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Text to Speech Implementation of E-Braille Bench with Smartphone APP

Ravinder Pal Singh[1], Ajay Singh Rana[2], Monika Mehra[3], Dakshim Chhabra[4], Amit Dubey[5]

(ECE, ME, Incubation Department), RIMT- Institute of Engineering and Technology

Abstract: **this paper presents an embedded system based approach to implement the text to speech (TTS) with Smartphone App, to facilitate learning of Braille literacy system, aimed primarily at children between 4 and 7 years, taking into account physical and functional aspects that assure as comfort, inspiration , perpetuity and user-friendliness with Braille language. The device communicates wirelessly with a smartphone mobile, computer system and it is integrated with smartphone app and software that will be tutor, the output will be audible & embossing at user end (blind) and evaluating the blind entered text by generating a sound of right or wrong word. So speech synthesis and Text to speech is used for the system.**

Speech Synthesis is the simulation of the human speech. The design is based on electronic system with enhanced computing algorithm is known as speech synthesizer. The text from Smartphone APP is communicating to the Braille Display and Braille Piezo cells. The Text to Speech (TTS) allows the teacher to provide the braille code embossed over braille display and listening over the loudspeaker to the visual impaired persons. The aim is to make the teacher independent from the hardware and simple conversation from text to speech by using Smartphone app or Computer App. The system will be portable solution for visual impaired students.

Keywords: **Text to Speech, Smartphone App, Bluetooth, Wifi, Zigbee, Arduino, Braille Teacher.**

I. INTRODUCTION

Today, as many organization and technologists focusing on designing of various equipment's, emerging technologies to enhance the same as smart technology for majority areas. The same is needed in other areas of the communities like the physically challenged and visually challenged people. To make their lives easy to survive at in every aspect and important parameters of the life; one of them is education. Currently, Braille's teaching of the traditional way is used, i.e. is a long and slow process, requiring constant motivation, love of learning and great skill also on the part of the teacher.

Although there are various braille equipments, Braille Learning Machines are designed to facilitate the learning of Braille, these are costlier and not under Smart Technologies. And the need of the Smart Braille System those will communicate with rest of the world's machines. The upcoming trend of IoT (Internet of Things), Smart Machines, Speech Controlling and Smartphone APP Controlled Machines, Based on the research projects carried oriented teaching Braille both internationally and nationally, features, advantages and disadvantages of each one and considering the challenges faced by the teachers of same area give the idea to design and develop a low cost Smart Braille Teacher with Smartphone APP to facilitate Braille's learning aimed to teach visually Impaired children between 4 to 10 years.

The design is tested with two microcontrollers Arduino UNO ATMEGA328P and Microcontroller 8051 with two mode of communication (i.e. wirelessly with Bluetooth module HC-05, Wifi and XBEE S1), Two types of GUI (i.e. Smartphone App and XCTU), Two types of input mechanism (i.e. Speech and Keyboard) and Two type of packaging (i.e Portable and braille desk). To teach the blind the teacher can use either smartphone app with typing or speech and Laptop and desktop with typing or speaking. The braille desk systemized with audible speaker, braille piezo cells or solenoids, LED Matrix Display (For teacher), MIC, Braille Keypad and Microcontroller. The portable solution systemized with braille refreshable display, MIC, braille keypad, microcontroller and battery bank. The feedback correct / incorrect mechanism tested for accurate learning.

About Braille and Proposed Research Methodology

Braille is writing system which enables blind and partially sighted people to read and write through touch. It was invented by Louis Braille (1809-1852), who was blind and became a teacher of the blind. It consists of patterns of raised dots arranged in cells of up to six dots in a 3 x 2 configuration. Each cell represents a letter, numeral or punctuation mark. Some frequently used words and letter combinations also have their own single cell patterns. Braille can be seen as the world's first binary encoding scheme for representing the characters of a writing system. The system as originally invented by Braille consists of two parts:

i) A character encoding for mapping characters of the French language to tuples of six bits or dots.

ii) A way of representing six-bit characters as raised dots in a Braille cell.

Today different Braille codes (or code pages) are used to map character sets of different languages to the six bit cells. Different Braille codes are also used for different uses like mathematics and music. However, because the six-dot Braille cell only offers 63 possible combinations (26 - 1 = 63), of which some are omitted because they feel the same (having the same dots pattern in a different position), many Braille characters have different meanings based on their context. Therefore, character mapping is not one-to-one.

There are a number of different versions of Braille:

i) ***Grade 1:*** This grade consists of the 26 standard letters of the alphabet and punctuation. It is only used by people who are first starting to read Braille.

ii) ***Grade 2:*** This grade consists of the 26 standard letters of the alphabet, punctuation and contractions. The contractions are employed to save space because a Braille page cannot fit as much text as a standard printed page. Books, signs in public places, menus, and most other Braille materials are written in Grade 2 Braille.

iii) ***Grade 3:*** This grade is used mainly in personal letters, diaries, and notes, and also in literature to some extent. It is a kind of shorthand, with entire words shortened to a few letters.

In current age the different number of braille systems and braille tutors are available such as Braille translator, Tactile graphic, Tangible symbol systems, Refreshable Braille display, Nemeth Braille (for math) and etc, from these technologies and the age of the smartphone smart electronics the idea arose to develop the Smart braille system to make the braille education more easy and fast; where the teacher can easily provide the braille education to the visually impaired personalities so to make them more independent. The research work carried out with a Smartphone App, Text to Speech, Speech to Text, Speech to braille embossing and use of different wireless channel with low cost approach.

II. SYSTEM ARCHITECTURE

A. The Smart Braille System is systemized in two flows as illustrated in the block diagrams fig (a), fig (b) and fig (c), fig (d) for forward and reverse communication respectively.

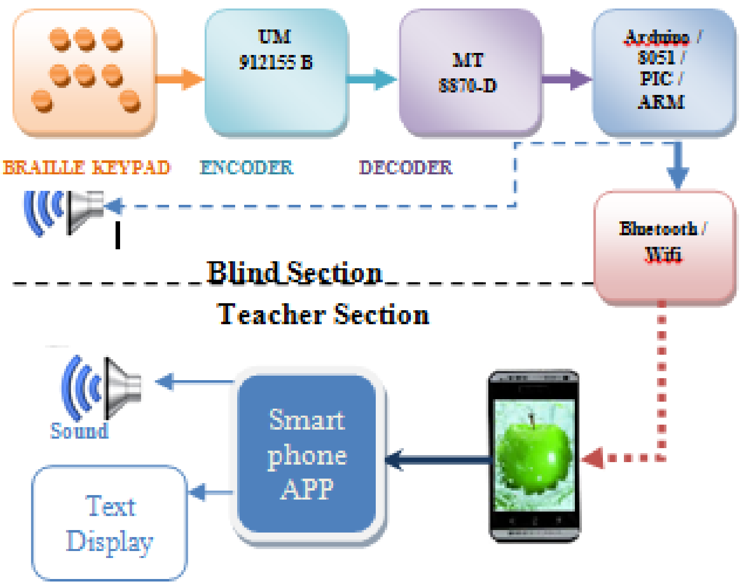


Fig (a): Forward Communication Link

In Smart braille system the Forward Communication Mode occur when the visually handicap or blind enter any braille code from braille keypad then audio and visual will be appeared on teacher end and braille desk. During this mode of communication, it consists of:-

i) Braille Keypad: with 8 keys, out of which 6 keys are used to type the character, two are for shift and enter operation.

ii) Encoder The Key pressed is processed by the Encoder and it produces a DTMF (Dual Tone Multi-Frequency) signal.

iii) Decoder: Decodes the frequency signal and sends the location of the key pressed to the any used microcontroller family (PIC/Arduino/8051/ARM).

iv) Microcontroller: It reads the data from the decoder processes it and sends the character to the PC via XBEE

v) XBEE/Bluetooth: This is used to transfer the character from the Micro controller to PC in wireless mode.

The forward path communication from blind to teacher and Reverse path communication algorithmic and software with the use of embedded c, Java Script for Text to Speech and tested with XTCU utility software over PC hyper-terminal / USB port.

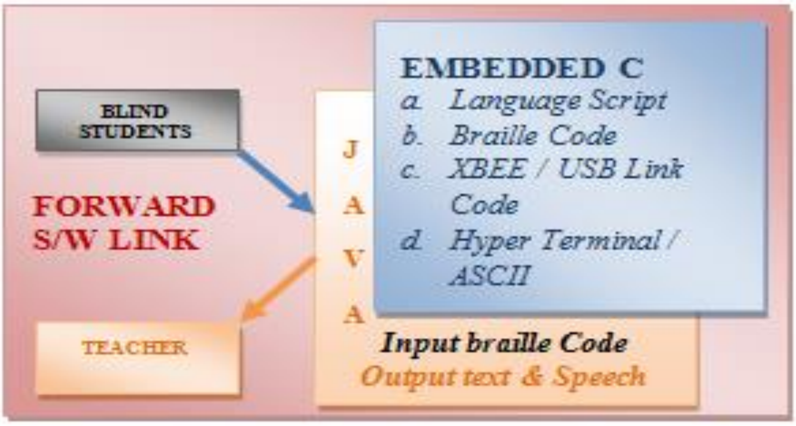


Fig (b): Forward Software Link

In Reverse Communication Mode occur when the Teacher of blind student enter any alphabet or character on smartphone App. braille code audio and piezo-cells/solenoids/ will be activated or pop-up on braille desk; for refreshable or pop-up systems used are:

i) Solenoids and braille piezo cells

ii) Current Driver: The current driver is used to drive the braille piezo cells or refreshable display.

iii) Shifting / Demux: ICs 74HC138 and 74HCT595 is used to make the solenoids / display / piezos as a refreshable display.

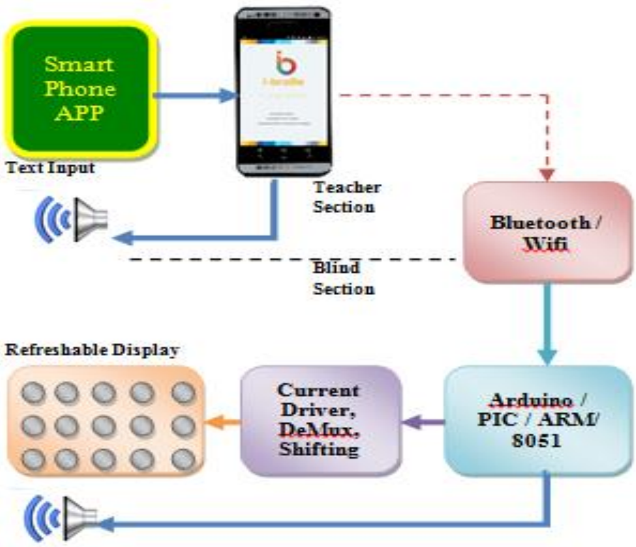


Fig (c): Reverse Communication Link

The all results achieved on ARM7 LPC2148, PIC16F, Arduino and 8051.

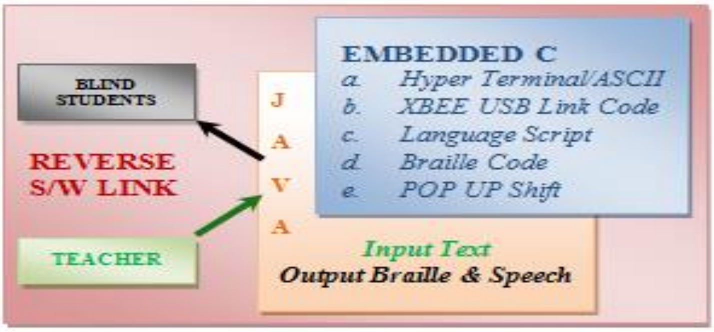


Fig (d): Reverse Software Link

The 95% accuracy is achieved for three to five words with space maximum length of 21 characters. For further improvement for a single to double line with maximum length 64 characters is to be done.

B. Major Components:

a. Arduino UNO R3: The Arduino Uno R3 (used as Microcontroller) is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

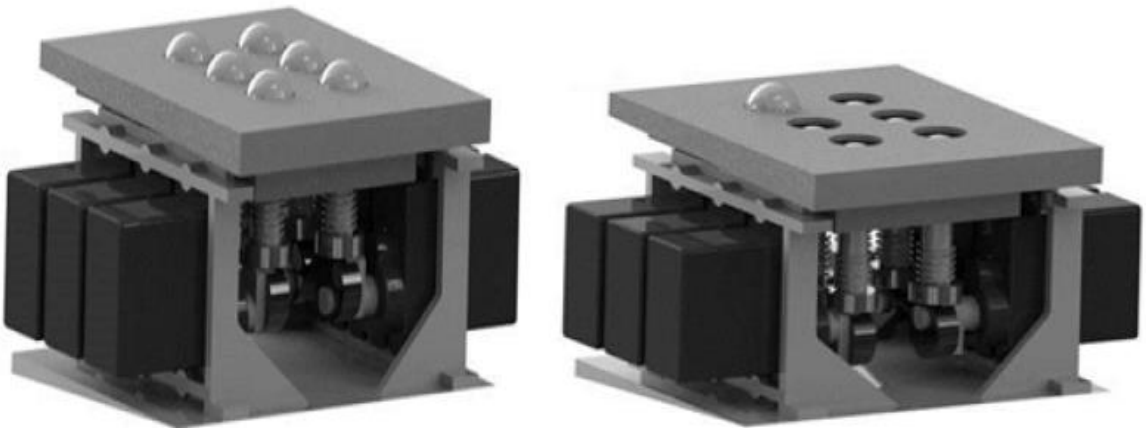
***b.* Bluetooth HC-05:** is an easy to use Bluetooth which can work both as a master and also as a slave, it works on Serial Port Protocol (SPP) with support for Enhanced Data Rate, which makes it first preference among hobbyist for designing a transparent wireless serial setup. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology.

In intelligent Braille system, HC-05 fulfills the requirement of Secured network with zero interference, which is achieved with AFH (Adaptive Frequency Hopping Feature). In this Arduino based Intelligent Braille System is working as master device and it can connects to multiple slave device.

III. ENGINEERING DESIGNS

a. Mechanical Design

The mechanical design is tested and simulated on solid works, formed in braille desk (a kind of desk, where blind student can receive and send the braille code). For this mechanism the servo system / solenoid system [1] will be used in where 5 to 6 braille boxes [1] will be used for receiving the braille code. And to send the braille code the braille Touch keyboard is designed with touch screen with three additional switches for enter, shift and speech output purpose. Both reading and sending mechanism will be evident by the following diagrams:



a) b)

Figures Represent servomechanism and Vowel a

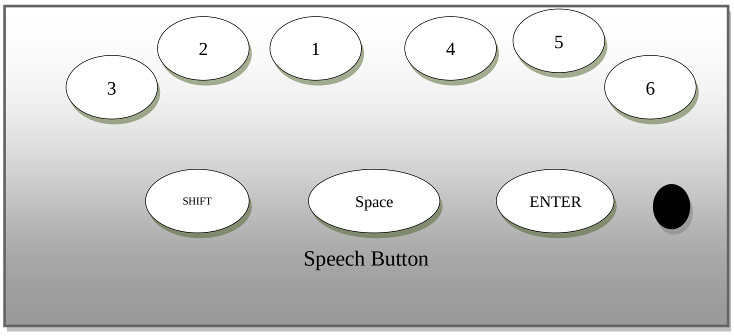
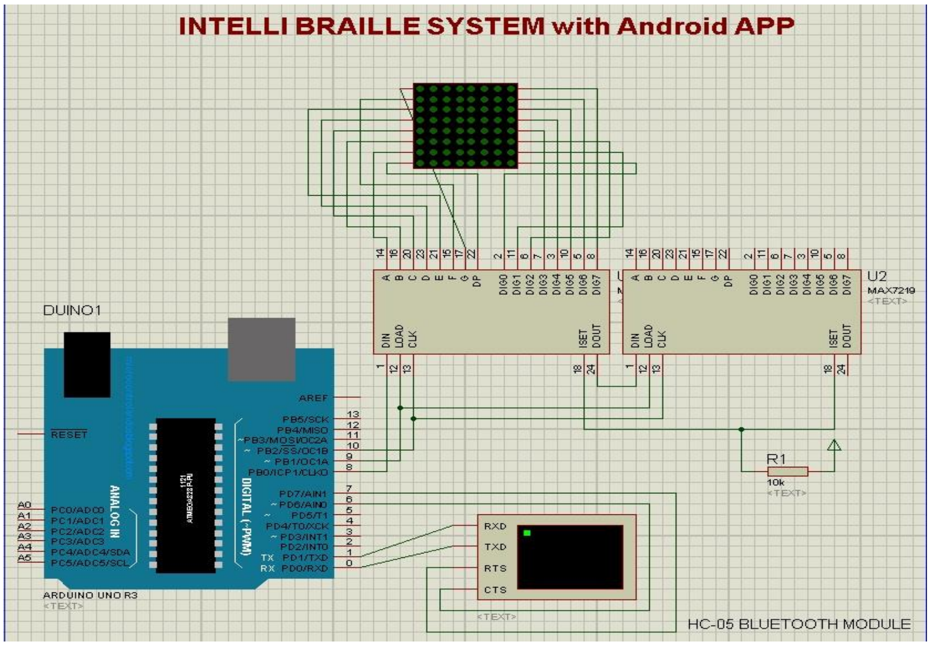


Figure represents the proposed Touch braille keypad

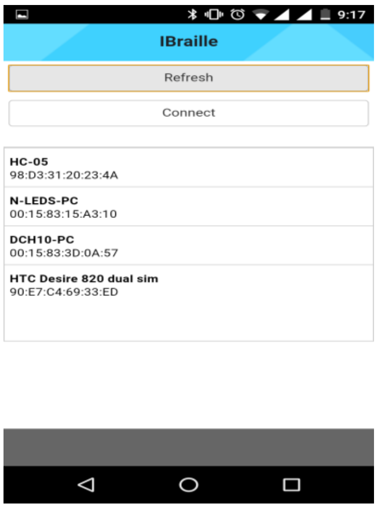
To type a word using the Braille Keypad, after pressing the keys related to a character according to Braille Code format, enter key is to touch to enter the character and the ASCII value will be sent to the mobile App after encoding and Decoding. This procedure is continued for the all other characters. Finally to get the Speech output of typed word (Speech output for each character can also be obtained by pressing speech key after entering the Character) enter key is pressed.



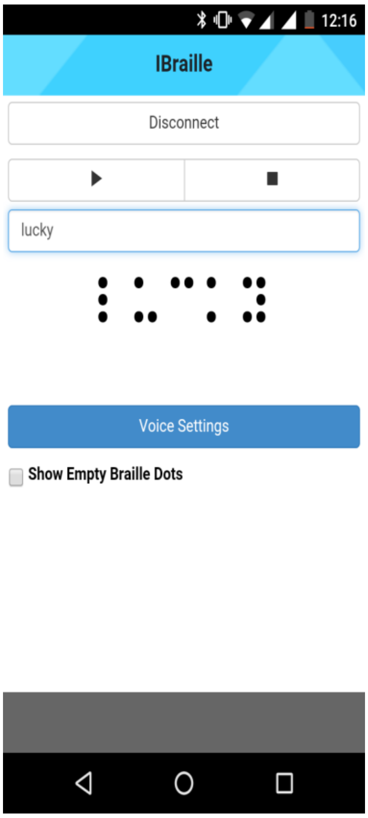
Schematic Diagram: Braille Matrix

IV. SMARTPHONE APP / SOFTWARE DEVELOPMENT

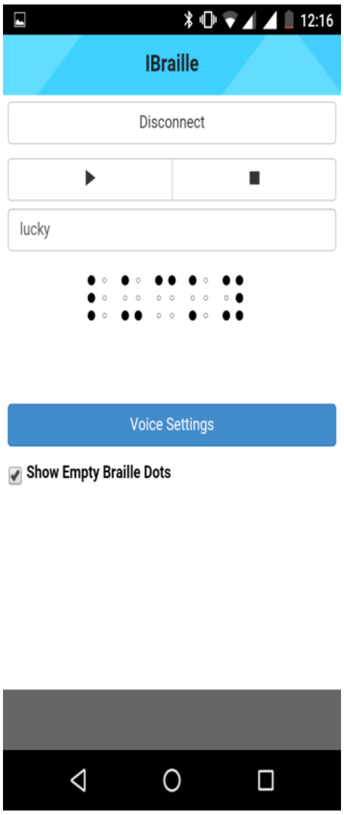
Front Window



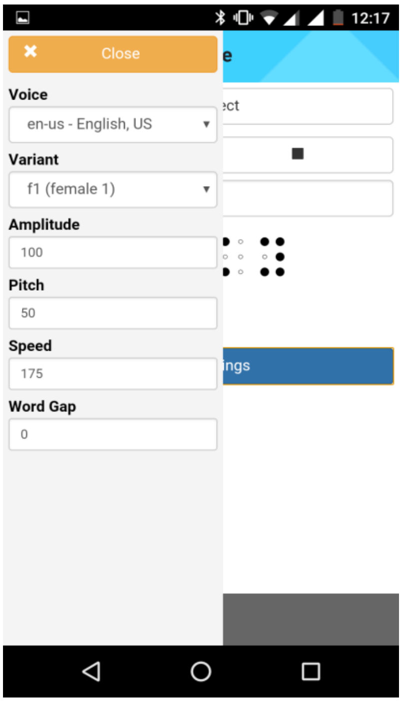
Connection Window



Braille Display Window Type 1



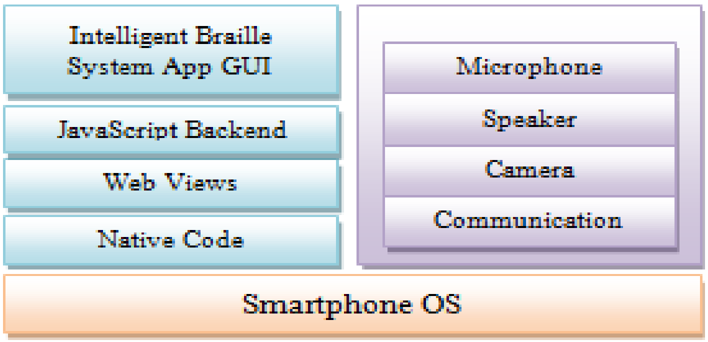
Braille Display Window Type 2



Voice Setting Window

Braille App Architecture

Porting the idea into fully-functional app and then to provide cross platform availability at the same time is challenging task, due to limitation of resources and different architecture by each OS. To facilitate the need of cross platform apps which are available on every platform, there come web apps frameworks such as crosswalk, Apache Cordova, which provides the ability to developer to build the app over HTML5, CSS3 with JavaScript over native technologies such as Java for Android, C# for Windows.

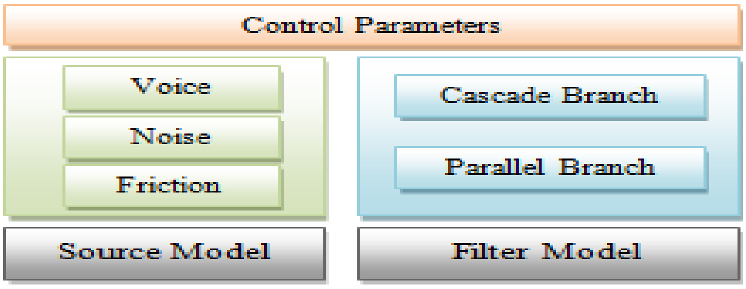


Intelligent Braille System App GUI is built on HTML5, CSS3 with JavaScript over the Twitter Bootstrap 3 Framework, which is the mobile first and widely used framework for the development of websites, mobile-apps, and web-apps. The web layout made on twitter bootstrap is supported by almost all platforms whether it is android or a new entrant Firefox OS. Currently, layouts processing in webkit based browsers are done by JavaScript V8 engine which is developed by Google. Most of the Mozilla's product uses gecko engine and similarly Microsoft has developed Trident engine as base of its browsers. The UI/UX of IBS app is run through the Web View, which is nothing but the instance of browser window which is called inside the app.

Intelligent Braille System App's JavaScript Backend is the main backbone of the app, which is use to synthesize the voice. These pre-processors are used for converting the text signal to speech signal. Text to Speech mechanism of the app is relying upon eSpeak synthesizer and partially on Klatt Synthesizer. The main aim behind choosing the eSpeak as backbone engine for the App is its support for Speech Synthesis Markup Language (SSML). SSML is further based upon Java Speech Markup Language and often embed as VoiceXML script to derive telephony Systems.

SSML is used in our project to introduce various flexibilities such as choice of Voices, option to adjust pitch, word gap, frequency, speed, amplitude and Voice Variant. Doing this has further enabled us to provide support for localization and regional languages (ISO 639_1 codes).

Text-to-Speech Synthesizer Model



Conversion of Binaries into JavaScript

Further, after successfully generating the binaries, a High Level Language to Low Level Virtual Machine Language converter such as Emscripten is used to convert the compiled binaries into JavaScript. The Conversion is done in order to make the app Cross Platform and to use the latest web based services. The generated JavaScript is further integrated with Intelligent Braille System's GUI. It further calls HTML5 Web Audio API. The output of generated through TTS is further processed using Audio Buffer interface of Web Audio API which stores the small instances of Audio and convert it into playable stream. Then the Audio Destination Node interface is utilized to set destination of Audio context which is in our case is the speaker of our mobile.

PSOLA and MBROLA Algorithms: PSOLA (Pitch Synchronous Overlap and Add) is a digital signal processing technique it is used in the app for speech formation and synthesis. It works by dividing the speech signal by overlapping in small segment. When there is a decrease in pitch the segments are moved away from each other, when the pitch is increased the segments are brought together using overlap-add method. PSOLA works well with and limited to variants of English Language. MBROLA is another synthesizer algorithm which supports many regional languages. Unlike PSOLA, MBROLA is time domain algorithm and requires preprocessing of text to phoneme and prosodic information in MBROLA format. Due to preprocessing it implies very low computational load during the Text-to-Speech Synthesis.

App communication with Intelligent Braille System Now a days let it be android, windows phone or iOS, Bluetooth is present in every device. Our aim was to initialize RF comm socket within these device, so that we could establish SPP Communication. We have achieved this by using an interface that is known as Bluetooth Socket. This interface acts as backbone for managing outgoing as well as incoming RF Comm connection. An incoming-event-listener which wakes up the app every time an incoming event occurs is being used. The event listener calls Bluetooth buffer which collects the temporary data and convert it into ASCII.

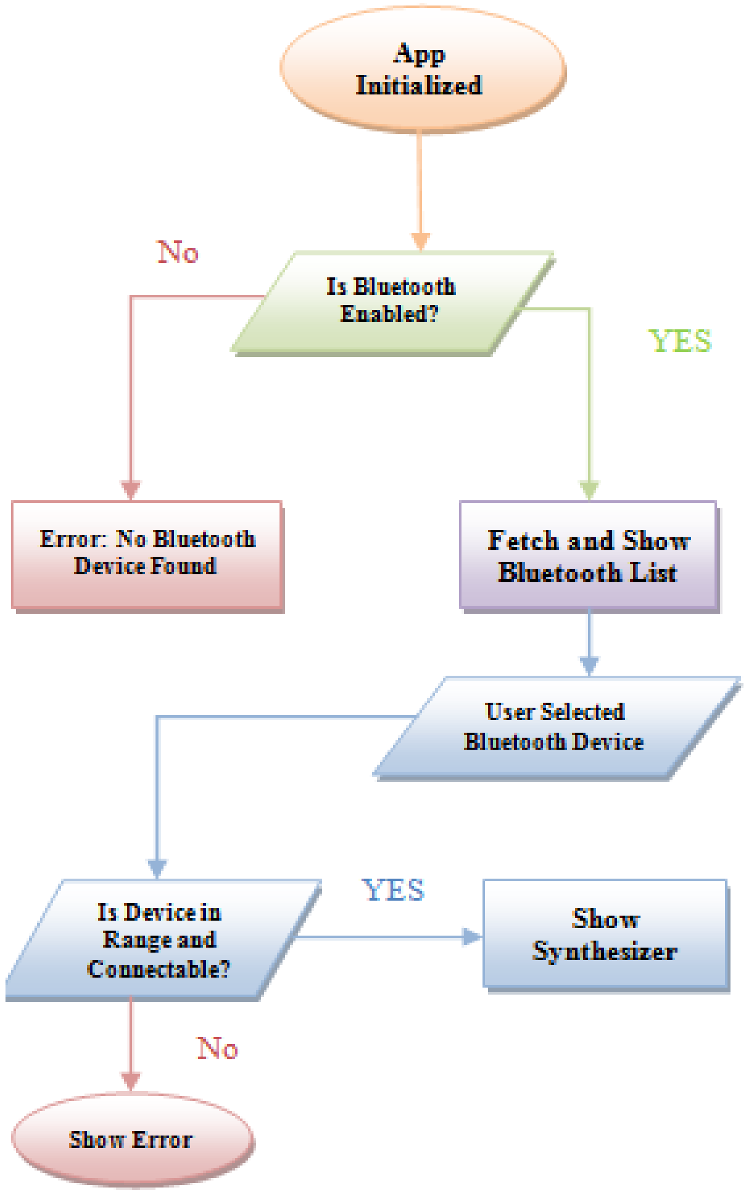


Figure: Flow Chart of App's Bluetooth Initialization

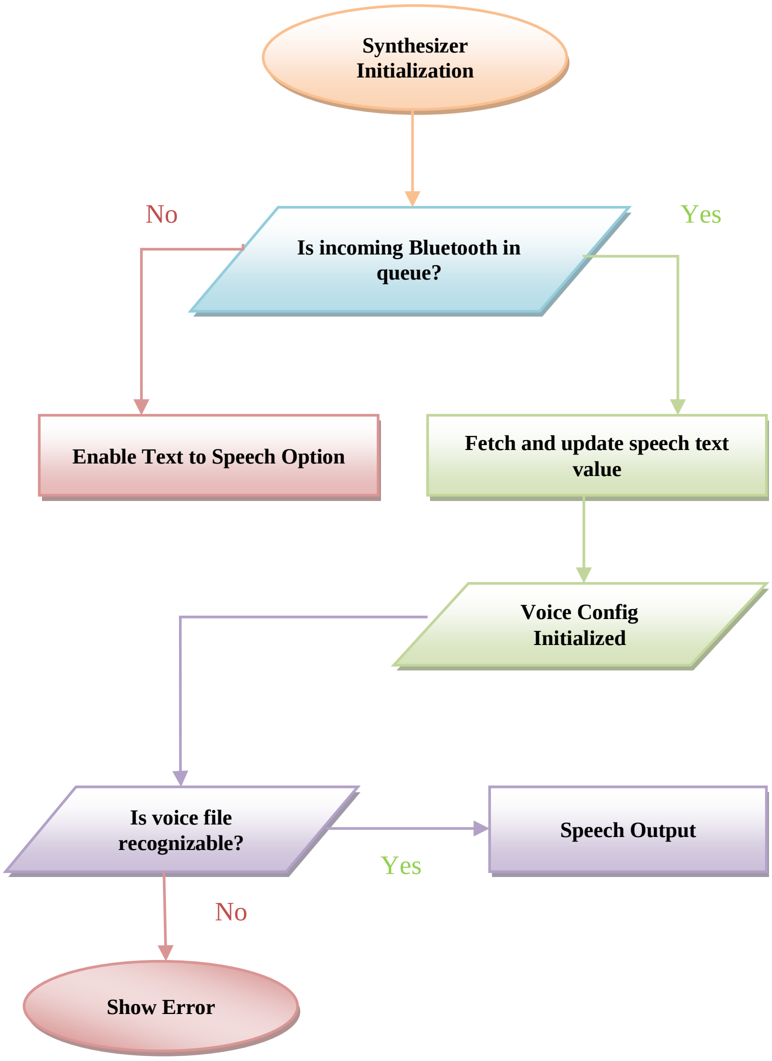


Figure: Flowchart of App Synthesizer

5. CONCLUSION

During the testing and implementation of intellectual braille app the satisfactory results are achieved with 0.3sec delay of communication from app to braille e-desk. The shift registers give the 0.1sec delayed shifting. The Text to speech and text to braille over the smartphone app is tested for US English. Further the same solution can be implemented in the portable solution like smart braille tablet with the flexible option of multiple languages, speech to braille system and image conversion to smart braille graphic system.

6. ACKNOWLEDGMENT

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