ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization

Vol. 5, Special Issue 6, July 2016

4th National Conference on Design Innovations for 3Cs "Compute-Communicate-Control"

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Dept. of ECE, MVJ College of Engineering, Bangalore-560067, India

Visual Sensing and Typing Aid for the Blind (VS-TAB)

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ABSTRACT: We live in a age where one cannot survive without depending or relying on the essence of technology. From the simplest of things like a calculator to more sophisticated and powerful machines like supercomputers, Nano-technology, etc. Technology has revolutionized the way we think, live and act. But still, Life is not so pleasant and comfortable if you try walking in a blind man's shoes. Many technologies (gadgets) have been invented and are still implementing so as to make the life of a blind person more comfortable and easier. We have tried to design and implement some devices in the view of easing daily tasks like walking, reading and typing problems at least upto an extend for the blind.

KEYWORDS: Atmega8 microcontroller, OCR, HC-SR04 distance sensor, webcam, USB and related softwares.

1. INTRODUCTION

Braille [1] is a script used by blind and visually impaired for reading and writing. It was created by Frenchman Louis Braille, who lost his eyesight due to a childhood accident at the age of 15. Braille characters are small rectangular blocks called *cells* that contain tiny palpable bumps called *raised dots*. The number and arrangement of these dots distinguish one character from another. But the short comings of braille script is that all the documents must be printed in braille. It becomes difficult to read for them when there is no braille version of any document available. So optical character recognition (OCR) is used to virtually see a character in normal font.Optical Character recognition (OCR) is a process of converting a printed document into ASCII characters that a computer can recognize. Several algorithms for character recognition have been developed based on feature selection [2], [3], [4]. Here we use a pattern matching based method for character recognition [5]. In OCR device the heart of the hardware is an 8 bit microcontroller ATmega8 from Atmel Corporation. The Atmel AVR (Advanced Virtual RISC) ATmega8 is a low-power CMOS 8bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed. To achieve typing aid USB is used as a part of communication between hardware and Personal Computer. Universal Serial Bus (USB) is an industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication, and power supply between computers and electronic devices. USB was designed to standardize the connection of computer peripherals (including keyboards, pointing devices, digital cameras, printers, portable media players, disk drives and network adapters) to personal computers, both to communicate and to supply electric power. USB has effectively replaced a variety of earlier interfaces, such as serial and parallel ports, as well as separate power chargers for portable devices. To achieve typing aid USB is used as a part of communication between hardware and Personal Computer. So our project is named as VS-TAB which is an acronym for Visual Sensing and Typing Aid for Blind to provide a device which makes their life easier by helping in reading, walking and typing.

1.1 LITERATURE SURVEY

According to World Health Organization facts [6], about 285 million people are visually impaired worldwide: 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired people live in developing countries. The Times of India has published an article on October 11, 2007 [7] that India is a home to world's largest number of blind people. Of the total people across the globe who are blind, over 15 million are from India.We have all observed blind people use White cane [8] while walking to avoid obstacles. They have difficulties in reading sign boards, books unless they are in braille. There are devices which perform automatic reading but they are

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quite expensive and are not affordable by all. Newer smart phones can also be used for the purpose but operating them which have many features is a challenging task for the blind people. Thus in this project we make an effort of facilitating them by providing a low cost, easy to use spectacles which performs OCR [9], [10] and obstacle sensing [11] and also a special typing aid [12] which enable them to type easily using braille script.

II. SYSTEM MODEL AND DESIGN METHODOLOGY

2.1.1 ATmega8 microcontroller:

The microcontroller used in this project is AVR ATmega8 [13] from Atmel Corporation. The Atmel AVR ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1MIPS (Million Instructions Per Second) per MHz, allowing the system designer to optimize power consumption versus processing speed.The Atmel AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 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. Pin diagram of ATmega8 is as shown in Fig.1.

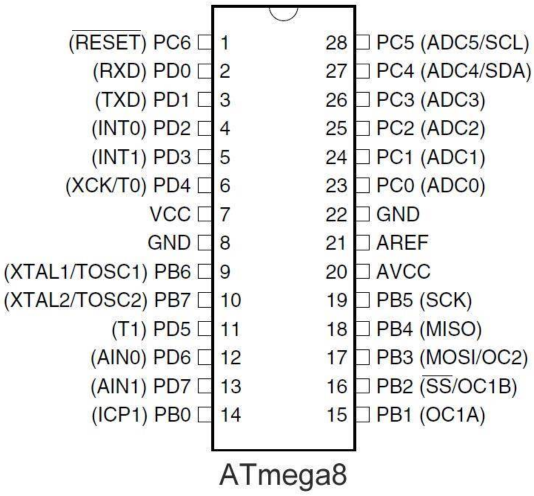


Fig. 1: Pin Diagram of ATmega

2.1.2 Optical Character Recognition and Obstacle Sensing:

The basic block diagram of Optical Character Recognition and Obstacle Sensing is as in Fig.2. The main blocks are web camera, micro sd card, character recognition, distance sensor, text to speech conversion and ear phone.

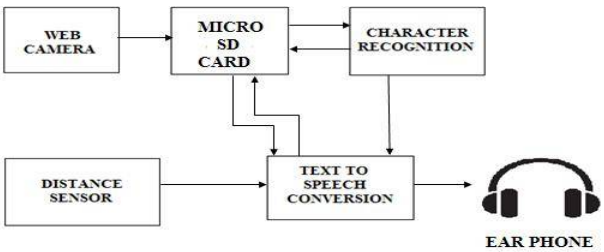


Fig.2: Basic block diagram of optical character recognition and obstacle sensing

Description:

- Image of a character written on sheet of paper is stored in microSD card. The microcontroller reads the image and performs Character Recognition process.

- Character Recognition process involves recognizing a character by comparing with sample templates and passing to Text to Speech Converter.
- Ultrasonic Distance sensor HC – SR04 is used to get the distance of nearby obstacles and send this information to Text to Speech Converter.
- Text to Speech converter converts the text information obtained from Character Recognition process or Distance Sensor to Audio Output depending upon the mode selected.

2.1.3 Image of a Character from Webcam:

Image of a character written on a sheet of paper is stored on a micro SD card with the name 'image_trial.bmp' in bitmap monochrome format. The image is stored as 64x64 array of pixels. This image is used by Character Recognition process to determine the character. The image is clicked by using a GUI developed using MATLAB's Guide tool, "Capture_Image" which captures image from webcam and stores it in monochrome bitmap format as shown in Fig.2. Preview button shows the live video from webcam. The Capture Image button captures the image and windows it into 64x64 monochrome image. The Save Image button prompts the user to save the image. Threshold selector is used in case the image is not suitable due to light conditions.

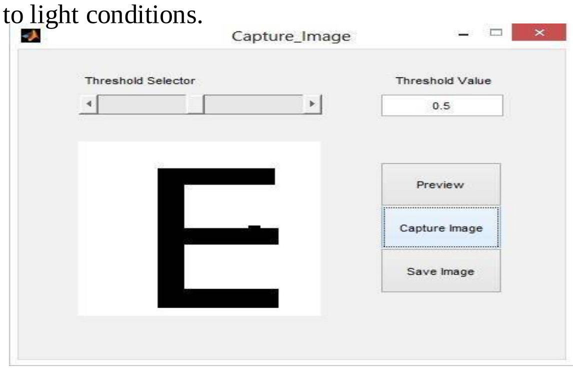
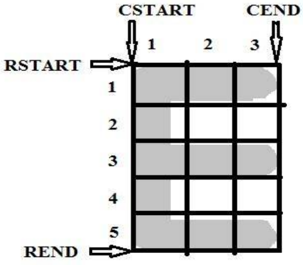


Fig.3: Snapshot of GUI "Capture_Image"

2.1.4 Optical Character Recognition:

The idea behind Optical Character Recognition (OCR) is to divide the image into 5 x 3 matrix. And then to recognize each segment out of seven segment. The microSD card is interfaced using Serial Peripheral Interface (SPI) as described above. An image is read sequentially from SD card. Each pixel is checked if it is black. The Row Start, Column Start, Row End and Column End are determined. Then using these borders a 5 x 3 matrix is formed as shown in Fig. 4. If cell (1,1) has more black pixels then respective bit in a matrix is set to '1' else set to '0'. Same process is done for all the cells. And from each cell in matrix we can get all the segments in seven segment and character is displayed on a seven segment display as in Fig. 5



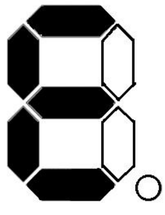


Fig. 4: 5x3 matrix of character   **Fig. 5:** Seven segment display of a character.

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ISSN (Online): 2278 – 8875

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2.1.5 Distance Sensor:

The HC-SR04 ultrasonic sensor [14] uses sonar to determine distance to an object like bats or dolphins do. We have used this module in our project to determine the distance between module and obstacle. The timing diagram of HC-SR04 is shown in Fig.6. To start measurement the following steps are to be followed,

i) Send a high pulse (5V) of 10µs to Trig pin of sensor module.

ii) The sensor sends 8 cycle of ultrasonic burst at 40kHz through its transducer and raises the Echo pin to logic '1' (5V).

iii) Start the timer when Echo pin is high.

iv) When the sensor detects ultrasonic from receiver, it will clear the Echo pin (0V).

v) Stop the timer when Echo pin is logic '0'. The time duration is proportional to the distance of the obstacle.

vi) An alarm tone is turned on if the obstacle is near (less than 1m) and the frequency of beeping increases as the obstacle is very near.

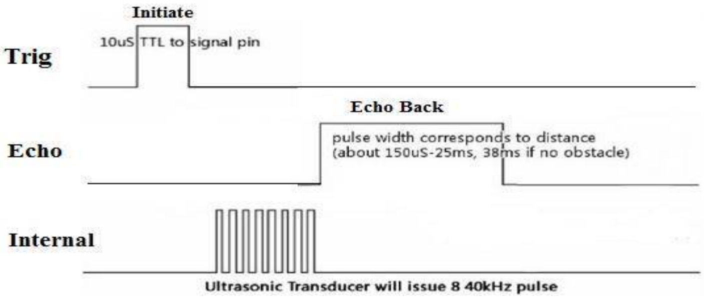

Fig. 6: Timing diagram of HC–SR04

2.1.6 Text To Speech Converter:

Text To Speech Converter block takes an alphabet as input and converts it to speech. This is achieved by playing a suitable Wave file for the alphabet.

Wave Format:

A Wave file is an audio file format, created by Microsoft, that has become a standard PC audio file format for everything from system and game sounds to CD-quality audio. It is the main format used on Windows systems for raw and typically uncompressed audio. The usual bit stream encoding is the linear pulse-code modulation (LPCM) format. A Wave file is identified by a file name extension of WAV (.wav). Used primarily in PCs, the Wave file format has been accepted as a viable interchange medium for other computer platforms, such as Macintosh. This allows content developers to freely move audio files between platforms for processing.

Fig.7. shows the hex dump of a Wave Audio File. The audio is sampled at 8000 samples/sec and is quantized. Thus each byte in Wave specifies the quantized value of the voltage of audio signal.

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ISSN (Online): 2278 – 8875

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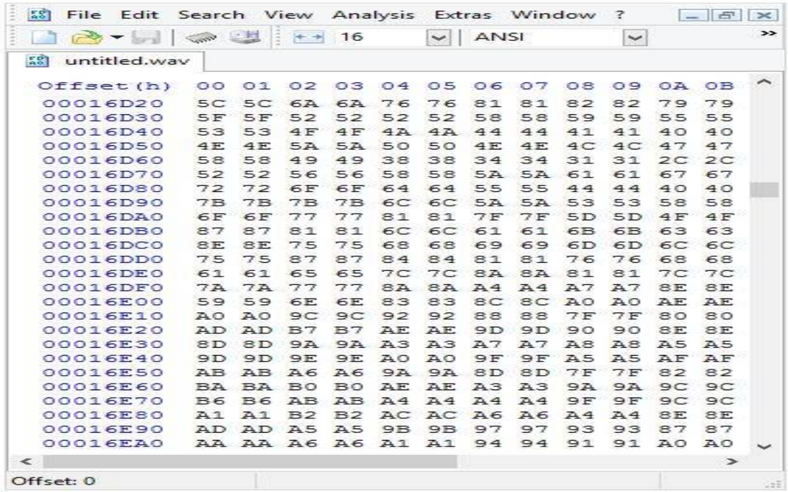

Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B
00016D20	5C	5C	6A	6A	76	76	81	81	82	82	79	79
00016D30	5F	5F	52	52	52	52	58	58	59	59	55	55
00016D40	53	53	4F	4F	4A	4A	44	44	41	41	40	40
00016D50	4E	4E	5A	5A	50	50	4E	4E	4C	4C	47	47
00016D60	58	58	49	49	38	38	34	34	31	31	2C	2C
00016D70	52	52	56	56	58	58	5A	5A	61	61	67	67
00016D80	72	72	6F	6F	64	64	55	55	44	44	40	40
00016D90	7B	7B	7B	7B	6C	6C	5A	5A	53	53	58	58
00016DA0	6F	6F	77	77	81	81	7F	7F	5D	5D	4F	4F
00016DB0	87	87	81	81	6C	6C	61	61	6B	6B	63	63
00016DC0	8E	8E	75	75	68	68	69	69	6D	6D	6C	6C
00016DD0	75	75	87	87	84	84	81	81	76	76	68	68
00016DE0	61	61	65	65	7C	7C	8A	8A	81	81	7C	7C
00016DF0	7A	7A	77	77	8A	8A	A4	A4	A7	A7	8E	8E
00016E00	59	59	6E	6E	83	83	8C	8C	A0	A0	AE	AE
00016E10	A0	A0	9C	9C	92	92	88	88	7F	7F	80	80
00016E20	AD	AD	B7	B7	AE	AE	9D	9D	90	90	8E	8E
00016E30	8D	8D	9A	9A	A3	A3	A7	A7	A8	A8	A5	A5
00016E40	9D	9D	9E	9E	A0	A0	9F	9F	A5	A5	AF	AF
00016E50	AB	AB	A6	A6	9A	9A	8D	8D	7F	7F	82	82
00016E60	BA	BA	B0	B0	AE	AE	A3	A3	9A	9A	9C	9C
00016E70	B6	B6	AB	AB	A4	A4	A4	A4	9F	9F	9C	9C
00016E80	A1	A1	B2	B2	AC	AC	A6	A6	A4	A4	8E	8E
00016E90	AD	AD	A5	A5	9B	9B	97	97	93	93	87	87
00016EA0	AA	AA	A6	A6	A1	A1	94	94	91	91	A0	A0

Fig. 7: Hex dump of Wave Audio File

Pulse Width Modulation (PWM):

PWM, is a technique for getting analog voltage with digital means. Digital control is used to create a square wave, a signal switched between on and off. This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off. The duration of"on time" is called the pulse width and the time period is the sum of "on time" and "off time".Duty cycle is measured in percentage. The percentage duty cycle specifically describes the percentage of time a digital signal is on over an interval or period of time given by the Eq. 3.1.

Duty Cycle = (Pulse Width / Time Period) * 100 %.......... (3.1)

If a digital signal spends half of the time on and the other half off, we would say the digital signal has a duty cycle of 50% and resembles an ideal square wave. If the percentage is higher than 50%, the digital signal spends more time in the high state than the low state and vice versa if the duty cycle is less than 50% as shown in Fig.8. The voltage obtained by changing the duty cycle is given by Eq. 3.2.

Voltage = (Vcc * Duty Cycle) / 100.. (3.2)

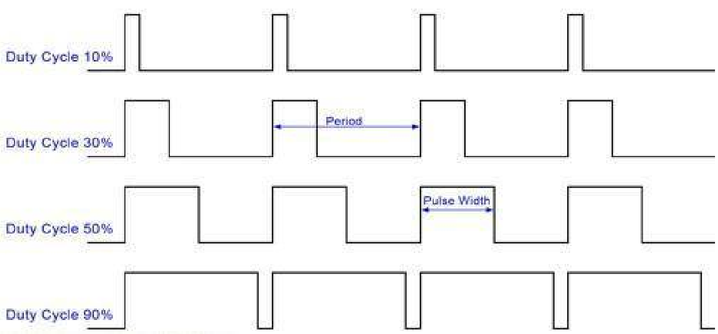

Fig.8: PWM for different Duty Cycle

For Vcc = +3.3 V hex value 0xFF corresponds to +3.3 V in PWM and for hex value 0x7F it corresponds to +1.65 V. To play an audio file the hex values of the Wave file are used to modulate the pulse width of the PWM to obtain voltages. Thus the hex values are read from a micro SD card corresponding to an alphabet and these values are used to modulate the duty cycle of PWM for every 125 µs / sample (1/8000). Time period of PWM is very much lesser than 125 µs in

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order to obtain voltages.

2.2 Typing Aid:

The basic block diagram of Typing Aid is as in Fig.9. The main blocks are push button matrix, keyboard controller, personal computer.

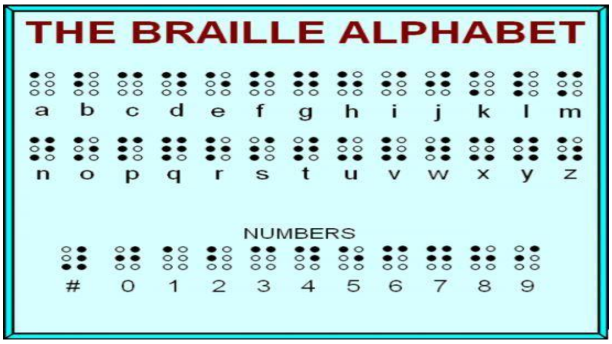
Fig.9: Basic block diagram of typing aid for blind people.

Description:

- Touch sensors consists of sensors arranged in the form of a braille cell. The input is provided by user by touching respective sensors and is passed to the Keyboard Controller for processing.
- Keyboard controller gets the information regarding the activated sensors and recognizes the character and sends it to a personal computer through USB.

2.2.1 Push Button Matrix:

The push buttons are arranged in the form of a matrix as a Braille Cell. To input a character, the combination of buttons must be activated corresponding to the code in Braille



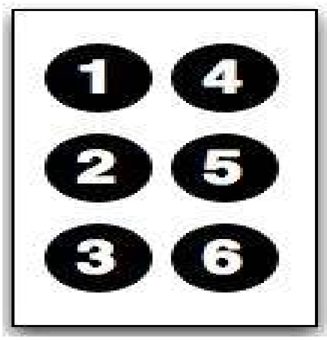


Fig. 10: Matrix of Push Button

Fig.11: Alpha numeric Braille codes

For example from Braille chart to type "A" the button 1 must be pressed, to type character "T" the user must press buttons 2,3,4,5. To type numbers the user must first type the "#" symbol as shown in chart and then the number. To type alphabets again the user must type "#" symbol again. Along with these some extra buttons are provided for SPACE,BACKSPACE, ENTER, CAPS LOCK.

2.2.2 Keyboard Controller:

To implement a Typing aid the communication channel used is USB 2.0. In Keyboard Controller the character is determined by the combination of these six buttons. Then the Controller transmits this information through USB [15] to thePersonal Computer. The Controller implements a Human Interface Device (HID) class. Every vendor class device requires a kernel driver, but HID [17] class devices do not. This means that we don't need a driver installer.

USB:USB uses differential encoding and decoding for communication at electrical level. USB device communication is based on *pipes* (logical channels). A pipe is a connection from the host controller to a logical entity, found on a device, and named an *endpoint*. Because pipes correspond 1-to-1 to endpoints, the terms are sometimes used interchangeably. A USB device could have up to 32 endpoints (16 IN, 16 OUT), but this device makes use of only two endpoints. One for control and another one for data. There are different transfer methods. Typing aid is implemented using *interrupt transfers*.When a USB device is first connected to a USB host, the USB device enumeration process is started. The enumeration starts by sending a reset signal to the USB device. The data rate of the USB device is determined during the reset signaling. After reset, the USB device's information is read by the host and the device is

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assigned a unique 7-bit address. If the device is supported by the host, the device drivers needed for communicating with the device are loaded and the device is set to a configured state. If the USB host is restarted, the enumeration process is repeated for all connected devices.The host controller directs traffic flow to devices, so no USB device can transfer any data on the bus without an explicit request from the host controller. In USB 2.0, the host controller polls the bus for traffic, usually in a round-robin fashion. The host sends a Packet to the USB device. Then the device replies with the information it has to the host controller.

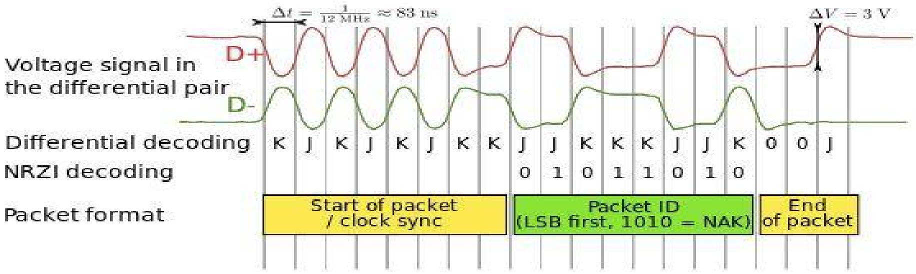

Fig.12: USB differential signals

Human Interface Device (HID): USB devices require drivers to be installed in order to use it. **USB human interfacedevice class** (**USB HID class**) is a part of the USB specification for computer peripherals:it specifies a device class (a type of computer hardware) for human interface devices such as keyboards, mice, game controllers and alphanumeric display devices. One of the benefits of a well-defined specification like the USB HID class is the abundance of device drivers available in most modern operating systems. The USB HID class devices and their basic functions are defined in USB-IF documentation without any specific software in mind. Because of these generic descriptions, it is easy for operating system designers to include functioning drivers for devices such as keyboards, mice, and other generic human interface devices. The inclusion of these generic drivers allows for faster deployment of devices and easier installation by end-users.To implement HID – USB Typing aid we have made use of V-USB [16] library for AVR microcontrollers which implements Human Interface Device (HID) class since USB is a closed protocol and one must registered to obtain the Vendor ID. The V-USB is for students to learn about USB communication.

III. SYSTEM DESIGN

3.1 Visual Sensing:

The System design of Visual Sensing part is as shown in Fig.13.
The working principle is as shown in Fig.13. Steps followed are:

1. On Power Up the microcontroller initializes all the I/O Ports, SPI communication, micro SD card and Distance Sensor module.
2. It checks whether the Push Button is pressed. If pressed the MODE is changed from "READ" to "WALK" or vice versa.

ISSN (Print) : 2320 – 3765
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International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 5, Special Issue 6, July 2016*

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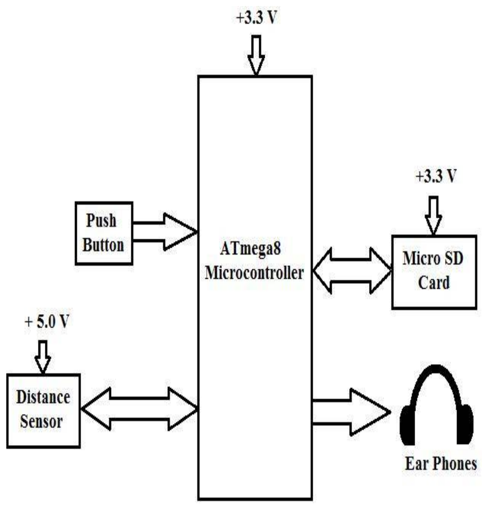

Fig. 13: System Design of Visual Sensing

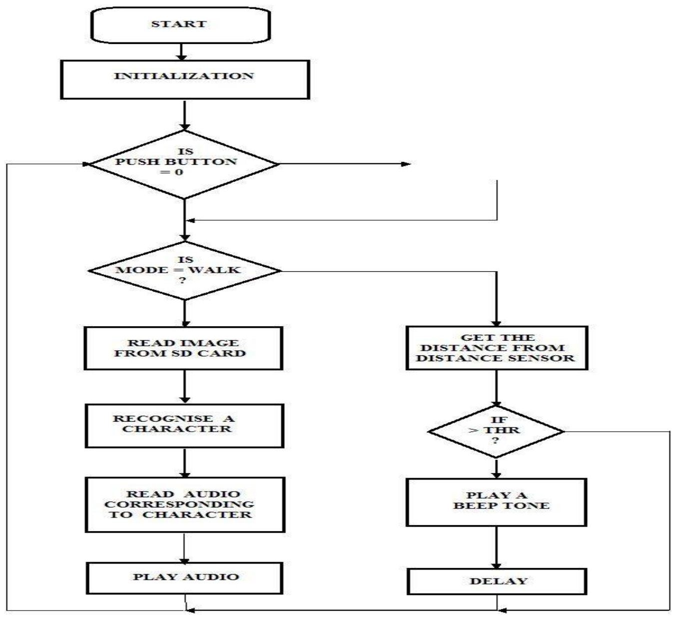

Fig. 14: Working Principle of Visual Sensing

3. Then it checks if MODE is "READ" it performs the following steps;

- Microcontroller reads an image from micro SD card.
- It recognizes the character.
- Once the character is recognized the audio file for corresponding character is read from micro SD card.
- The audio file is played.
- Then it returns to Step 2.

4.If MODE is "WALK", then it performs following steps;

- Microcontroller continuously measures the distance through Distance Sensor.
- If the distance is lesser than threshold (around 1.5 m) a beep tone is played continuously with a delay proportional to the distance between the user and the nearest obstacle.
- If the distance is greater than threshold, no beep tone is played.
- Then controller returns to Step 2.

3.2 Typing Aid: The system design of Typing Aid is as shown in Fig.15.
The working principle is as shown in Fig.15. Steps followed are:

1. The microcontroller waits for the host to get ready and send an input request.
2. When input request is received the microcontroller checks for any pressed key.
3. If not pressed the microcontroller waits for the key to be pressed.
4. If the key is pressed, the character is determined using Braille code and a USB report is built depending upon the key pressed.
5. Then this report is sent to the host through USB.

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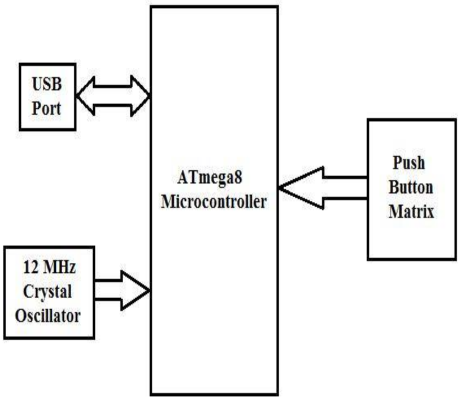

Fig. 15: System design of Typing Aid

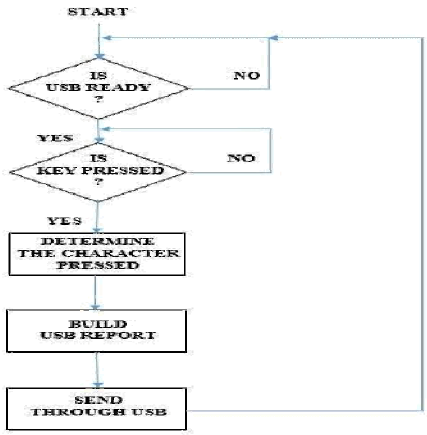

Fig. 16: Working Principle of Typing Aid

IV. RESULTS

4.1 Visual Sensing:

The final implementation of Visual Sensing Gadget is a shown in Fig.17.
The device works as stated:

- On power ON the system will be in "READ" mode and performs character recognition and reads out the character which can be heard through ear phone.
- If button is pressed then the device enters "WALK" mode and the sensor starts working. If there is any obstacle at a distance lesser than 1.5 m the beep tone is heard.
- On button press the device toggles between "READ" mode and "WALK" mode.
-

Fig.17: Implementation of Visual Sensing

The image taken from webcam is as shown in Fig.18 and also the waveform of played audio file for the character "E" in image in micro SD card as in Fig. 19.

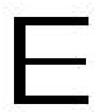

Fig. 18: Image of character "E" taken from webcam

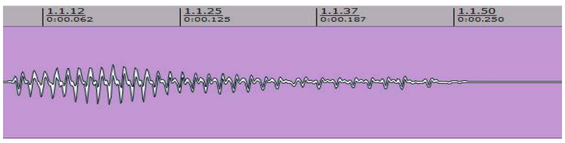

Fig.19: Waveform of audio for character "E".

4.2 Typing Aid:

The final implementation of Typing Aid Gadget is a shown in figure. The device recognizes the typed character and is

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4th National Conference on Design Innovations for 3Cs "Compute-Communicate-Control"

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typed on a Microsoft Word window. The device also includes numbers and special keys such as SPACE, BACKSPACE, ENTER and CAPS LOCK.

Fig.20: Implementation of Typing aid.

VI. CONCLUSION

This model was designed and implemented in the view of easing the daily tasks like walking, reading and typing for the blind. The gadgets can be directly used by blind for safe walking, reading and typing. So we hope our devices become helpful for the millions of people who are visually impaired and blind. The future works are as follows:

- Placing a Camera Module on the gadget to get the image and recognizing the character in Real time.
- Improving the recognition technique for 14 segment so that characters like "W", "M", "R" etc. can be read.
- Using the recognition technique iteratively to read all characters in a word and reading out the word and also the entire document.
- Implementing touch sensors instead of buttons in Typing Aid.

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