Low Cost Wireless Electronic Braille Reader

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Abstract. Electronic Braille readers are getting popular worldwide day by day among the visually disabled people. Bangladesh has over half a million blind people and due to the high cost of the available Electronic Braille in the market, most of these people are unable to take advantage of this technology. To make proper use of this technology, a Servo motor based wireless electronic braille was designed. Currently available servo motor based and piezoelectric based braille have some issues with their mechanical features and price respectively. This paper is about the design and construction of a Wireless Electronic Braille Device with resolved mechanical functionality, wireless data transfer availability and much lower cost than available electronic braille of this type. The proposed design ensures correct mechanical functionality, accuracy, security, faster data transfer and lower cost.

Keywords: Wireless, E-Braille, Low cost, Apps, Servo motor

1 INTRODUCTION

Braille is a tactile writing language of raised dots, mainly used by the blind and visually impaired. It is developed for our hap-tics perception, a combination of the sense of touch, movement and finger pressure.
The dots are arranged in cells. Every cell consists of a majority of six dots in a small rectangle. A finger tip can feel the whole cell at once. The system gives 63 combinations and one blank step. In six dots Braille, each cell consists of a 3x2 matrix of raised dots. Each cell is made up of six raised dots that relate to a letter, number or character. These dots are raised roughly 0.9mm by pressure from a cylindrical pin, causing identification underneath the thick paper. The existing system lacks portability with insufficient power management. The visually impaired do not have access to e-documents and SMS without through knowledge and training to how to use the device with simplicity of operation.

Fig. 1. Real device view

Current systems available are based on Stepper motors, Servo motors and Piezoelectric crystals. Stepper motor based E-Braille has power issues whereas Piezoelectric crystal based E-Braille is very costly. On the other hand, current Servo motor based Braille does not have precise cell dimension and also suffers from initial mechanical placement error[1].

In this proposed electronic Braille system, the main objective is to eliminate the barriers that the currently available Servo motor based E-Braille suffers from and make it available within a reasonable price to the visually challenged children and adults who are deprived from using the embedded -tech device due to their lack of knowledge to use computers. The system is designed in such a way so that they can reach the e-documents with ease and also can compose short message text for sending it to the computer.

The proposed device is developed by using embedded technology with peripheral communication, wireless transceiver, Bluetooth module, rechargeable and portable batteries etc. In our proposed system, the device possesses a microSD socket for accessing stored eBooks and also has an interface for browsing them. The device can also interface with mobile phones via Bluetooth and a costumed application can capture SMS for display in Braille, can adjust the height of the pin size and can also adjust the refreshing rate of the text. The battery backup is reasonable with a tested 5 hours of uninterrupted power supply.

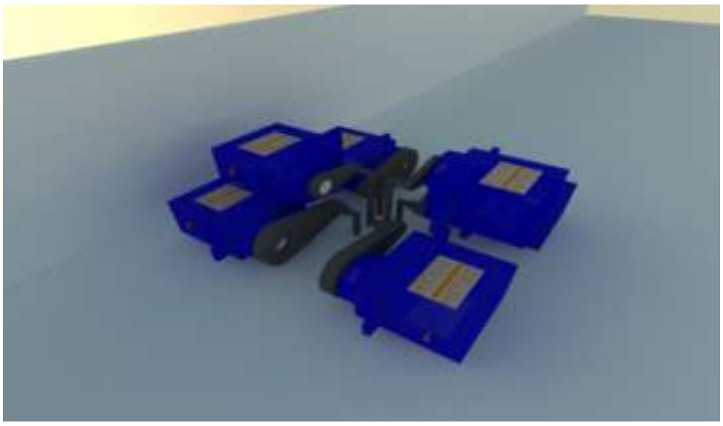

Fig. 2. Internal servo placement

2 DESIGN ARCHITECTURE

Architecture of the device can be analyzed on two platforms, Hardware and Software. The device contains mainly four parts. First part is the bluetooth transceiver which is responsible for the wireless data transferring. Second is the microcontroller which is interfaced with bluetooth and the third part which is the servo system containing 6 servo motors. The fourth part of the hardware is the Power control circuit which is connected with the servo system to limit the peak current. Here, the microcontroller is compatible with the Arduino Software libraries.

The boards functions as:

a) To produce Braille text, the microcontroller receives text from the removable memory or the wireless transceiver

b) Send them to the control board via serial interface.

c) The microcontroller then convert the ASCII characters into Braille symbol and then equivalent servo control signals to actuate the Braille pins.

d) There is another input part with six input buttons arranged like Braille text which can be used to send Braille text signal to the microcontroller and the controller generates equivalent ASCII character and can send it to the corresponding bluetooth device.

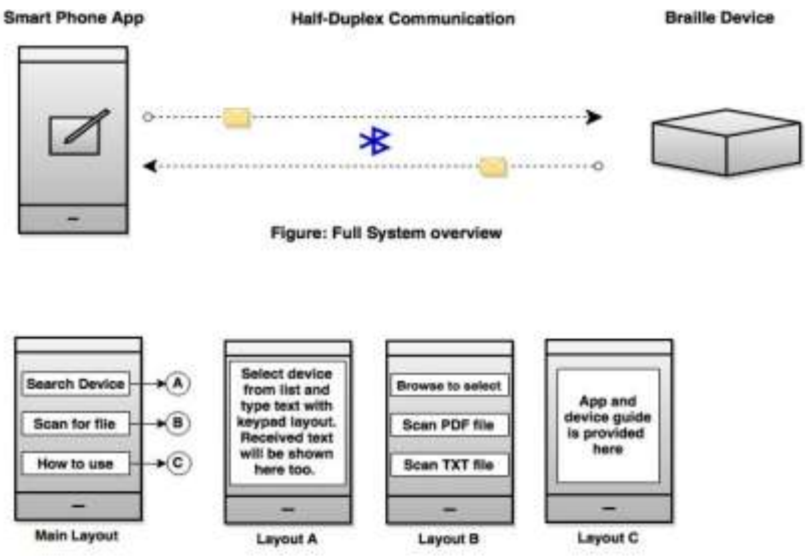

Fig. 3. The overview of the built Braille System.

3 HARDWARE ARCHITECTURE

The hardware design consists of six parts. Each of the parts has separate functions. They are given in the following sections.

3.1 BRAILLE INTERFACE

Braille Interface consists of a plate on top of two stacks of six servos. Each servo is responsible for lowering and raising a pin, which will emerge through perforations on the top plate to form a Braille dot. The perforations serve as guides for the pins, restricting their motion along the vertical axis and together they form two six-dot Braille cells which users will touch[2]. Micro servos are chosen for their lower price and the ability to maintain their positions when no power is supplied.

This reduces power consumption as compared to mechanisms where power is required to maintain the state of the Braille dots at all times[3]. Figure-2 shows the dimension of the Braille interface.

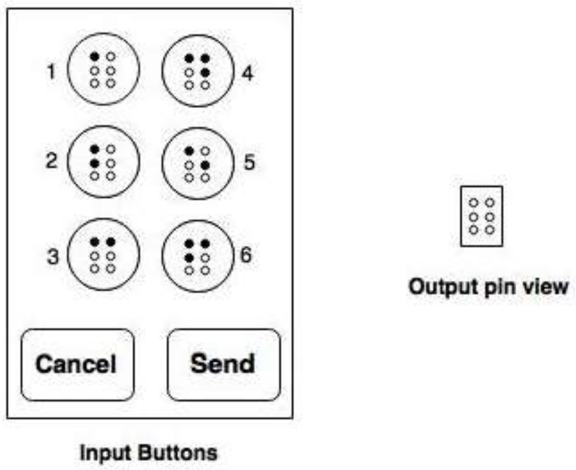

Fig. 4. Braille interface dimension

3.2 REMOVABLE MEMORY

The purpose of a removable memory in this design is to store e-books. A micro-SD card will be used as removable memory. A microSD card is one of the smallest flash memory cards on the market today. Here SD stands for Secure Digital. Secure Digital or (SD) is a non-volatile memory card format for use in portable devices, such as mobile phones, digital camera, GPS navigation system etc. Most technical measurements for the microSD card put it at 15x11x1. It is interfaced to the controller by SPI protocol, which is supported by the ATMEGA328 of the controller.

3.3 WIRELESS BLUETOOTH

The purpose of a wireless receiver in this design is to send and receive data from a mobile device. The Bluetooth communication protocol was chosen since mobile devices can communicate wirelessly to close range peripherals via Bluetooth.

3.4 CONTROLLER

Atmega328 is a AVR microcontroller that is developed by Atmel corporation. AVR is an 8-bit microcontroller belonging to the family of reduced instruction set computing(RISC).In RISC architecture the instruction set of the computer are not only fewer in number but also simpler and faster in operation compared to CISC architecture. The AVR core combines a rich instruction set with 32 general purpose working registers. All the32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers[4].

3.5 POWER SUPPLY

The power module consists of two 3.3V 1A voltage regulators, one 3.3V 500mA voltage regulator, a fuel gauging IC and a two-cell 7.4V rechargeable lithium-polymer battery (LiPo). The device is designed such that all modules are powered at 3.3V. This is because communication with the microSD card utilizes the SPI interface, which operates only at 3.3V while all other modules have a wider operating voltage range inclusive of 3.3V. If a different supply voltage is used, we would have to up and down-convert the voltage of the data signals on the SPI interface. Each one of the two 1A voltage regulators is responsible for powering six servos, while the 500mA voltage regulator is responsible for powering all the other modules[5].

4 PROGRAMMING IDE

In the proposed system ATMEGA microcontroller has been used as this supports Arduino platform which is the efficient IDE tool uses simplified library functions of C/C++. It is inexpensive and can support windows, Mac OS x and Linux. It makes input/output operations much easier. Arduino is a open-source single-board microcontroller, descendant of the open-source Wiring platform, designed to make the process of using electronics in multidisciplinary projects more accessible[6].

The Arduino IDE is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring project. It refers to an open-source electronics platform or board and the software used to program it. In essence, this platform provides a way to build and program electronic components. Arduino programming language is a simplified form of C/C++ programming language based on what Arduino calls "sketches," which use basic programming structures, variables and functions. These are then converted into a C++ program. Other open-source electronics prototyping projects, such as Wiring and Processing, provide the underpinnings for Arduino technology[4].

4.1 COORDINATION OF FRAMEWORK

4.1.1 Initialization

- **Library initialization**: Here servo.h library is needed to be included to operate servo motors.
- **Variable Initialization**: An array of six servo motor variables provided with servo.h library and few global variables have been initialized according to device requirement.

4.1.2 Void Setup

Step 1(Ready Device): This function comes first time when the device is switched on and runs for one time only.

- Hardware Serial Communication baud rate(9600) is fixed here and microcontroller establishes serial communicates over bluetooth device.
- Microcontroller arms and ensures initial position of rotation of all these six servos by giving specific rotation value.
- Then goes to Step 2.

4.1.2 Void Loop

Step 2(Mood Selection): This step fixes device mode such as send, receive and end mood.

- If send mode is selected then goes to step 3.
- If receive mode is selected then it goes to step 4.
- Otherwise goes to step 5.

Step 3(Send Mode): Enables braille input buttons, decodes them into ANSII character and sends them into smartphone via bluetooth.

- Microcontroller reads all the braille input buttons dedicatedly in this step
- Takes input in braille format
- If user press send button then microcontroller decodes braille input into ANSII character and send this via serial communication over bluetooth
- If user press cancel button then microcontroller considers this entry as wrong or unnecessary and does not decode to send
- User must to press send button to send every individual character
- After pressing send or cancel button, it goes to step 3 to check device mode
- This job will be continued until user change the device mood and microcontroller will often check device mood at the time of operation

Step 4(Receive Mode): Disables braille input buttons, receives and presents incoming data in braille format.

- In this step microcontroller disables input button and only concentrates into receiving ANSII characters from smartphone via serial communication over bluetooth
- Encodes this ANSII character into braille system
- Fixes which servo will pull up their pins or which will not
- After every character representation, goes to step 3 to check device mode.

Step 5(End mood): Denotes whether user wants to go to the standby or sleep mode

- Device does not give any power to bluetooth module or servo motors and does not take any input from any button without mode selection button

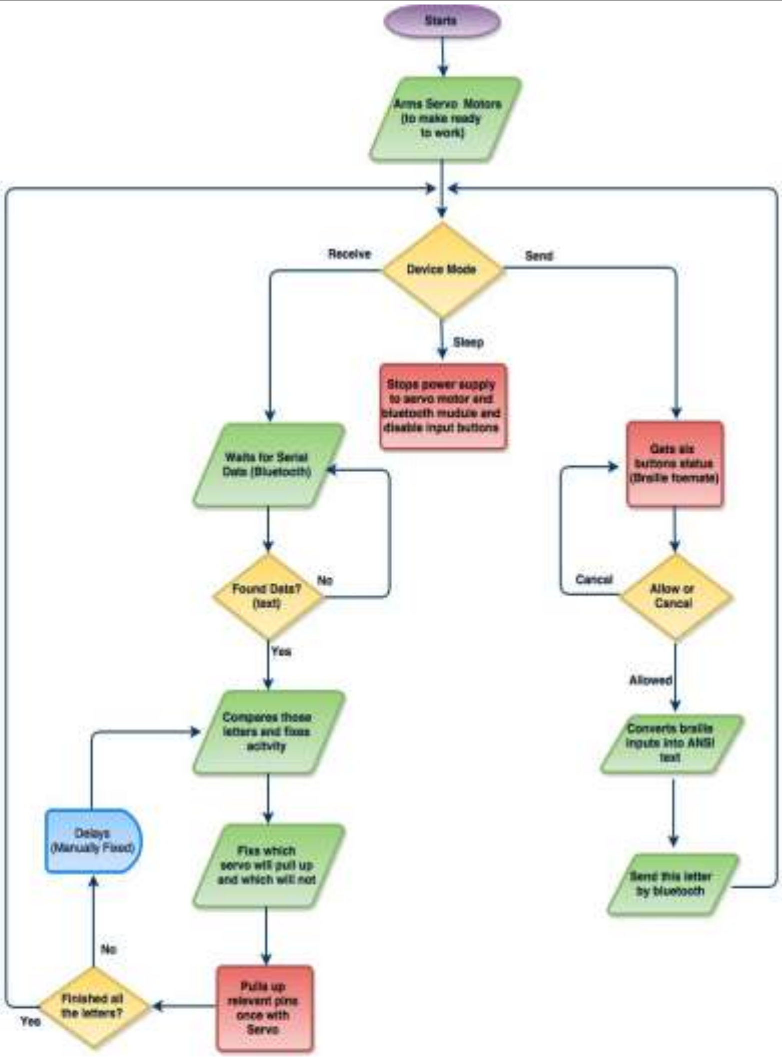

Fig. 5. Overall system flowchart

5. HARDWARE MANAGEMENT

5.1 SERVO DISPLACEMENT CONTROL

A severe mechanical problem arises when the servo system gets the initial power. Any servo system ends up in an ambiguous position when initial power is supplied. If this happens in a Servo based Braille system, the Braille touchpad pins will be disoriented. But this problem is solved by fetching power from the microcontroller to the servo system rather than fetching power directly from the power supply. After turning on the device, the microcontroller is started first and then its MCU firmware starts servo signal from a pre-calibrated value. After ensuring proper and pre-calibrated servo signal, the Microcontroller provides signal to a relay which is connected with servo main power supply. As soon as the servo starts, it has no chance to move back to any ambiguous position because calibrated servo signal has already started before the servo is switched on. Figure-2 shows the actual dimension of a Braille where the horizontal pin to pin distance is 3.7mm and vertical pin to pin distance is 2.5mm. The required dot height of a Braille is 0.019" and refresh rate is at least 7.5 characters/s[7]. To make the Braille device user friendly, above mentioned actual dimension is maintained and to make it more user friendly the refresh rate (gaping time), character staying time and pin height are kept adjustable so that the user can adjust those according to his/her comfort level.

5.2 POWER MANAGEMENT

In this device LM2596S power module is used As a power regulator. It was found that it starts operation from input voltage as low as 2.58V and for 2.58V input, output is 2.55V. This allows to use large input voltage range. So two lithium cell in series can provide enough voltage. Both batteries are set to discharge as low as 2.7V (2.7+2.7V=5.4V). We can use various types of batteries. The device running time can be enhanced up to 5 hours by using Panasonic NCR18650B battery[8].

The Braille interface requires 300mA to 1300mA (1.5watt to 6.5watt) depending on which characters are being displayed. When more pins rise up, the device consumes more power. Although digital servo is faster than analogue servo but digital servo is power hungry and costly[9]. The required response time and precision level is comfortably achievable by using of analogue servo system. The braille head pins are directly mounted to servo without using any extra mechanical gear which makes it less power hungry and adequate responsive. It also makes it simple and less noisy[10].

6. RESULT

The device has been tested several times with the help of some visually impaired people of Narsingdi, Bangladesh. The device performed perfectly and it was up to their satisfactory level.

Fig. 6. Testing by visually impaired persons

7. CONCLUSION

The messages and e-text in ASCII form can be converted successfully into Braille text with this low cost Wireless Electronic Braille Reader and hence we can conclude that the blind can get a chance to access and utilize the e-doc and web resources with ease and simplicity. The designed portable device is powered up by rechargeable lithium polymer battery and executed on open source powerful software environment It is easy to handle by the visually impaired users with their abilities.

Future work in this field can be done by adding a facility to read data from Flash drives, enabling voice command function and to add a GSM module for providing texting service for the visually impaired. This would make the system more easy to handle and provide step by step instructions to access the internet and extract the technology to the maximum limit.

Acknowledgements

Testing of the Low Cost Wireless Electronic Braille would not be possible without the help and cooperation of the visually impaired people of Narsingdi, Bangladesh. A video of the device being tested by some visually impaired people is available on our youtube channel in the following web link.
https://www.youtube.com/Nabilphysics

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