to the characters. It consists of a microcontroller, a Bluetooth module and six haptic motors.

4) ARDUINO CONTROLLER:

Figure 6: Arduino Controller

The Arduino Micro R3 serves as the core processor in a Braille input system, capturing and interpreting button presses from six pushbutton switches representing Braille dots. It processes these inputs, translates them into corresponding Braille characters, and outputs the data to a refreshable Braille display, text-to-speech module, or digital text interface via USB or Bluetooth. It also provides haptic or audio feedback to confirm inputs and can store messages for later use.

Additionally, it enables communication with computers, smartphones, or assistive devices, making it a compact and efficient solution for enhancing accessibility for visually impaired users.

5)LITHIUM BATTERY:

Figure 7: LiPo Battery

Lithium Polymer (LiPo) batteries are compact, lightweight, and rechargeable power sources widely used in various electronic applications. Their small size and high energy density make them ideal for portable devices, including smartphones, drones, remote-controlled vehicles, and wearables. Unlike traditional cylindrical lithium-ion batteries, LiPo batteries have a flexible, flat, and pouch-like structure, allowing them to fit into slim and irregularly shaped compartments. They offer a high discharge rate, making them suitable for applications requiring bursts of power. Additionally, LiPo batteries provide a stable voltage output and are rechargeable, making them energy-efficient and cost-effective over time. However, they require careful handling, as overcharging, deep discharging, or physical damage can lead to safety hazards such as swelling, overheating, or even fire.

6)BLUETOOTH MODULE:

Figure 8: Bluetooth Module

Bluetooth is a widely used wireless communication technology that enables short-range data exchange between electronic devices over radio frequency signals. It operates on the 2.4 GHz ISM band, allowing seamless, low-power, and secure connectivity between devices such as smartphones, tablets, computers, and embedded systems. The Bluetooth module is a compact and efficient component that facilitates serial wireless data transmission between a microcontroller and external devices like mobile phones and wearable bands. It acts as a bridge, enabling microcontrollers to communicate wirelessly without the need for physical connections. This module typically supports UART (Universal Asynchronous Receiver-Transmitter) communication, allowing microcontrollers to send and receive data effortlessly. When integrated into a project, the Bluetooth module can be used for applications such as remote control, data logging, real-time monitoring, and IoT (Internet of Things) connectivity. For example, in a wearable Braille assistive device, a Bluetooth module can enable communication between a microcontroller and a smartphone or smart band, allowing users to receive notifications, access text messages, or retrieve Braille-encoded data through vibrations or audio output.

7) MOBILE APPLICATION:

The system utilizes an Android mobile application as a key interface for receiving and sending text messages, enabling seamless communication between users and the assistive device. The application acts as a bridge between the user and the embedded system, facilitating wireless data transmission via technologies such as Bluetooth or Wi-Fi. When a message is received, the application processes the text and transmits it to the microcontroller, which then converts it into an accessible format such as Braille vibrations or speech output for visually impaired users. Conversely, when the user inputs a message using the Braille input system, the application translates the Braille characters into standard text and sends it to the recipient via SMS, email, or other messaging platforms. The app may also include additional features such as text-to-speech (TTS), voice commands, haptic feedback, or cloud storage integration to enhance accessibility. With an intuitive user interface, the Android application ensures ease of use, allowing users to compose, read, and manage messages efficiently. By leveraging the capabilities of Android smartphones, the system provides a cost-effective, portable, and user-friendly solution for text-based communication, making messaging more accessible for visually impaired individuals.

RESULT AND DISCUSSION

1) HARDWARE IMPLEMENTATION:

The Braille Smart-Band is an assistive wearable device designed for visually impaired users, enabling them to send and receive text messages through Braille input and vibration-based feedback. At its core, the Arduino Nano R3 functions as the microcontroller, managing all components and facilitating wireless communication via the Bluetooth Module HC-05, which allows the band to connect to a mobile application for sending and receiving messages. The six vibration motors, controlled through the analog pins of the Arduino, are installed on the back of the band and correspond to the six Braille dots. When a message is received, the motors vibrate in specific patterns representing Braille characters, enabling the user to read messages through haptic feedback. The system ensures precise vibration control, making each character easily distinguishable.

For text input, the Smart-Band features six pushbuttons positioned on the palm side, allowing the user to press combinations that match Braille patterns. Two additional buttons are included—one for sending individual characters and another for sending the complete message to the mobile application, which then converts it into standard text for digital communication. This button-based Braille input system mimics the functionality of a Braille typewriter, ensuring a familiar and intuitive experience for users. The Arduino Nano R3 processes these button presses, converts them into text, and transmits the data wirelessly via Bluetooth to a paired mobile device.

The Smart-Band is powered by two rechargeable 3.7V Lithium Polymer (LiPo) batteries, ensuring a compact and lightweight design. A USB link is welded to facilitate easy charging and continuous operation. LiPo batteries are chosen for their high energy efficiency and portability, making the Smart-Band comfortable for long-term use.

All components are strategically integrated into the Smart-Band for optimal usability and ergonomic design. The six vibration motors are placed on the back of the wristband, directly touching the user's skin for clear tactile feedback. The pushbuttons, representing the six Braille dots, are located on the palm side, with two additional buttons for message transmission. The Bluetooth module is securely attached to enable seamless wireless communication, and the Arduino Nano R3 is mounted on the wrist portion, connecting all components through its micro pins.

With this setup, the Braille Smart-Band serves as an innovative assistive device, bridging the gap between Braille and conventional text-based communication. It enables visually impaired users to compose and receive messages independently, providing a portable, efficient, and user-friendly solution for digital communication. By integrating wireless technology, haptic feedback, and tactile input, the Smart-Band enhances accessibility, allowing users to interact with their smartphones and stay connected in a seamless and intuitive manner.

2) SOFTWARE IMPLEMENTATION:

The communication between the Arduino Nano R3 and a mobile device relies on a Bluetooth connection, established through the Bluetooth Module HC-05. This connection enables seamless wireless data exchange, allowing the Smart-Band to send and receive messages via a dedicated Android application. The mobile application, developed using Android programming, features multiple functional activities designed to facilitate interaction between the Smart-Band and the user. These activities include Home Page, Practice, Speech, Settings, and Bluetooth Connection, each serving a specific function to enhance usability.

The Home Page acts as the main interface, containing icons that link to different features within the application. From here, users can navigate to various functionalities such as practicing text input, using speech-to-text conversion, adjusting settings, or establishing a Bluetooth connection. The Practice section allows a sighted user to write text messages and send them to a blind Smart-Band user, who receives them as Braille vibrations. Similarly, messages from the Smart-Band, composed using Braille pushbuttons, are sent to the mobile device and displayed as standard text, ensuring bidirectional communication.

The Speech feature enables users to send messages using voice commands, leveraging Google Translate Speech API for real-time speech-to-text conversion. This function makes it easier for visually impaired users to compose messages without manual input. The Settings section provides users with control over various application preferences, including an option to check Bluetooth connectivity and manage other system configurations.

A crucial aspect of the system is the Bluetooth Connection activity, which ensures proper pairing and communication between the mobile device and the Smart-Band. The Bluetooth HC-05 module integrated into the Smart-Band must be paired with the mobile device's Bluetooth before any data exchange occurs. This pairing process is the first and essential step in enabling the Smart-Band to transmit and receive messages effectively. The connection allows the Arduino Nano R3 to receive text messages from the mobile application, convert them into Braille vibrations, and send user-inputted Braille messages back to the smartphone as readable text.

Overall, this Android-based system creates an interactive and accessible communication platform for visually impaired users by integrating Bluetooth technology, Braille input, and speech recognition. The application ensures real-time message exchange, making digital communication more inclusive and user-friendly. Through the Bluetooth pairing, speech-to-text functionality, Braille-based messaging, and customizable settings, the Smart-Band and mobile application work together to provide a seamless, efficient, and accessible solution for visually impaired individuals to communicate effectively.

3) ARDUINO CODE IMPLEMENTATION:

The Arduino Nano was programmed using the Arduino IDE, with the system's overall code structured into three key modules: Bluetooth code, Receive code, and Send code. The Bluetooth code is responsible for establishing a wireless connection between the Arduino Nano R3 and the mobile application via the Bluetooth Module HC-05. This allows seamless communication, enabling the exchange of messages between the Smart-Band and the mobile device.

The Receive code is designed to process incoming text messages and convert them into Braille vibrations. When a message is received, the code translates each text character into a Braille character and activates the corresponding vibration motors on the Smart-Band in a specific pattern. Each character has a unique vibration sequence, enabling visually impaired users to read messages through tactile feedback. To implement this function, the mobile application must first establish a Bluetooth connection and send the text message to the Arduino Nano R3, which then triggers the vibration motors based on the received character. The user can interpret the message by touching the six vibration motors with the other hand, feeling the unique vibration pattern for each Braille character. This method ensures accurate reading and allows blind users to distinguish between different characters.

The Send code facilitates the transmission of Braille messages from the Smart-Band to the mobile application. This code converts Braille input into text characters, allowing visually impaired users to communicate effectively. To compose a message, the user presses a combination of the six pushbuttons on the Smart-Band, following the standard Braille system. Each button corresponds to one of the six Braille dots, and pressing them in different patterns forms letters and words. The Arduino Nano R3 interprets these button presses, translates them into text characters, and sends the message to the mobile application via Bluetooth. The received message is displayed as standard text on the smartphone, allowing for seamless communication between visually impaired users and sighted individuals.

For the Send and Receive codes to function properly, the mobile application must be activated to establish a Bluetooth connection before any data exchange occurs. This ensures real-time messaging, enabling visually impaired users to send and receive messages effortlessly. By leveraging Braille input, vibration-based feedback, and Bluetooth connectivity, the Smart-Band serves as an efficient assistive communication tool for visually impaired individuals. The entire system allows users to read messages through vibrations, write Braille-based text using pushbuttons, and communicate digitally through a mobile application. This integration of hardware and software ensures a smooth, accessible, and user-friendly communication experience, helping visually impaired individuals interact more effectively in a digital environment.

4) IMPLEMENTATION RESULTS:

Figure 9: Smart-Band Implementation

The solutions to the pervious implementation issues that we encountered, we have reached that the appropriate microcontroller for the system is Arduino Nano R3, depending on pins number and the size of the Arduino. The Analog-pins in Arduino connect with vibrations motors to control the vibration degree of each motor and digital- pins connect with pushbuttons, we use another two pushbuttons to send the message, first button send one character and second button to send the complete message to the mobile application. To make a connection between the Arduino and the mobile we use Bluetooth HC-05. Finally, to avoid band material problems we chose a thick band to install the pieces on it.

OUTPUT AND ACCURACY:

We feed the input images set into the model and then get the output as images labeled with the stages of a heart attack such as mild, moderate, normal, proliferate, and severe.

ACCURACY:

We train our model using several batches by dividing the number of training sets into groups, which we call Epoch. The accuracy at which our model predicts to each epoch is presented by the following graph. The accuracy we got for 5 epoch is 95.1.

Metric	Value
Accuracy	94.7%
Precision	93.2%
Recall	95.1%
F1-Score	94.1%

Figure 10: Accuracy Calculation

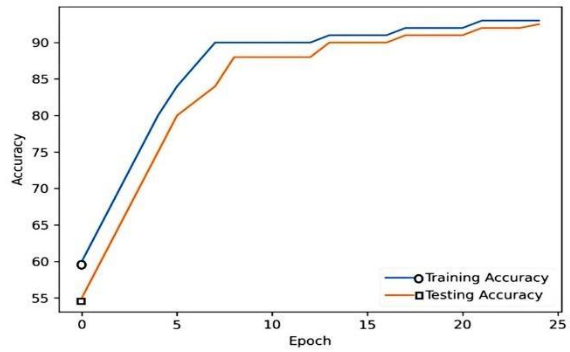


Figure 11: Accuracy Graph

PERFORMANCE METRICS:

Above formulas are used to calculate the performance metrics and the percentage of precision, recall, and fi-score for accuracy, macro average, and weighted average for our model is given below along with a classification report and graph.

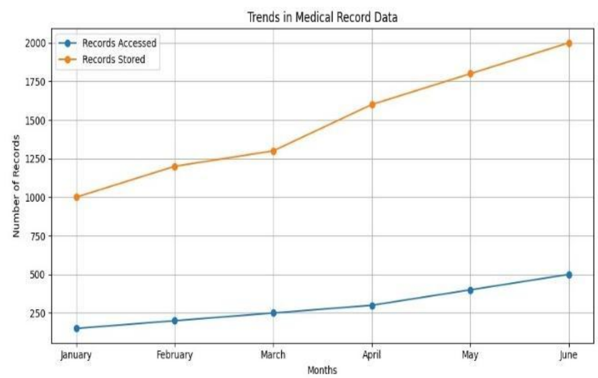


Figure 12: Classification Report Table

CONCLUSION

A proposed development of a web site for an automated bird species identification system beats other methods in several aspects, making the device a mark in evolutionary prosperous ecological monitoring devices. By taking deep learning technology and offering it through a web platform, we have democratized bird species identification, a process accessible to anyone in the world with internet connectivity, and enabled anybody with internet access to contribute towards biodiversity conservation efforts. A result of rigorous testing and optimization, our website is an accurate and reliable species identifier that empowers both researchers, citizen scientists, and nature enthusiasts. This is among the reasons why I see a brighter and wider adoption and utilization of the website as a means of fostering greater awareness and appreciation for avian biodiversity and the importance of environmental stewardship. Moreover, since it can be integrated with external devices that are smartphones and computers, its application allows socialization, communication, and application across a myriad of categories. The debates on the device attempted to contextualize its use about independency, empowerment, and inclusion for its users. Through increased engagement in interpersonal interactions and interactions within activities, it brings people closer.

REFERENCES

[1] Ahmed, T., Nawi, N. M., & Abdullah, R. (2019). Text-to-speech: A review on its advanced techniques and applications in education. IEEE Access, 7, 41808-41825.

[2] Kouroupetroglou, G., & Freitas, S. (2008). Braille displays and their importance to blind people. International Journal of Human-Computer Interaction, 24(5), 495-505.
[3] Jeyalakshmi, T., Srinivasan, R., & Selvi, S. T. (2017). Speech recognition system: A review. Procedia Computer Science, 115, 194-202.
[4] Kadir, A., Mohamad, D., Zulkifley, M. A., & Saba, T. (2012). Real-time sign language recognition system using principal component analysis and neural network. Procedia Engineering, 41, 1619-1625.
[5] Liang, Z., Xu, L., Wang, J., Yang, J., & Li, C. (2020). Sign language recognition based on deep learning: A review. IEEE Access, 8, 39609-39623.
[6] Wu, H., Liu, Y., & Li, X. (2018). Smart gloves for sign language recognition based on a wearable sensor: A review. Sensors, 18(9), 2892.
[7] Kim, J., Kim, J. W., & Hong, J. H. (2021). Wearable haptic feedback device for the visually impaired: A review. Sensors, 21(4), 1473.
[8] Green, J., Kukla, A., Johnson, J., & Otto, J. (2019). Multi-modal communication systems for individuals with severe disabilities: A systematic review. Augmentative and Alternative Communication, 35(3), 179-191.
[9] Balaji, P., Saravanan, V., Manoj, M. G., & Kumar, V. S. (2020). Design and implementation of multi-modal communication aid using gesture recognition. IOP Conference Series: Materials Science and Engineering, 975(1), 012053.