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DESIGN, CONSTRUCTION AND TESTING OF A SMART STATIC AND DYNAMIC OBSTACLE WALKING STICK WITH EMF DETECTOR FOR THE BLINDS USING MCU AND CONTROLLING SOFTWARE

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ABSTRACT
Smart static and dynamic obstacle walking stick with EMF detector is an upgraded smart stick designed for blind people for optimal navigation and electrical safety. An advanced blind stick prototype that allows visually challenged people to navigate walking paths and identify electronic gadgets with ease using modern technologies is hereby developed. The blind stick is integrated with ultrasonic sensor along with an EMF detector. This prototype first uses ultrasonic sensors to sense obstacles ahead using ultrasonic waves. On sensing obstacles, the sensor directs this data to the microcontroller. The microcontroller then processes this data and examine if the obstacle is close enough. If the obstacle is not that close the circuit does nothing. If the obstacle is close the microcontroller sends a signal to sound a buzzer. One more feature is that it allows the blind to detect the presence of EMF (electromagnetic field/electromagnetic waves) in the region he/she is, if there is, the microcontroller also sends a signal to a vibration motor (i.e. the output is in form of vibration), and if otherwise, the circuit does not trigger and thus, the vibration motor does nothing. The results obtained from the measurements have shown that this project work is optimally working and indeed operative.

Keywords: Arduino Nano 328, ultrasonic sensor, EMF detector, Vibration motor, Buzzer.

INTRODUCTION

The survey of WHO (World Health Organization) carried out in 2011 tells us that in the world, about 1% of the human population are visually impaired and amongst them about 10% are fully blind. The main problem with blind people is mobility (Shubha, *et al.*, 2015). This project proposes a tool for visually impaired people that will provide them navigation. Long white cane is the old-style mobility tool used to sense obstacles in the path of a blind person. We are transforming this cane to a smart one with some electronic components which is more advantageous.

Another issue which shall be considered in this research work is the electromagnetic field radiation. There are a lot of electronic devices that still have small radiation even if the device is turned off without being unplugged. Basically, these devices can be found in home applications such as computer's battery, microwave, wireless telephone, television and etc. For example, this can happen during work on computer or watch on the TV, where the body is engulfed in an "electronic smog" emanating from the device; referring the EMF outlet sockets. In CRT-based monitors, the spot of electrons that sweep the screen can generate pulsed electromagnetic radiation (PEMR) (De Hoop, *et al*. 2011). This energy will escape in the form of radiations in very low-frequency and low energy. Thus, these unnatural radiations behavior can disrupt the body's bio magnetic field within which millions of electrical impulses regulate the activities of the cells. Unfortunately, the continuous exposure to pulsed electromagnetic radiation (PEMR) (De Hoop, *et al*. 2011) can cause adverse effects to the human without our concerning on it in our daily life (Smith, 2006).

The conventional and oldest mobility aids for persons with visual impairments are characterized with many limitations. Some inventions also require a separate power supply or navigator which makes the user carry it in a bag every time they travel outdoor. These bulky designs will definitely make the user to be exhausted. Several attempts have been made to design obstacle avoidance devices for the blind using components with limited number of applications.

The ultimate aim of this work is to obtain and improvise a smart static and dynamic obstacle walking stick with EMF detector using MCU and controlling software for the blind.

Theoretical considerations

Hardware and software components;

A concise explanation of the components that were used in the design and construction of the project is elaborated in this section. It includes the physical components (Arduino Nano board, ultrasonic sensor, electromagnetic field detector and others) and also the processing software, the components mentioned latter are as follows:

Micro-controller Unit (Arduino Nano)

Arduino is a physical computing panel that was released under open source license and based on a simple microcontroller board (Figure 1). Integrated Development Environment (IDE) is dedicated for coding the device. In most applications, the Arduino board is used as a controller. Initially, the device requires a direct connection to a computer at the first setting steps. However, it can operate resourcefully without this connection according to the application necessities.

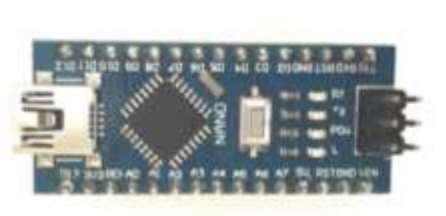


Fig. 1: Arduino Nano Board.

RESISTOR

Resistors commonly perform the function of current restraint; resistor comes in deferent sizes, related to the power they can safely dispel. All electrical wires have resistance, depending on its material, diameter and length*(www.electronicshub.com*). Wires that must conduct very heavy currents (ground wires on lighting rods, for example) have large diameters to reduce resistance. Ohm's law state that current flow depends on circuit resistance:

$$I = \frac{V}{R} \qquad \text{.. 1}$$

Circuit resistance can be calculated from the current flow and the voltage:

$$R = \frac{V}{I} \qquad \text{... 2}$$

Fig. 2: Picture of resistor

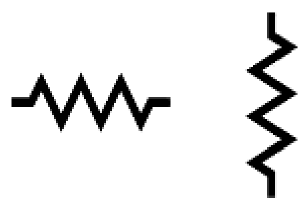


fig. 3: symbol of resistor

ULTRASONIC SENSOR HC-SR04

Ultrasonic sensor is the most effective part of any ultrasonic device. The principle of operation of an ultrasonic sensor can be used to understand the operation of smart stick due to the similarity of operation. In other words, by calculating the time required for sending and receiving the ultrasonic wave, several information affiliated to the obstacle that causes the reflection of the wave can be measured such as the distance to the sensor, size, figure, etc.

The sensor contains the transmitter Tx, which is used to transfer the signals that're used to detect the targets, and the receiver Rx, which receive the signals from the detected targets.

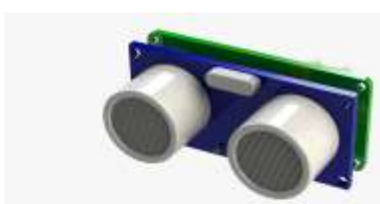


Fig. 4: The Ultrasonic Sensor.

An ultrasonic sensor is a device that uses ultrasonic waves to measure an object's proximity. Ultrasonic transducers which are the microphone and speaker tandems send and receive ultra-high frequency sound waves to obtain an object's distance or closeness. The ultra-high frequency sound waves are reflected from an object's surface creating a unique echo pattern.

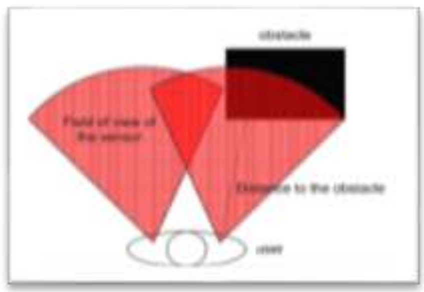


Fig. 5: sent and reflected waves; ultrasonic sensor basic operation

SWITCH

A switch is an electronic device, which is used to power the circuit "ON" or "OFF" when the switch is in its closed position {or "ON" position}. Current will flow, when the resistance of the switch contact is very small, however when the switch is in its open position {or OFF position} it does not allow the flow of the current because of the high resistance between the switch contacts (*www.electronicshub.com*).

The working principle of switch depends on "ON/ OFF" mechanism. Various electrical or electronic circuits use switches to control or trigger the whole circuit.

Fig. 6: A switch

JUMPER WIRES

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two or more points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easier to modify a circuit as the situation demands.

Fig.7: Jumper wire

Though jumper wires come in a variety of colors, the colors don't actually signify anything. This means that a red jumper wire is technically the same as a black one. But the colors could be advantageous to you in order to differentiate between types of connections, such as ground or power parts of the circuit.

VERO BOARD

Vero board is a brand of strip board, a pre-constructed circuit board material of copper strips on an insulating bonded paper board which was invented and developed in the early 1960s by the Electronics Department of Vero Precision Engineering Ltd (VPE). It was introduced as a general purpose material for use in constructing electronic circuits differing from purpose designed printed circuit boards (PCBs) in that a variety of electronic circuits may be constructed using a standard wiring board.

Fig. 8: diagram of a Vero-board

BUZZER

A buzzer is a small and efficient component to add sound feature to the system. It is very small and compact 2-pin structure hence can be easily used on breadboard and even on PCBs which makes this a widely used component in most electronic applications.

There are two types of buzzers that are commonly available. The one shown here is a simple buzzer which when activated will make a Continuous "Beeeeeeppp...." sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit in it.

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V.

Fig. 9: Buzzer

VIBRATION MOTOR

Vibration motor is a DC motor without a core and the size of this motor is dense. These motors are applicable for different applications like pagers, handsets, cell phones, etc. The main feature of this motor is its magnetic properties, lightweight, and small motor size. Based on these features, the motor performance is highly consistent. The configuration of these motors can be done in two varieties: one is coin model and another one is a cylinder model. The vibration motor specifications mainly include: type, max operating torque, max.centrifugal force, weight range, rated current and output.

Frequency/rotational speed: F (vibration) = (Motor RPM)/60

Force of vibration $F = m\omega r^2$……………………………………3

Where 'm' is electric weight mass, 'r' is the offset distance of mass and 'ω' is the motor's speed.

Angular speed $\omega = 2\pi f$ …………………………………………. 4

The above equations could be used to calculate the centrifugal force. Based on the relationship of every component in the above equations, we can therefore infer that a high-weight mass with a high-offset from the shaft will lead to more force & vibration amplitude. also, when the vibration motor is subjected to an increased voltage, it will upraise the speed, frequency and amplitude of the vibration.

The Electromotive Force (EMF), also called back EMF, is the voltage that appears at the brush terminals when the shaft is rotating. The EMF has an internal resistance of zero. The voltage amplitude is strictly proportional to the shaft speed and its polarity depends on the direction of rotation. The linear proportionality between EMF and speed is defined as the motor voltage constant, K. As the EMF is proportional to the shaft speed, its voltage can be given:

E.M.F, $V = K\omega$…………………………………………. 5

Where ω is the rotational speed of the motor measured in rpm (revolution per minute).

This clearly shows that increase in voltage will cause a corresponding increase in the rotational speed and vice-versa.

Fig. 10: A Vibration Motor

METHODOLOGY

Design procedure and analysis

This chapter discusses the design and construction procedures of this project. In constructing this project, the system was subdivided into three units namely;

1. Power supply unit
2. EMF detector unit
3. Arduino-sensor unit

POWER SUPPLY UNIT

The system uses two 9-volt batteries direct-current supply, i.e. making a total of 18volts power supply.

One of which supplies power to the Arduino Nano with some of the components interfaced with it (ultrasonic sensors and buzzer), and the other one supplies power to the EMF detector and vibration motor.

EMF DETECTOR UNIT

The EMF detector detects issues in the electromagnetic field by the measurable changes in the quantity of electric or magnetic energy that radiates in the field that is being considered. This is complete with the highly-sensitive components which are part of the arrangement of this test and measurement device. According to the fluctuations in the quantity of electric or magnetic energy (if there are any), the EMF detector can specify existent issues in the work of electrical wiring and power lines. With this method, bigger problems can be prevented and it can also serve as a tool to identify electronic gadgets by the blinds etc.

In our daily life, there are a lot of electronic devices that still have small radiation even if the device is turned off without being unplugged. Basically, these devices can be found in home applications such as computer's battery, microwave, wireless telephone, television and etc. For example, this can happen during work on computer or watch on the TV, where the body is engulfed in an "electronic smog" emanating from the device; referring the EMF outlet sockets. In CRT-based monitors, the spot of electrons that sweep the screen can generate pulsed electromagnetic radiation (PEMR) (De Hoop, *et al*. 2011). This energy will escape in the form of radiations in very low-frequency and low energy. Thus, these unnatural radiations behavior can disrupt the body's bio magnetic field within which millions of electrical impulses regulate the activities of the cells. Unfortunately, the continuous exposure to PEMR can cause adverse effects to the human without our concerning on it in our daily life (Smith, 2006).

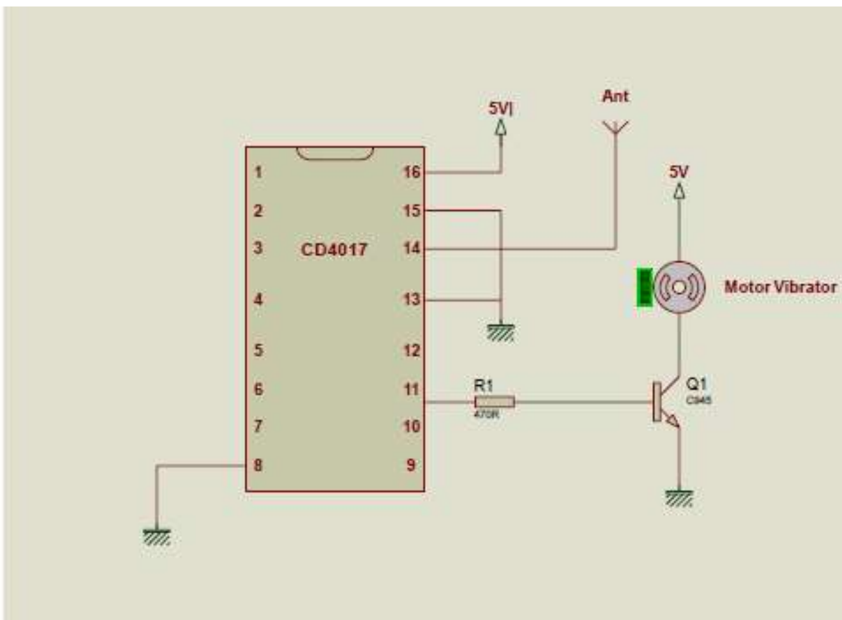
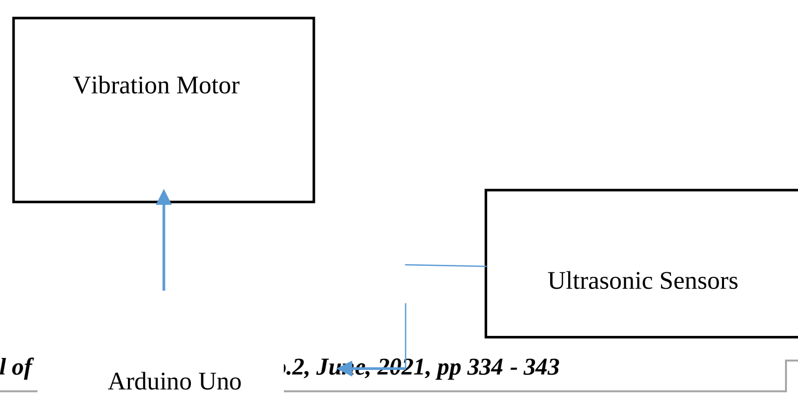


Fig. 11: EMF detector circuit.

ARDUINO-SENSOR UNIT



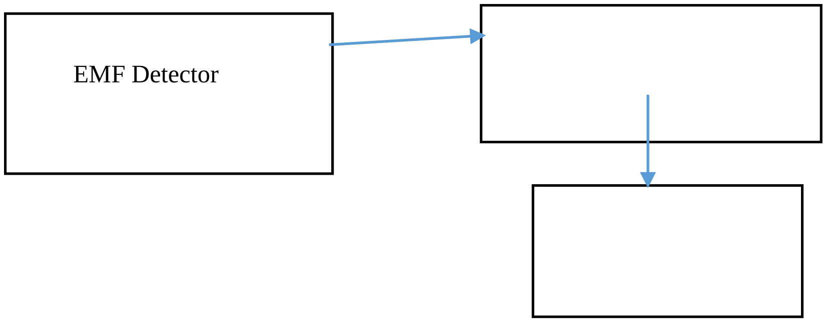


Fig.12: Block diagram of the project

The Arduino Nano is a microcontroller board based on the ATmega328. It has 14 digital Input and Output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16MHz ceramic resonator, USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to sustain the microcontroller.

CONSTRUCTION AND TESTING

Packaging process was done in order to put together all the components discussed in the preceding chapters into a single smart stick. A PVC pipe was used as the stick for the coupling process which has all the electrical components used embedded in it.

TESTING TOOLS

Testing tools are materials used to measure the functionality of the component or the entire circuit. The tool used for this purpose is digital multi-meter.

DIGITAL MULTI-METER

A digital multi-meter was used to measure the electrical values principally voltage (volts), current (amps) and resistance (ohms). It is a standard diagnostic tool for technicians in the electrical/electronic industries.

RESULT

The proposed design consists of ultrasonic sensor (HC-SR04) that was coupled with an EMF detector. The combination altogether is controlled by the Arduino board to identify the distance between an object and the sensor, and also to sense the presence of electromagnetic field. In this project, the materials: human, wood and stone were chosen for test to validate the system's effectiveness.

The measurements have been recorded over the distances of (5- 40) cm at different angles (from 0 to 180 degrees). The controller is interfaced with a computer to display the measured distances by the ultrasonic sensors. The efficiency of the designed system for a specified obstacle is measured by evaluating the percentage error using equation (6).

$$Error = \frac{real\ distance - measured\ distance}{real\ distance} *100\% \quad .... (1)$$

Where the parameters (real distance) and (measured distance) represent the distance in (cm) between the object and the system measured manually by the sensor respectively. Several reasons could lead to this error such as the change of temperature, wind speed and random noises; in fact, these reasons affect the ultrasonic waves.

HUMAN OBSTACLE

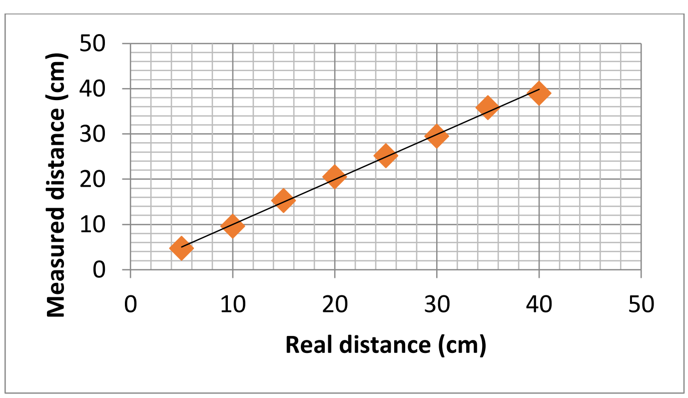


Fig. 13: Relationship between Measurement and Actual Distance for human Obstacle.

Table 1: Experimental results (human obstacle)

Real distance (cm)	Measured distance (cm)	Error % (wood)
5	5.2	4.00%
10	10.0	0.00%
15	14.9	0.67%
20	20.1	0.50%
25	25.4	1.60%
30	30.2	0.67%
35	35.5	1.43%
40	41.0	2.50%

WOOD OBSTACLE

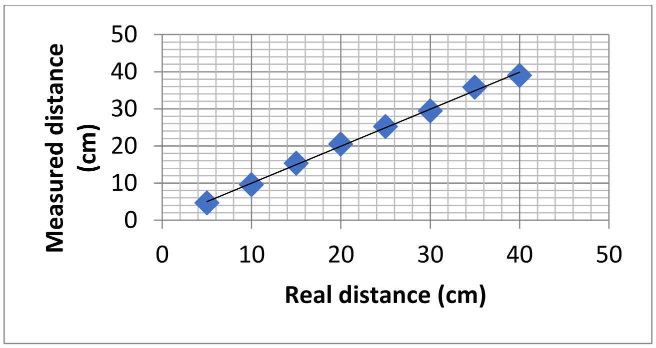


Fig. 14: Relationship between Measurement and Actual Distance for wood Obstacle

Table 2: Experimental Results (wood Obstacle).

Real distance (cm)	Measured distance (cm)	Error % (wood)
5	4.4	12%
10	9.0	10%
15	14.9	6.0%
20	20.7	3.5%
25	24.0	4.0%
30	28.8	4.0%
35	37.0	5.7%
40	39.0	2.5%

STONE OBSTACLE

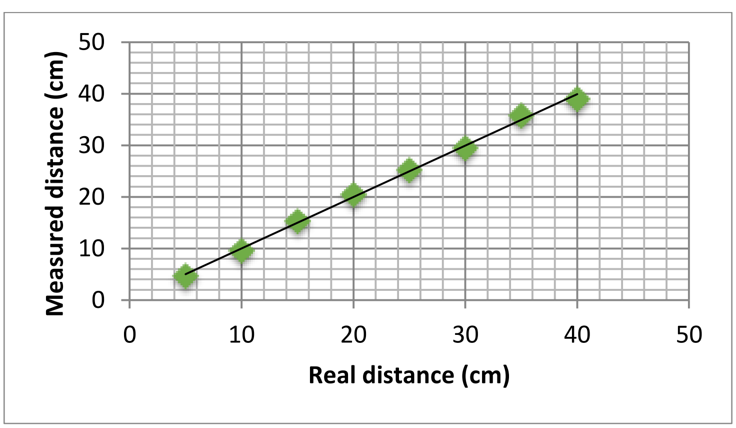


Fig. 15: Relationship between measurement and actual Distance for stone obstacle

Table 3: Experimental Results (stone Obstacle).

Real distance (cm)	Measured distance (cm)	Error % (stone)
5	4.7	6.0%
10	9.6	4.0%
15	15.3	2.0%
20	20.5	2.5%
25	25.2	0.8%
30	29.5	1.7%
35	35.8	2.3%
40	39.0	2.5%

DISCUSSION

Figure 13 and Table 1 summarizes the results of distance measurements in case of human obstacle. It can be noticed that the maximum percentage error between the actual distance and measured distance is about 2% and most readings are less than 1%. This shows that it detects humans accurately at a minimal error. In case of wood obstacle; as explained in Figure 14 and Table 2; the percentage error of most measurements is larger than the measurements in case of stone obstacle. It ranges from 2.5-12%, which is still accurate but not as much as that of human and stone obstacles. In case of stone obstacle; as shown in Figure 15 and Table 3; the percentage error of most measurements is smaller than the measurements in case of wood obstacle and greater than the measurements of the human obstacle. It ranges from 0.8-6.0% which is still efficient and effective.

Considering the evaluated percentage errors for the measured distances against the respective obstacles, it could be concluded that the prototype is working efficiently at an acceptable error.

5.0 CONCLUSION

It is worth mentioning at this stage to say that this project was successfully constructed and implemented. An Arduino Nano was used as the controller which suffices the whole project, the components: ultrasonic sensor, buzzer, EMF detector and vibration motor were all interfaced with it.

To evaluate the sensitivity of the ultrasonic sensor, three materials: human, wood and stone were used as obstacles. The errors inferred as a result of the calculation between the real and actual distances were miniscule and negligible which shows that the project is undoubtedly valid and effective.

Hence, it could be seen that a smart static and dynamic obstacle walking stick with EMF detector using MCU and controlling software has been improvised. The figure below shows the physical description of the improvised prototype;

Fig.16: The smart stick with EMF detector

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