Autonomous Solar Smart Cap (ASSC) for Pedestrian Safety

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Abstract— **In this paper, a solar energy driven wearable autonomous smart cap for pedestrian safety has been proposed. A flexible solar panel capable of providing 10.2V and 120mA has been used as means of powering up wearable smart cap. The objective is to introduce cost-effective, autonomous and user-friendly device for avoiding pedestrian accidents on roads due to the use of mobile phones as the usage of mobile phones by the pedestrians is a vital concern of safety. There has been immense increase in the number of accidents noticed in the past few years due to the massive use of mobile phones on the roads. The flexible solar panel has been used as the means to power the cap. The flexible solar panel employed in the proposed system has very less weight and is extremely flexible which make it feasible to be installed on the cap. The idea of using a flexible solar panel has the grounds for eliminating the dependency of the proposed smart cap on primary batteries which gets fueled up with time. The propounded system is an efficient system which has the ability to detect the obstacle in the path of a mobile user and alert the pedestrian in a user-friendly manner in order to avoid the accident. The propounded system has been tested with the various volunteers and the response has been very much positive. The proposed system has been reviewed as accurate and user-friendly.**

Keywords—energy harvesting; pedestrian; wearable smart cap; flexible solar panel; autonomous.

I. Introduction

With the growth of technology and the advent of next generation wireless standards, the reach of mobile communication is expected to grow over 90% in the coming years [1]. The cellular phone usage has become quite popular within the last decade [2]. Nowadays, the mobile phones have become requisite part of our life and has led to the addiction among the adolescent age groups. The people are always busy on their phones in receiving or making calls, checking their friends on Facebook, chatting on WhatsApp, checking emails and listening to music. It has become virtually impossible to avoid unnecessary interruption. However, the number of accidents have been reported in the past few years due to the extensive usage of mobile phones while walking across a road or driving [3]. A pedestrian who is engaged in mobile phone while crossing street is potentially at more risk [4]. The studies reveal that mobile-phone related injuries among pedestrians have increased relative to total pedestrian injuries [5]. Day to day pedestrian crashes has led to an important issue globally as pedestrians are a highly vulnerable road user group [6].

In order to prevent pedestrian injuries and to avoid pedestrian accidents, the proposed system has been developed that warns the pedestrian users when it detects [7] an obstacle in the way while walking on road. The process of extracting energy from the environment in order to store and convert it to a usable form is known as energy harvesting. With the advancement, in wireless technology, the energy harvesting has gained popularity as an alternative of the conventional batteries [8]. As these conventional batteries, can store a limited amount of power for a short period of time, the energy harvesting techniques [9] are generally employed as the power source nowadays in various systems. The most common types of energy harvesting techniques are photonic, thermal, and vibration. The commonly photonic harvesters rely on solar energy [10] that is drawn by employing solar panels consisting of grids of solar cells. These grid solar cells can be integrated in a system so as to achieve self-powered i.e. autonomous operation [11].

In the proposed system, a solar energy driven smart wearable cap has been introduced that has the capability of detecting the obstacles in the pathway and alerting the pedestrian user. It is an autonomous cap that deploys solar energy to operate the system by employing a flexible solar panel. However, in the absence of solar energy, the system switches to battery mode and uses battery as the source of power supply for smart cap.

II. Proposed System and Components

To design and fabricate the desired system with the required features and services, the number of components have been deployed where each component has different functionality associated with it. The description of various components that have been deployed in the proposed system has been listed below.

A. Atmega8 Microcontroller

ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. It is a 28 pin IC that has an operating voltage of 4.5V to 5.5V with current requirement of 3.6mA in its active mode and operating temperature range of -40^{0}C to 85^{0}C [12]. These features make it relevant for the

B. Accelerometer

The ADXL335 accelerometer has been employed in the proposed system. It is a small, thin, low power, complete 3-axis accelerometer i.e. it has 3output pins named as X_{out}, Y_{out} and Z_{out}. It has single supply operation with operating voltage of 1.8V to 3.6V and current requirement of 350 μA [13]. An analog output is yielded by accelerometer analogous to its 3D space. This accelerometer is integrated on GY-61 breakout board with its Y_{out} pin connected to Atmega 8 microcontroller because its orientation is required only in y-direction in the proposed system [14] as illustrated in Fig 1 with symbol A1.

C. Ultrasonic Ranging Module

The three HC-SR04 ultrasonic ranging modules of dimension 45mm x 20mm x 15mm has been deployed in the proposed system so as to measure the distance of obstacle from the modules in all possible three directions (left, right and front). It endeavors excellent non-contact range detection with high accuracy and stable readings in one package which made it suitable for the proposed system. This ultrasonic module uses sonar to determine distance from an object within the range of 2-400 cm or 1`` to 13 feet. Unlike other sharp range finders its operation is not affected by sunlight or black material. To operate it requires power supply of +5V DC and a working current of 15mA with ultrasonic frequency of 40kHz. To start the operation, the Trig pin of module is applied with a pulse high (5V) for at least 10μs (trigger input pulse width), after which the module transmits 8 cycles of ultrasonic burst at 40kHz and waits for the reflected ultrasonic burst that are attained after striking from an object. The sensor detects the reflected ultrasonic waves and sets echo pin to high (5V) and measures the delay for a period (width) that is proportional to the distance from the object [15] corresponding to which an echo pulse is produced which is further applied to the microcontroller to perform calculations. These three ultrasonic ranging modules are represented by symbols US1, US2 and US3 in Fig. 1.

D. Flexible Solar Panel

The proposed system of smart cap can be made to work on a +9V Duracell battery. In order to enhance the system reliability, the battery has been replaced by a flexible solar panel of dimension 75mm x 253mm x 0.6mm [16] which has capability of providing 10.2 V and 120mA current output. Its small size and flexible nature provides the feature of ease of mounting on the cap and ensures surface conformity. The flexible solar panel is represented by symbol S1 in Fig. 1.

E. Schottky diodes and autonomous circuit

The three Schottky diodes (1N5819) been deployed in the proposed system so as to construct a circuit that makes the system autonomous. The Schottky diodes were preferred because of their low voltage drop and fast switching capability which makes it suitable for the circuit. The fig. 1 illustrates the arrangement of three diodes with solar panel, battery and rest of the system. The diode (D4) is connected between solar panel and battery in order to charge battery with excess power from solar panel. Further, the diode (D3) is connected between battery and with rest of the system so as to supply power to the system. It is connected in order to provide reverse- battery protection whereas diode (D2) is connected between solar panel and with rest of the system so as to supply power to system through solar panel. This complete set up keeps the whole system active even during the absence of sunlight by providing power to system with the help of battery [17].

F. Systematic Arrangement

In the proposed system, in order to allow free neck movement to the user, an empty pen refill has been used which is connected to a metal belt that rests around the neck and to the cap congregation. The pen refill allows the user to turn head left or right by bending according to the motion of head. The metal contacts allow to detect the bend in the pipe and this information is provided to Atmega8 which further initializes the ultrasonic sensor.

Some additional components that has been used in the system are Vibration Motor, SPDT Switch and Potentiometer. The Vibration Motor represented with symbol M1 in fig. 1 has been used to produce vibrations in the bottle cap to provide sensation at neck of pedestrian user. The proposed system can work under two different modes - long-range mode and short-range mode. In long-range mode, it alerts the user from an obstacle present at a distance of 4 meters whereas in short-range mode, it alerts the user from an obstacle present at a distance of 2 meters.

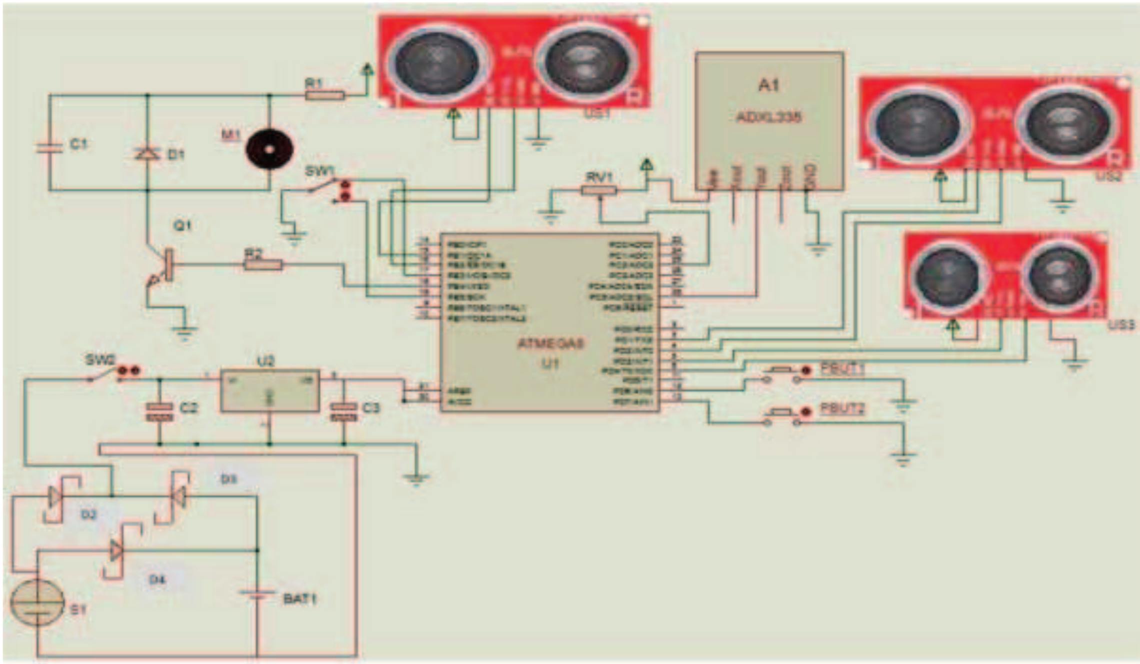

Fig. 1. Circuit diagram of proposed system

This is achieved by using an SPDT switch which is connected to ATmega8 as shown in fig. 1 with symbol SW1. Further to enable the ranging modules according to varying downward head bend of the user, a potentiometer has been used so as to adjust downward head bend threshold by varying the potentiometer settings [14] as represented in fig. 1 with symbol RV1.

III. Operation

The three HC-SR04 ultrasonic ranging modules have been deployed in the proposed system so as to measure the distance of obstacle from the modules in all the possible three directions (left, right and front). So, they are arranged in such a manner that one module is present at the left, second at the right and third at the front of the smart cap. When a pedestrian who is wearing the smart cap while walking on the street with his head bend downwards, the sensor of ultrasonic ranging module gets activated as soon as they receive a 10µs pulse, in respond to which an echo pulse is generated by the activated module which is further applied to Atmega8 microcontroller. The microcontroller measures the turn-on time of the echo pulse so as to calculate the distance of the user from an obstacle. If the calculated distance is within the range in accordance to the range selector-SPDT switch (SW1), a pulse will be transmitted to the transistor (Q1) to activate the vibration motor by the Atmega8. The vibration motor produces vibrations on the neck of the user through bottle cap that is attached to the smart cap assembly through empty pen refill. As the distance between the obstacle and user decreases, there is increase in vibrations per minute. The power is supplied to the system differently through two different ways as discussed below:

A. By means of Flexible Solar Panel under the presence of sunlight

When the user is using the smart cap in the presence of sunlight, the power is supplied to the system with the help of solar panel. The solar panel uses the sunlight to get activated and then it converts the available solar energy into electrical energy and supplies it to the system in order to start the operation.

B. By means of Duracell 9V battery

When the user is using the smart cap in the absence of sunlight, the flexible solar panel is replaced by +9V Duracell battery automatically by the circuit in order to operate the system efficiently. This automatic circuit operates with the help of three Schottky diodes arranged in such a manner that one of the diode (D4) is connected between solar panel and battery in order to charge the battery with extra power received by solar panel. The diode (D2) is connected between solar panel and the system whereas the diode (D3) is connected between battery and the system in order to supply power to the system through solar panel or through battery whichever is in operation. Fig. 2 illustrates the autonomous nature of the proposed system by means of flowchart which indicates that the system employs battery or solar panel as means of power supply depending on the presence or absence of sunlight.

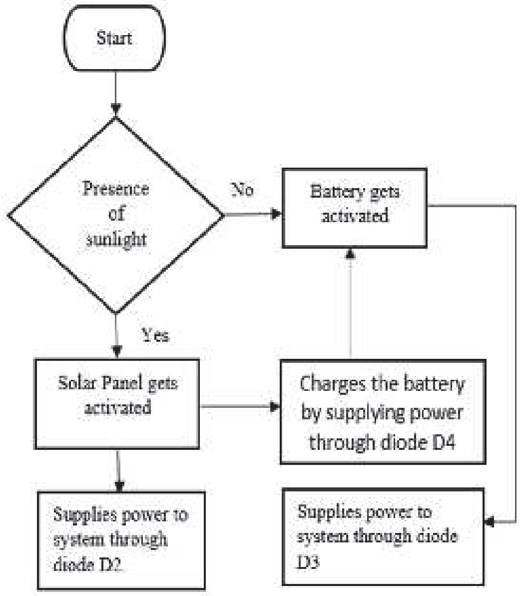

Fig. 2 Flowchart illustrating the autonomous nature of the proposed system

IV. Experimental Validation And Results

To perform testing of system, the vibration meter has been used. It measures the vibrations and oscillations of the system. In order to test the system, the vibration meter was connected to the metal belt at which bottle cap is connected and obstacles were introduced in front of the smart cap so as to measure the vibration rate as shown in fig. 2. It was observed that number of vibrations increases with the decrease in distance between the cap and the obstacle. The complete autonomous system has been set up in order to check the workability of the proposed system with autonomous circuit under the absence and presence of sunlight as illustrated in fig. 3. The complete system works in both the conditions efficiently. A closer view of circuit is shown in fig. 4.

Fig. 3. Testing of proposed system using vibration meter

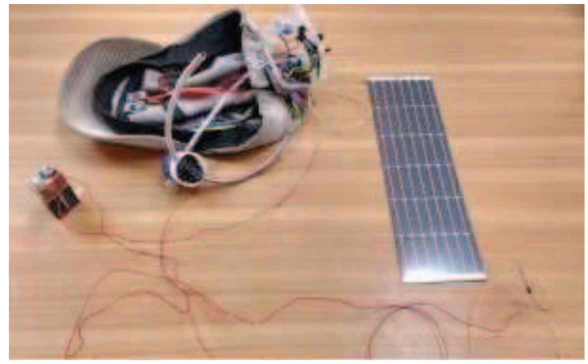

Fig. 4 Complete set up of proposed system

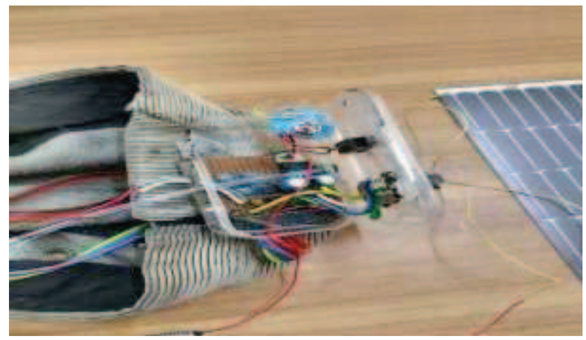

Fig. 5 Cap circuit of the proposed system

V. Conclusion

In this paper, the autonomous solar driven smart cap has been suitably designed and tested for achieving safety among pedestrian users using smartphones. The proposed system can be suitably employed to avoid road accidents among pedestrian users. The proposed smart cap offers benefits of flexible and light weight user friendly solar panel as the means of powering the cap which makes it autonomous in nature. It works under two modes – long range mode (4 meters distance) and short-range mode (2 meters distance). The users can adjust the mode according to their requirement. The proposed system is energy efficient as it employs solar energy to provide power to the system and simultaneously the extra solar energy is utilized to charge the battery that can be used to supply power to the system in absence of sunlight in order to keep the system working in all the conditions.

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