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Original Article

Design and Implementation of Digital Braille System for the Visually Impaired

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Abstract - *According to World Health Organization (WHO), there are approximately 2.2 billion people who are visually impaired in the world (Oct 2019). Braille is a tactile writing system used by people who are visually impaired and is typically written on embossed paper. Reading is the most important form of learning. According to Varao Sousa [11], reading reduces mind wandering and increases understanding. For visually impaired people, reading refers to braille reading through touch. In this digital age, where everything is done online, the visually impaired have a hard time trying to access digital content or read electronic documents. Digital braille or electronic braille is a way in which the visually impaired can access information using electronic braille displays where the digital content on the screen is converted into braille and is made available for use. Many electronic braille systems are printed onto paper, and this form of braille is susceptible to wear and tear. Most electronic braille systems used are very expensive, especially in developing countries such as India. Hence, we are proposing a digital braille system that is affordable and easy to use. The digital braille system designed converts digital text from documents to braille using python script. The system is driven by electromagnetic push-pull solenoids connected to an Arduino Uno board. The vertical movements of the solenoids represent the braille characters. Each character is read, and the corresponding dots representing the character in the braille alphabet is displayed. The system can also be a handy tool for teaching and training visually impaired people.*

Keywords - *Digital braille, Solenoids, Arduino, Visually impaired, Braille, Teaching, Training, Digitalization.*

I. INTRODUCTION

Nearly 40 million people in India are visually impaired, which is 20% of the world's visually impaired population. Braille is a form of reading and writing for visually impaired people that was developed in 1824 by Louis Braille. Visually impaired people rely on their sense of hearing and sense of touch to read and write. In this information age where everything is done with a click of a button, visually impaired people face many challenges.

Since the invention of smartphones and other internet-enabled devices, there has been a drastic change in how we communicate with each other. The internet has certainly made many aspects of our lives easier, but for those with a disability, digital exclusion is still a real problem. One of the major problems is the accessibility of specialized devices and resources. At present, companies mainly focus on the most active users who usually have stronger purchasing power and a higher level of digital literacy. Users with any type of disability are often overlooked in this market-driven and technology-oriented approach. Visually impaired people have a tough time finding good reading materials in accessible formats. Internet, the biggest repository of information and reading materials, is mostly inaccessible for visually impaired people. Even though a visually impaired person can use screen reading software, it does not make the surfing experience very smooth because the sites are not designed accordingly.

Nowadays, screen reading software has revolutionised the way the visually impaired obtain computer skills. Software such as JAWS (Job Access with Speech) enables the visually impaired to read text content displayed on computer screens by using a braille display or listening software. Screen readers help in improving computer literacy and allow greater access to the resources that are available on the internet. Contrarily, this software is very expensive due to the high cost of software licences, with each JAWS licence costing upwards of Rs 28,000. Most visually impaired people in India come from rural and poorly developed areas and have a hard time affording such technology. The obstructions faced by disabled people is determined by environmental barriers in society, so if we want to help sight-impaired users engage with the world around them, digital care is vital. Hence, in this paper, we propose a reliable Digital Braille System that can aid visually impaired people to read digital content easily and affordably.

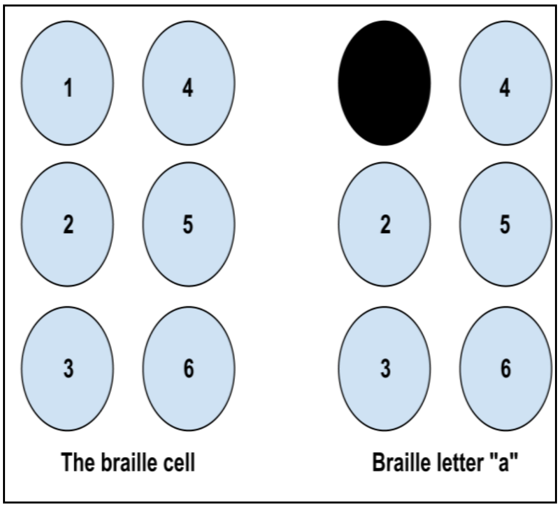

Fig. 1 An example of braille cell

Braille cells are built as rectangular cell blocks containing six dots. The braille cells have raised dots that represent the corresponding braille alphabet. The digital braille system implemented in this paper can be used to convert text from documents into braille. The braille cells are constructed using six electromagnetic push-pull solenoids representing the braille alphabet. These solenoids are connected to an Arduino Uno board which is the microcontroller for the system. This device can also be used as a trainer kit in the education sector to teach Braille to visually impaired people.

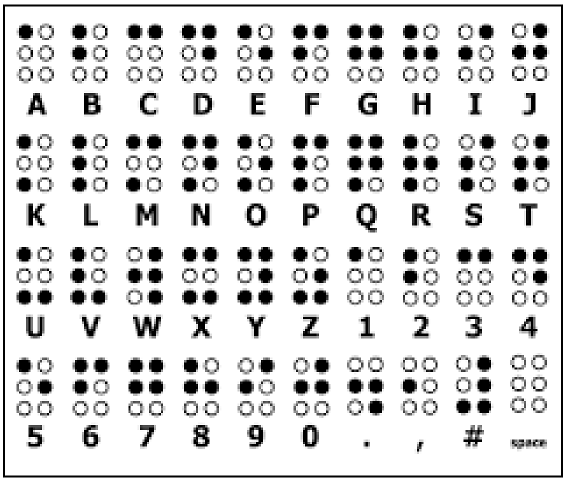

Fig. 2 The braille representation of english alphabet

II. LITERATURE SURVEY

The refreshable braille display model developed in [3] used rotary actuators and stepper motors. The braille cell consisted of eight pins. Four stepper motors were used to control the pins. Each stepper motor was provided with its own driver IC. An 8051 microcontroller was used to control the four stepper motors. The stepper motors used to draw a very high amount of current. The microcontroller cannot provide or handle this amount of current; hence the driver IC is used. However, these are highly complicated and intense. The model proposed in [5] implemented a refreshable Braille display controller that utilized Arduino because it is easily programmable. The controller for the refreshable Braille display developed had been designed for multiple Braille cells. The system used Arduino that was pre-programmed with English and Devanagari text to actuate braille cells consisting of 6 light-emitting diodes. The use of LEDs was inefficient and impractical for the visually impaired. The system implemented was not portable due to the use of many components. Awang Damit in [8] developed an education tool for the visually impaired where the input was taken from the user, and the corresponding braille code in either English or Arabic was conveyed using solenoid pins. The system had three main components—input unit, control unit and output unit. Microcontroller PIC16F877A was used as the control unit. The output unit consisted of 6 pin solenoids and Liquid Crystal Display (LCD). The model implemented did not take large inputs at once and was incapable of mapping the characters to braille at a convenient pace. The use of PIC16F877A microcontroller is expensive and inconvenient when compared to Arduino microcontrollers which are easy to use and program. The proposed system in [9] was based on the concept of one Braille cell since Braille reading is done character by character. Marcelo Bernart Schmidt developed a system with integrated hardware and software to provide digital access to braille for visually impaired people. The Braille cell was formed by six PWM (Pulse Width Modulation) servos with six steel needles at its axes. Servos were actuated by an

Arduino based platform that receives the characters to be represented on the cell through the serial port of a computer. The single braille cell was big, which is not portable. The system was customized for each user, which was expensive. The braille display developed in [12] consisted of six piezoelectric linear motors, a cover frame, a body frame, and a circuit frame. The actuator used in this was piezoelectric linear motors. The braille display system consisted of the user interface including the input device, the braille control board that converted the input information into the control signal to the braille cells, and the braille display unit providing tactile information. Actuation of piezoelectric linear motor requires a PWM signal of 60V supplied to the piezoelectric material. Such a high voltage is likely to cause an increase in the size and cost of the controller.

III. DESIGN AND IMPLEMENTATION

In this section, the working of the proposed digital braille system is explained. The system has three main modules— text analysis module, python scripting module and Arduino character mapping module, as shown in fig. 4. The text file from a user is fed as input. The text analysis module compares the text given as input from the file to its equivalent English alphabet and numbers. The built-in libraries and file handling functions provided in python programming are used to convert files into braille patterns. The programmed python script analyses the text, converts it into simple, readable text and feeds the text letter by letter to the Arduino board. The Arduino microcontroller maps the letters into corresponding braille characters. This is called Arduino character mapping. The signals representing the braille alphabet is sent from the Arduino to the respective solenoid pins. The braille script is displayed by the braille cell formed by the solenoids. Then these patterns formed on braille cells are sensed by the fingertips of the visually impaired users.

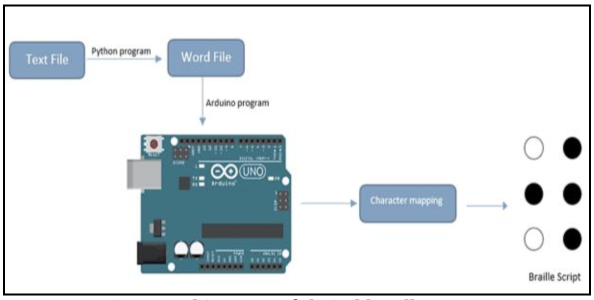

Fig. 3 Architecture of digital braille system

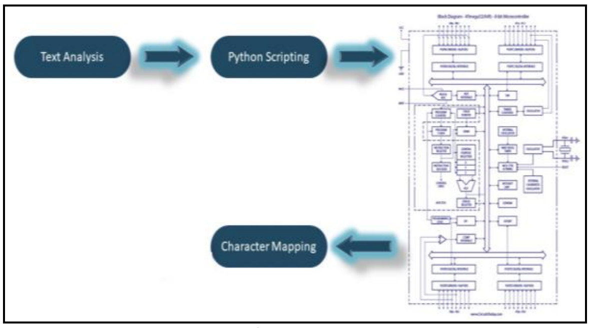

Fig. 4 Modules of the digital braille system

The digital braille system has been designed using electromagnetic push-pull solenoids and an Arduino UNO microcontroller board. The vertical movements of the solenoids represent the braille characters. Solenoids are used as actuators because of their quick operation and these useless forces, which is convenient for tactile reading. Solenoids are the most suitable actuators in terms of size, cost, simplified installation and ease of use. The six solenoids were placed together in 3 parallel rows with 2 solenoids in each row to form a Braille cell. The one end of each solenoid is connected to the positive terminal of the 5volt battery, and the other end of each solenoid is connected to the drain of individual Nchannel MOSFETS. An LCD is connected to Arduino to display the characters.

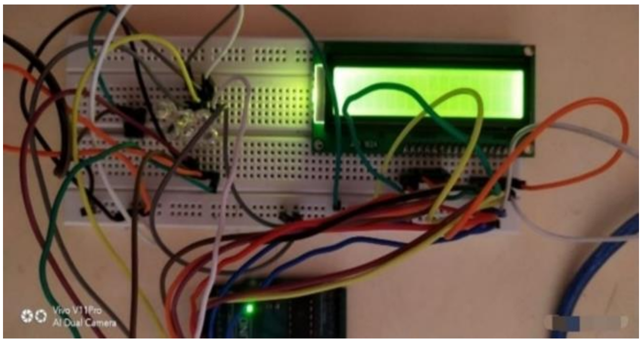

Fig. 5 Snapshot of the digital braille system

The base of each MOSFET was connected to different output digital pins of the Arduino UNO, and the emitter of the MOSFETS was connected to the negative terminal of the battery. The n-type MOSFETS work as a switch. When an input file is fed from the computer to the Arduino, it converts the input file to individual braille characters and gives an electric signal to the digital output pins. This electric signal switches on the MOSFET, which amplifies the current and allows electricity to pass through the solenoids, causing them to move vertically up and down. This changes the position of the dots forming the desired patterns, which is then read by the user. An LCD is used to display the characters being converted so that the device can be used as a teaching tool for learning braille.

IV. CONCLUSION

The digital braille system achieved converts electronic documents and other digital content into braille and helps visually impaired people to read and access them easily. A fully functional Digital Braille is successfully designed and implemented using an Arduino board and push-pull solenoids. The final prototype met all of the major design specifications. The solenoids use less force which is convenient for tactile reading. And also, Arduino is a microcontroller-based platform that is easily programmable and is a standalone system allowing for portability. So, the system implemented with these components is capable of reading text. The text that is read is then actuated in braille form. The research done proved the theory that Braille can be read from the braille cell simply by placing the fingers due to the patterns actuating rather than sliding the fingers across the already formed braille patterns. The digital braille system developed allows visually impaired people to access any electronic text easily and read on the move. This innovative prototype demonstrates that it is possible to create a digital braille module at a reasonable price and improve the daily life of the visually impaired. The digital braille system helps visually impaired people gain computer literacy. The benefits gained would transform reading for the blind and encourage digital consumption among the young.

V. FUTURE ENHANCEMENTS

Further development would be required to implement greater usability functions. There are many possibilities for the development of digital braille in the future from all the research conducted for the project. The functionality for adjusting the speed of reading would also be crucial to the usability of the device. The digital braille system could be modified to be implemented along with speech software. The use of audio together with the Braille system could be an effective learning tool.

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