Smart Wheel Chair for Visually Impaired

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Abstract -- The visually impaired persons suffer from lack of confidence, restricted mobility and dependence on others in their daily life. This paper proposes an embedded system design of a smart wheel chair aiming for visually impaired using high-end technical tools like AVR Studio, ATMEGA 16 Development Board (Atmel Corporation), proximity sensors and DTMF Decoder. The movement of wheelchair is controlled by cellular phones specifically designed for the visually challenged people (Toshiba, Huawei, Sens are companies that manufacture such specific mobiles). In this paper existing designs of wheel chair are also discussed. In addition to being user-friendly, the proposed design also provides a high degree of mobility and defence against obstacles for the visually impaired. Further the design is also tested using Printed Circuit Board (PCB) and the results obtained are in perfect accordance with the expectations. This proposed smart chair design outperforms the existing designs in terms of obstacle avoidance and technology.

Keywords - Dual Tone Multi Frequency (DTMF), Cellular Phone, ATMEGA 16 Development Board (Atmel), Proximity Sensor, AVR Studio

I. Introduction

A wheelchair is a device that comes in variations where it is propelled by motors or by the seated occupant turning the rear wheels by hand. Often there are handles behind the seat for someone else to do the pushing. Wheelchairs are used by people for whom walking is difficult or impossible due to illness, injury, or disability. People who have difficulty sitting and walking often need to use a wheel bench. Wheelchair is basically of two types-Electric Powered and Manually Propelled. The most beneficial advantage of the electric powered wheelchair over the Manually Propelled one is that the occupant has to no longer do labour (Using hands to rotate the wheels and move the wheelchair) but instead he can control the speed and direction of the wheelchair just by pressing buttons or using his voice. The technology has made everything so easy to understand and user-friendly. This paper proposes a smart and intelligent transportation system [4],[13],[17],[18],[20],[23],[27],[28] that can assist the disabled people [23] especially the visually challenged people to control the direction of their wheelchair using a cellular phone [15] which acts as a controlling device [9]. The wheelchair moves by means of a geared motor and communication is established with the wheelchair using a mobile phone [7],[10],[15],[19],[29],[30]. The system includes many important components including the microcontroller, the motor driver circuit, sensors [24],[27],[31]. The Pie chart in Figure 1 shows the percentages of blinds in different regions of the world.

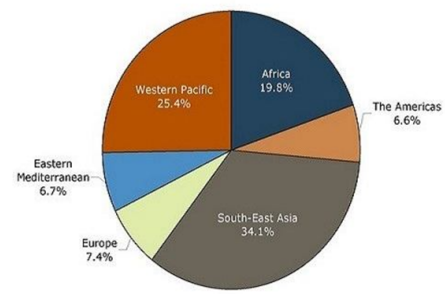

Fig. 1: Percentage of visually challenged people in the world

As per the definition, the wheelchair is a device which is used by the disabled. This paper specifically deals with the designing and implementation of such a smart robotic wheelchair [3],[16],[25] which can help the visually impaired [11] in their motion from one place to another. Many kinds of joystick Controllers can be used for the movement of the microcontroller-based EPW such as Voice Recognition Module (VR Module) [26], the Touch screen [22],[26], The Keypad matrix and the Wireless network [21]. But still, the major and utmost priority is given to the cellular phone being used as a controller for controlling the wheelchair. Today, each individual carries his or her personal cell phone and moreover, when talking about the controller with the visually disabled person's point of view, there are actually several mobile phones (Toshiba, Huawei, Sens are companies that manufacture such specific mobiles as shown in Figure 2) which are specifically made for the visually impaired people. These specific mobile phones help the blind realize the buttons on the sensitive surface of the cell phone using their fingers and these phones are used mainly for calling and receiving purposes. Hence, they are more useful than any other controller. Also, Mobile phones are easily available to us as compared to other electronic device controllers such as VR Module, joystick controllers, etc.

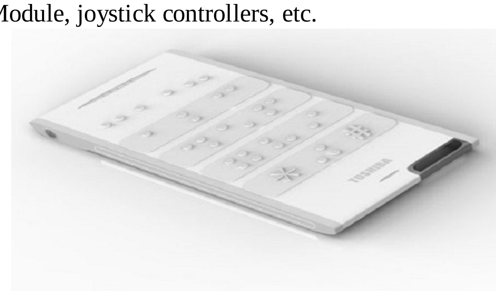

Fig. 2: Cellular Phone for visually challenged by Toshiba

The paper is organized as follows. In section 2, the proposed design is presented in detail. In section 3, a brief layout of the functioning of the smart wheelchair is presented. In section 4, the design is tested using Printed Circuit Board. The conclusion is drawn in Section 5.

II. The Proposed Design

The proposed design of smart wheelchair for visually impaired is an embedded system using AVR Studio and ATMEGA 16 Development Board (Atmel).

Fig. 3: Cellular Phone controlled Wheelchair

A. Components Involved

The components used in the design are categorised as Hardware Components and Software Components which are explained below.

1) Hardware Components:

ATMEGA 16 Microcontroller(ATMEL) - The ATmega 16 is a low-power CMOS (Complementary MOSFET) 8-bit microcontroller based on the AVR in RISC (Reduced Instruction Set Computing) architecture and has many useful applications [1],[8],[15]. The AVR (Alf and Vegard's Risc Processor) Core combines a rich instruction set with 32 general-purpose working registers. All the 32 registers are directly connected to the arithmetic logic unit, allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The pin diagram of ATMega16 is shown in figure 4. This architecture is code-efficient.

The ATMEGA 16 has the following features

- 16kB of in-system programmable Flash program memory
- 512 bytes of EEPROM(Electrically Erasable Programmable Read-Only Memory)1kb SRAM(Static Random-Access Memory)
- 32 general-purpose input/output (I/O) lines
- 32 general-purpose working registers
- Three flexible timers/counters with compare modes
- Internal and external interrupts
- A serial programmable USART(Universal Synchronous Asynchronous Receiver Transmitter)
- A byte-oriented two-wire serial interface
- An 8-channel 10-bit Analog to Digital Converter(ADC)
- An SPI serial port(Serial Peripheral Interface)
- Six software-selectable power-saving modes
- Battery-An external 12 Volts, 7Ah battery is used to give power to the wheelchair. It acts as a voltage source to the whole circuit.

Operating Voltage: 5V

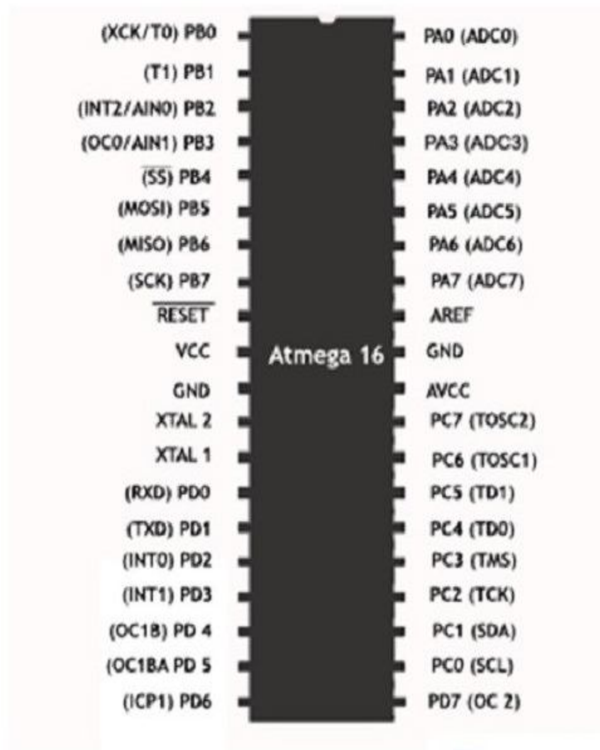

Fig. 4: ATMEGA 16 Pin Diagram

Motors - M1 and M2 are 2 motors which receive power from the motor driver IC and are used for driving the 2 wheels of the wheelchair in the direction required. Motors provide the power which starts, stops, rotates (in clockwise and anti-clockwise direction) the wheelchair.

Proximity Sensors - A proximity sensor [12],[14],[20],[31],[32] is a sensor able to detect the presence of nearby objects without any physical contact. Figure 5 shows a proximity sensor. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object. These sensors employ feedback [34] route to signal the microcontroller that the object's presence has been detected.

Operating Voltage: 5V

Fig. 5: Proximity Sensor

DTMF Decoder - Dual-tone multi-frequency signalling (DTMF) Decoder [10],[19],[30], as shown in figure 6, is used for telecommunication signalling over analog telephone lines in the voice-frequency band between telephone handsets and other communications devices and the switching center [2],[5],[15],[29]. "Live" tone signals are fed from telephone line/Mobile phone or radio into soundcard of computer/microcontroller chip and the DTMF decoder decodes the input. Either line- or microphone input jack is used.

Fig. 6: DTMF Decoder

ATMEGA 16 Development Board - This development board is manufactured for learning the basic and advance concepts for beginners and professionals as well. This board contains a lot of features covering almost all section of AVR microcontroller. This board is suitable for many controllers like ATmega16, ATmega32, ATmega163, ATmega164P, ATmega1284P, ATmega324P, ATmega644, ATmega644P, ATmega8535 etc. Figure 7 shows an ATMega16 Development Board.

The ATMEGA 16 Development Board has the following features

- 4 Ports output connectors for general use.
- 7 Ports for ADC.
- 5V power output ports.
- 8 LED output for viewing the output.
- USART output.
- On-Board Power supply.
- 4 PWM output.
- Hardware Interrupt.
- Port for 16X2 alphanumeric LCD.
- Buzzer for sound signal.
- DC motor output using L293D.
- Stepper motor controller using ULN2803.
- Fair power supply distribution.
- Touch screen connector.
- 7805 Voltage Regulator

Fig. 7: ATMEGA 16 Development Board

The AVR development Board consists of L293D Motor Driver, Voltage Regulator, capacitors, resistors and LEDs. Capacitors bypass ripple from the regulated supply, Resistors limit the current through LEDs and the LEDs acts as the ''power-on'' indicators.

Interconnects – 1-pin, 2-pin, 4-pin and 8-pin interconnects are employed in this design.

USB Programmer (USBasp) – USBasp, as shown in figure 8, is a USB in-circuit programmer for Atmel AVR controllers. It simply consists of an ATMega88 or an ATMega8 and a couple of passive components. The programmer uses a firmware-only USB driver, no special USB controller is needed. USB Programmer has following features.

- Works under multiple platforms. Linux, Mac OS X and Windows are tested.
- No special controllers or smd components are needed.
- Programming speed is up to 5kBytes/sec.
- SCK option to support targets with low clock speed (< 1,5MHz).
- Planned: serial interface to target (e.g. for debugging).

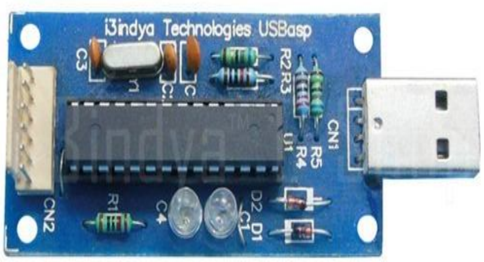

Fig. 8: USB Programmer

Cellular Phone - Cellular Phone [10],[19],[29],[30] acts as an input device through which the input command is given.

2) ***Software Components:*** The Source Program is written in 'C' Language and compiled using the AVR Studio to generate the Intel Hex Code. The generated hex code is programmed into the chip i.e., the ATmega 16 microcontroller chip using a suitable programmer (like AVR Burner) [8]. The code is well commented and easy to understand. The flowchart for software development is shown in figure 9.

AVR Studio- AVR Studio is an Integrated Development Platform (IDP) for developing and debugging ATMEL AVR Microcontroller (MCU) based applications. The Software provides the user with a seamless and easy-to-use environment to write, build and debug applications written in C/C++ or assembly code. AVR Studio is integrated with the ATMEL Framework (ASF) which is a large library of free source codes. It further simplifies embedded MCU designs to reduce development time and cost.

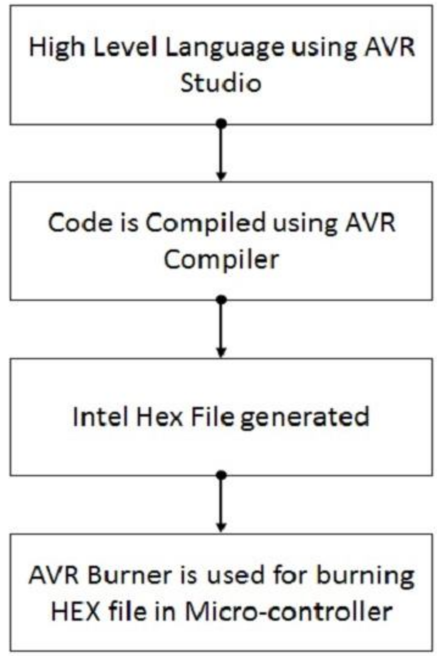

Fig. 9: Flow Chart for software development

B. The Design

Motor Driver L293D is interfaced with the microcontroller's port B. Port pins PB0 and PB1, and PB2 and PB3 of the microcontroller control motors M1 and M2, respectively. Motor drivers are enabled in pairs.

The proximity sensor consists of 3 pins which are used for representing the LED present on the sensor. The three pins represents V_{cc} Pin (positive voltage supply, +5V), Data out pin (This pin tells the microcontroller chip whether the sensor has detected an object in front of it or not) and the ground pin (Zero voltage). The proximity sensor also consists of 8 pin IC and the connections can be made easily by looking at the back of the sensor where all the components are interlinked to each other using soldering. The data out pin of the sensor is connected with the D0 pin of port D. If multiple sensors are used, then the data out pin of each of the sensor can be connected to D0, D1,D2 and so on. As a result, the code can be changed accordingly.

The cellular phone is connected with the DTMF Decoder using a 3.5mm jack cable.

The four pins of the DTMF decoder are connected to A0, A1, A2 and A3 of port A of the microcontroller in a serial order. Also, connect the ground pin and the voltage supply pin of the DTMF decoder to the ground and +5V supply of the microcontroller chip respectively.

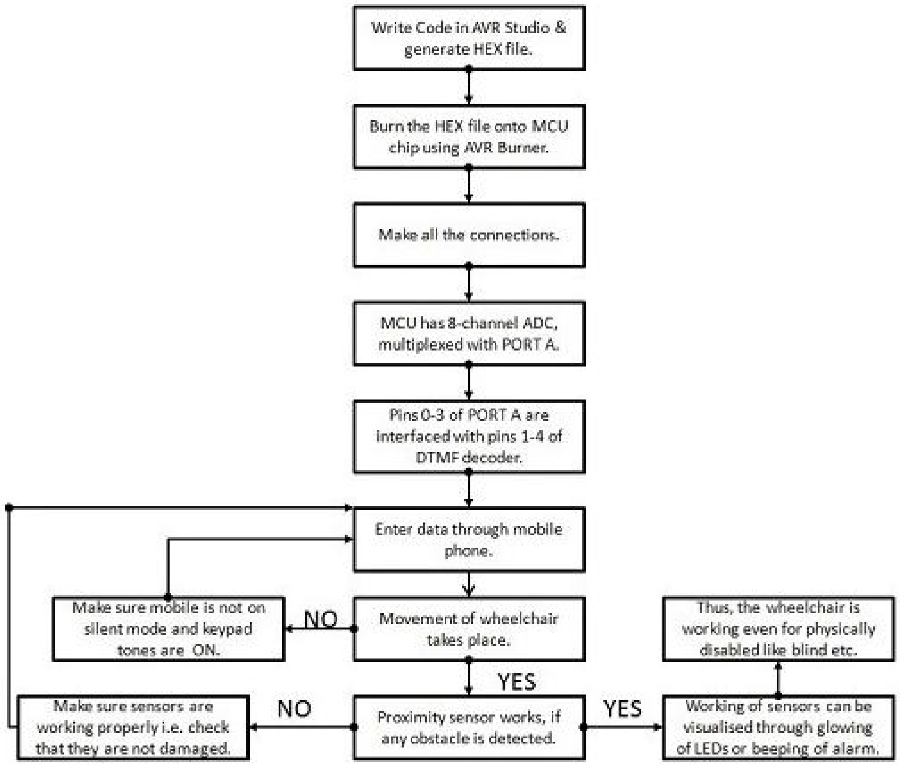

Fig. 10: Algorithm for Design

1) How to Use:

To use the smart wheelchair, the visually impaired person has to follow the following steps:

STEP 1 : Determine the direction of motion of smart wheelchair by pressing the respective key on the cellular phone (Refer Table 1).

STEP 2: The motion of the wheelchair in that direction starts and the emission of a beep sound detects the occurrence of any obstacle in that direction (obstacle avoidance) [6],[33],[35].

STEP 3 : The motion of the wheelchair is interrupted and as a result it stops.

STEP 4 : Change the direction of the wheelchair (Refer Table 1).

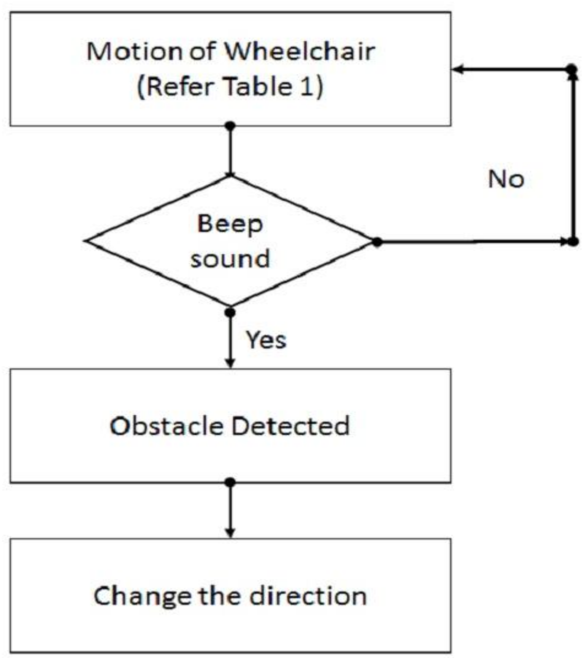

Fig. 11: Flow chart for working

Table I
Commands for Movement

KEY PRESSED	OPERATION/MOVEMENT
1	FORWARD RIGHT TURN(Around a Pivot)
2	FORWARD
3	REVERSE LEFT TURN(Around a Pivot)
4	RIGHT
5	STOP
6	LEFT
7	FORWARD LEFT TURN(Around a Pivot)
8	BACKWARD
9	REVERSE RIGHT TURN(Around a Pivot)

III. Testing Of Design

An actual size, single side PCB (Printed Circuit Board) for the cell phone control for wheelchair is shown in the figure 12. Assemble the circuit on a PCB as it minimises time and assembly errors. Carefully assemble the components and double-check for any overlooked error. Use IC bases for IC1 (ATMega 16) and IC2 (L293D). Before putting the microcontroller and other IC's on the PCB, check the correct supply voltage. Suitable connectors are provided on the PCB to connect geared motors M1 and M2. Connect the motors and power the circuit with 12V battery. Connect the proximity sensors at the suitable ports accordingly. Now, the circuit is ready for use. For instance, when you press the key on your cell phone which enables the forward motion of the wheelchair, both the motors rotate in forward (clock-wise) direction simultaneously and the motion stops as soon as the proximity sensor encounters an object ahead. Fit the motors properly with the wheels and the cell phone in your hand to control the movement of the wheelchair.

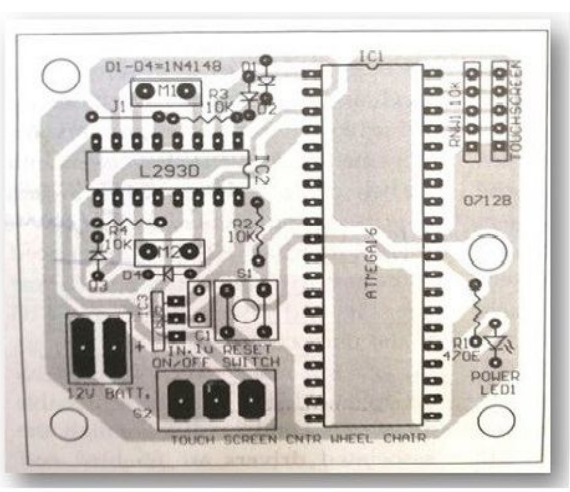

Fig. 12 : Component Layout of PCB

III. Conclusion

In this paper an embedded design called The Smart Wheelchair is proposed for the visually impaired. This design is different from the conventional designs as it allows the visually challenged a high degree of mobility and defence against obstacles in the direction of motion. Since, the motion of the smart wheelchair is controlled using the cellular phone, therefore, the physical labour is minimised. This user friendly chair reduces the dependency on helper to a great extent. This smart chair offers a safe, simplified and a self-dependent lifestyle to the visually challenged. The design is also tested and results obtained are in perfect accordance with the expectations.

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