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A NAVIGATION SYSTEM FOR THE VISUALLY IMPAIRED USING EMBEDDED TECHNOLOGY

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ABSTRACT

India is one of the countries with a huge population of blind and visually impaired with very least population of them using Navigation systems. Many navigation systems are available in the market but most of them are either costly or lack in accuracy and user friendliness. Bearing all this in mind we have designed and implemented a GSM and GPS based navigation system. This system has an ARM cortex multiprocessor as the core element. While navigating in an unknown geographical area, the user can effectively use this system to precisely know where he/she is using the GPS. The user is provided with a touch keypad and a microphone, using which he can take notes like mapping the area for future movement there. Also the user can obtain information regarding weather and light conditions at the given time and area using the temperature and light sensors provided. The blind usually uses a cane or walking stick to identify obstacles in the path and move around. But sometimes it cannot detect obstacles like overhanging tree branch or a person suddenly moving across. Here the user can be warned by auditory impulses regarding the obstacle using sensors. Similarly the visually impaired can be lost in a surrounding or if he wishes to convey an emergency signal to his caretaker, a simple one touch button can send a SMS via the GSM module to the caretaker, regarding the precise location of the user. At time of low light, say during evening or night, the light sensor detects it and a LED light goes on. This enables the user to indicate other persons in the surrounding area that he is there. These are the various applications of this system using modern computer science and communication technologies where cheap and effective service can be given to the users.

Keywords: visually impaired, navigation system, embedded technology.

1. INTRODUCTION

The Computer science researches in recent years have been focusing their work in the area of healthcare. The goal is to assist and aid people with effective technology on affordable prices in their day to day life. Recent survey shows India has now became the world's largest number of blind people. There are 39 million blind people across the globe, 90% of them are living in developing countries, over them 15 million people are from India [1]. The visually impaired and blind people have the need of support for interacting with the world in the same way a normal person would do. Available solutions helping visually impaired and blind people to read, write and navigate still have to improve. Navigation in unknown outdoor and indoor environments for visually impaired and blind people is a major challenge for them. The commonest item which helps in their navigation is usually cane using which they can only detect some obstacles in their path. But this does not solve the problem of navigation. They have to rely on other persons to move around and find the location [2]. But the accuracy of information is questionable. Trained dogs are available for the last two to three decades [2]. They efficiently avoid obstacles, provides safety but they have to be pre trained in the geographic location and they should be trained fresh if they have to go to newer places. Also the user cannot know his precise location in a new geographical area. So the advent of Electronic Navigation systems was simply a huge leap in navigation for the blind and visually impaired; however most of them are not capable of providing the precision that the visually impaired and blind people require. The lack of precision is due to the localization method used and the guiding through selected routes [3]. The usage of the blind navigation system is very less and not efficiently used for Indian environment. Also the lack of user friendliness makes them less useful for the consumers. In order to overcome the problems stated above, here a system is designed which can give Audio output through microphone to the user, Device to take notes using a touch keypad when needed, An MP3 player to play the user's favourite music when needed and a SD card for storage, Device to identify the direction in which the user is moving, Sensor to detect the temperature of surrounding, Device to note the present time, latitude and longitude location of the user and send location to mobiles of user's caretakers as SMS, Sensor to detect the obstacle in path and a Sensor to detect brightness of the surrounding and switch on a light if it is dark. All the above applications are provided with this system which has an ARM cortex M3 which functions as a microcontroller.

2. HARDWARE DESCRIPTION

a) Hardware architecture

The system uses ARM Cortex-M3 as Microcontroller. Users are assisted through voice messages using Voice Codec and Head phone. GPS is used to locate the current latitude, longitude and time of the user. GSM is used to send the corresponding location to user's caretaker through SMS. Proximity sensor is used to sense whether any obstacle is present in user's path. If present, voice output will be given to 'STOP' along with the distance of obstacle from user. Also vibrator will be

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switched on. Otherwise the user will be given a voice message to 'GO'. Light sensor is used to detect the brightness of user's surrounding and if darkness exists, light is switched on. Whenever temperature is asked by user, it is sensed using LM35 Temperature sensor. Touch Capacitive Sensor is used to control the system. Direction in which the user is travelling is computed using MEMS and DC-Servo Motor and a voice output related to direction is received by the user. All data are stored in a 2-GB Memory SD-Card. Figure-1 shows block diagram of the Navigation system.

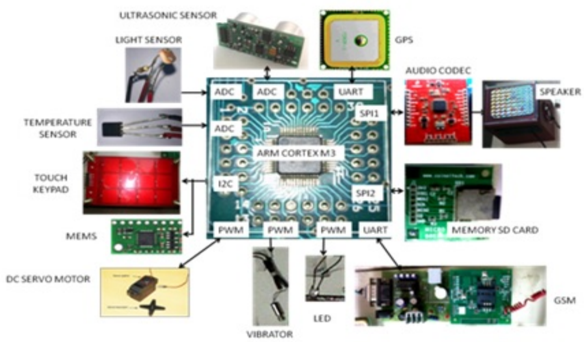

Figure-1. Block diagram of voice based navigation system.

b) Microcontroller

Microcontrollers are like single chip computers which are often embedded into other systems as processing/controlling unit. Most of the items we use everyday contains a microcontroller embedded in it like automobiles, washing machines, microwave ovens, televisions etc. Microcontrollers are useful to the extent that they communicate with other devices, such as sensors, motors, switches, keypads, displays, memory and even other microcontrollers. Microcontroller used in our system is ARM Cortex- M3 LPC1313. It had MEMS and Capacitive Touch Keypad connected to it through its I2C port, PIN 15, 16. Temperature sensor is connected to ARM through ADC0 port, PIN 32. Audio CODEC and Memory SD Card are interfaced through SPI1 port, PIN 10, 22, 27 and 28. DC Servo Motor is connected through PWM port, PIN 34. Figure-2 shows ARM Cortex M3 microcontroller (LPC1313).

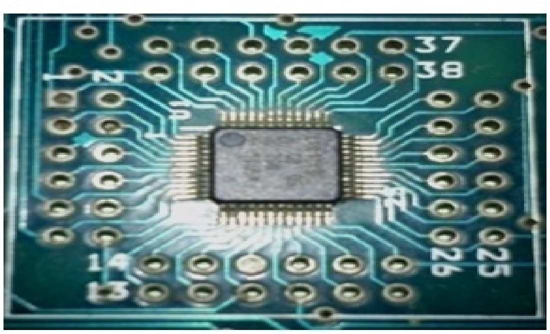

Figure-2. ARM Cortex-M3 microcontroller (LPC1313).

c) Magnetometer and accelerometer

Modern accelerometers are small micro electro mechanical systems (MEMS) consisting of a cantilever beam with a proof mass. Thus they sense acceleration in only one direction. Magnetometer is the compass needed to sense the direction. Magnetometer and Accelerometer is used to detect the direction in which the user is travelling. MEMS is connected through I2C interface to the ARM Processor. The output of the MEMS is processed in microcontroller to produce voice output in degree Celsius. It thus helps the user to know whether he is travelling in the proper direction. LSM303DLH is the MEMS module being used in the system. Figure-3 shows the pin configuration.

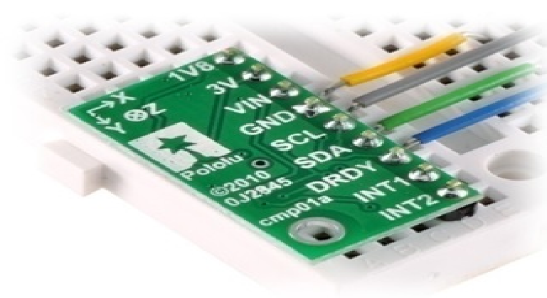

Figure-3. Pin configuration of magnetometer and accelerometer LSM303DLH.

d) Capacitive touch sensor

The Touch sensor devices are based on frequency changes caused by input capacitance. he finger acts as conductor placed over GND plate and touch pad, this significantly increase the TS input capacitance. When the finger is out of touch pad, the capacity is much lower than when the finger is near the touch pad. All this process is monitored by TS sensor and as soon as the capacitance change in given short time section exceed required limit, the sensor signalize touch by activating output signal. It is required to control all the commands in the system. For inserting any instruction or notes, the user needs the Touch Keypad. MPR121 is the capacitive touch sensor being used in our system. It contains 12 electrodes. MPR121 is interfaced to ARM through I2C port. Figure-4 shows prototype of Capacitive Touch Sensor.

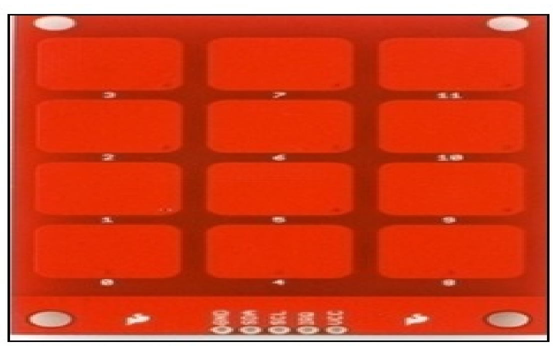

Figure-4. Prototype of capacitive touch sensor PR121.

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e) Audio codec

The system assists the user through voice messages. This feature is only possible due to audio CODEC. Audio CODEC is responsible to convert MP3 files to voice form. Pre recorded audio MP3 files are stored in the memory SD card. Whenever the microcontroller calls a particular MP3 file, it is processed and played using audio codec. We can listen to the output of audio CODEC through a speaker or headphone [Figure 5]. The system uses VS1053b audio CODEC. It contains 48 pins. VS1053b is a single-chip MP3 audio decoder. Figure-4 prototype of Audio CODEC.

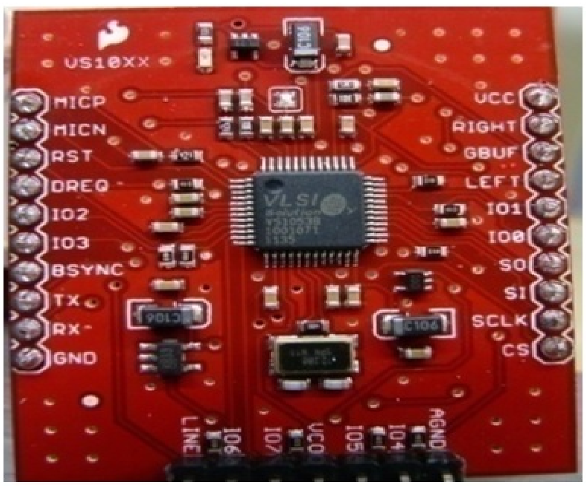

Figure-5. Prototype of audio CODEC.

f) DC servo

A servo is a small device with circuitry built right in. It has a position able shaft that can be arranged in a number of angled positions via a coded signal. The position of the shaft changes as it receives different signals. Despite their small size, servo motors are powerful but don't consume much energy. A servo motor operates on the principal of "proportional control." This means the motor will only run as hard as necessary to accomplish the task at hand. If the shaft needs to turn a great deal, the motor will run at full speed. If the movement is small, the motor will run more slowly. A control wire sends coded signals to the shaft using "pulse width modulation." With pulse-coded modulation, the shaft knows to move to achieve a certain angle, based on the duration of the pulse sent via the control wire. A 1.5 millisecond pulse will make the motor turn to the 90-degree position. Shorter than 1.5 moves it to 0 degrees, and longer will turn it to 180 degrees. Figure-5a shows the DC servo. DC Servo motor is connected PWM pin of microcontroller. Here, pin PI01_9 is interfaced with DC Servo motor. Figure-6(a) Prototype of DC Servo, (b) changing of rotation by PWM.

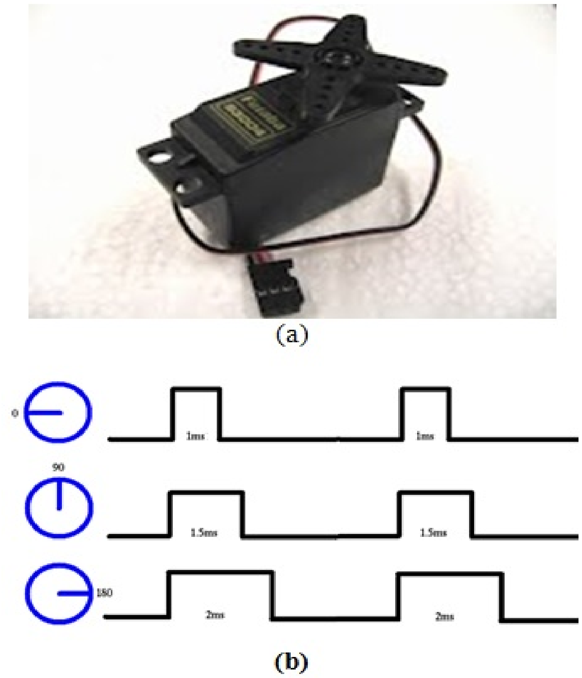

Figure-6. (a) Prototype of DC servo, **(b)** changing of rotation by PWM.

g) Temperature sensor

Temperature sensor used in the system is LM35. The temperature sensing system LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 cover a full −55 to +150°C temperature range. The LM35’s low output impedance, linear output and precise inherent calibration make interfacing to readout or control circuitry especially easy. The analog O/P of LM35 is sent to pin of ARM where it converts into digital data through its inbuilt ADC. Figure-6 shows the prototype of LM35 sensor. Figure-7 shows prototype of Temperature Sensor.

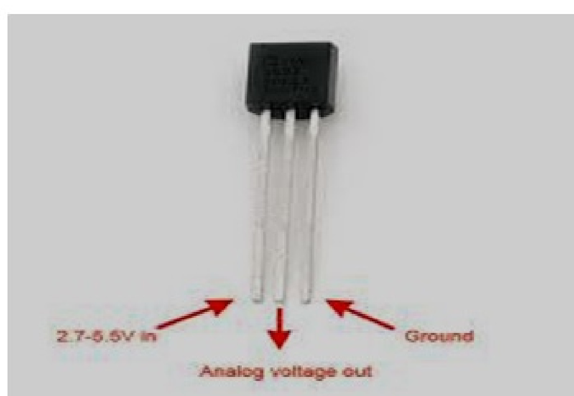

Figure-7. Prototype of temperature sensor.

h) Light sensor

A light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. The photo resistor, or light dependent resistor, LDR, finds many uses as a low cost photo sensitive element and was used for many years in photographic light meters as well as in other applications such as flame, smoke and burglar detectors, card readers and lighting controls for street lamps. Light sensor used in the system is N5AC 501085 LDR photocell. It detects light intensity and passes the information digitally. It is connected to one of the ADC pins of microcontroller. The sensor is needed for the device to detect the low light conditions such as darkness and the information should be relayed to the user as audio warning. Also in case of darkness, a LED light is switched on for user's assistance in dark. Figure-8 shows prototype of light sensor.

Figure-8. Prototype of light sensor.

i) Global Positioning System

GPS (Global Positioning System) is used to detect the current location and time of the user. GPS is connected through UART to the ARM Processor. The output of GPS is processed in microcontroller to produce voice output in latitude and longitude [Figure-9]. It thus helps the user to know whether he is travelling through decided path. LS20031 is the GPS module being used in the system.

Figure-9. Pin description.

j) Global system for mobile communication

GSM (Global System for Mobile Communication) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM modem is connected through UART to the ARM Processor. GPS produces the current latitude and longitude. User can send these details to the mobile number he wishes using GSM. It thus helps the user to inform others the path in which he is travelling and current location in which he is present. Figure-10 shows prototype of GSM modem.

Figure-10. Prototype of GSM modem.

k) Ultrasonic sensor

Ultrasonic sensor is used to detect any obstacle in the direction in which the user is travelling. Ultrasonic sensor is connected through ADC interface to the ARM Processor. The output of the Ultrasonic sensor is processed in microcontroller to produce voice output of whether any obstacle is present in path and if so it specifies the distance (in cms) between the obstacle and user. It thus helps the user to navigate safely. SRF04 is the Ultrasonic module being used in the system. Figure-11 shows the prototype of SRF04.

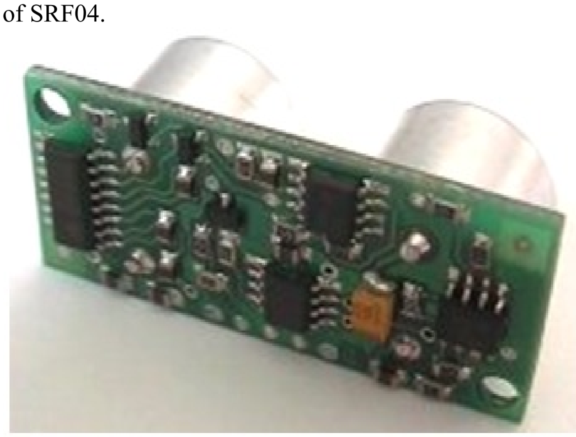

Figure-11. Prototype of ultrasonic sensor SRF04.

3. SOFTWARE DESCRIPTION

a) Embedded C

Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems.

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Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations. In 2008, the C Standards Committee extended the C language to address these issues by providing a common standard for all implementations to adhere to. It includes a number of features not available in normal C, such as, fixed-point arithmetic, named address spaces, and basic I/O hardware addressing. Embedded C use most of the syntax and semantics of standard C, e.g., main() function, variable definition, data type declaration, conditional statements (if, switch. case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros, unions, etc. In this system the software component is embedded C.

b) LPCXpresso IDE

LPCXpresso's IDE is a highly-integrated software development environment for many microcontrollers including ARM cortex M3. LPCXpresso is based on a simplified Eclipse with many LPC-specific enhancements. It also features the current version of the industry standard GNU tool chain with a proprietary optimized C library. The LPCXpresso IDE can build an executable of any size with full code optimization, and it supports a download limit of 128KB after registration. It contains C compiler, debugger, flash programming support and examples. It connects to the target board via the LPC-LINK, which is built in as part of the LPCXpresso board. The LPC1311/13/42/43 operates at CPU frequencies of up to 72 MHz. The peripheral complement of the LPC1311/13/42/43 includes up to 32 kB of flash memory, up to 8 kB of data memory, USB Device (LPC1342/43 only), one Fast-mode Plus I2C-bus interface, one UART, four general purpose timers, and up to 42 general purpose I/O pins.

4. IMPLEMENTATION

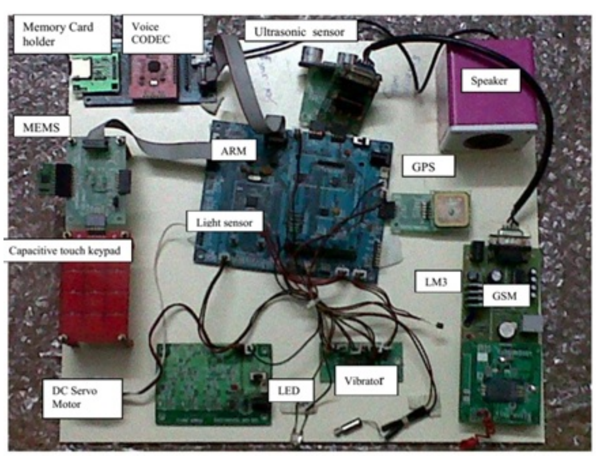

Figure-12. Prototype of navigation device for visually impaired.

User input is decoded from the capacitive touch keypad. The corresponding sensory information is outputted via audible messages using a head phone (Figure-12). Temperature sensor announces the environmental temperature in degree Celsius. System will announce whether it is light or dark and if it is dark, the lights will automatically turn on. Ultrasonic sensor is used to detect any obstacle in the path user is travelling. MEMS and DC Servo motor is used for a quick tactile feedback to indicate the direction the user is heading. GPS is used to detect the current location in which user is present. GSM is used to send the current location of user as SMS to user's caretakers. Pre recorded MP3 audio files are stored in a FAT-32 formatted Memory SD card for the entertainment of user. Additionally, user can enter notes in the memory card using touch keypad.

5. CONCLUSIONS

The scope of this project is to device a system that will give more independence to the visually impaired in terms of their navigational ability in unknown areas and to improve their comfort and safety during when walking without any help such as human Guides or Guide dogs. The system has ARM processor at its heart to aid in navigation for the visually impaired. ARM processor is installed with LPXpresso software. GPS and GSM are implemented. Also the temperature sensor, ultrasonic sensor, light sensor, magnetometer and accelerometer and capacitive touch keypad are installed and working perfectly. Audio CODEC and speakers are also fitted. Using this now the user can take notes using the touch pad screen when walking in unknown areas. The user will be informed on the conditions of the surrounding temperature conditions, light and time via speaker. Also the user can listen to his/her preferred music. Ultrasonic sensor is used to detect the obstacle in user's path. The MEMS and DC Servo will sense the direction and inform the user whether he is walking in right direction or not. Current position of user can be found using GPS and GSM can be used to send an SMS a remote mobile phone. Future work can be done by adding more advanced functionalities for more comfortable navigation by the user.

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