Designing a prototype of a waterproof doorbell motion sensor: an exemplification in STEAM learning

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ABSTRACT: Designing a prototype of an appropriate tool can serve as a crucial example of science, technology, engineering, the arts and mathematics (STEAM) education for students. In this article is presented a prototype of a passive infrared (PIR) waterproof doorbell motion sensor as such an example. The PIR sensor is an electronic sensor that gives a signal when its rays are crossed. It measures the infrared (IR) light radiating from the objects within its field of view and can detect a change in motion in its surroundings within a different range of radius, hence it is most often used in motion detectors. This type of sensor is most commonly used in security alarms and automatic lighting applications. It detects general movement, but does not give information about the person or object that has moved. The developed prototype of a waterproof doorbell motion sensor detects motion within its range, around five meters, of an unusual motion. Using this sensor, electrical power consumption can be minimised, making it an efficient and low-cost device, thus making it a particularly suitable tool for educational purposes.

INTRODUCTION

There have been rapid technological advances over the last decades, particularly in electronics. New technologies are pervasive in all areas of life, including workplaces and homes. For some people, home automation has become a necessity, especially for those who often leave their homes, thus may require a security monitoring system, or those who are obliged to care for disabled or elderly family members and need to adapt the house to their special requirements [1][2].

Advanced technological developments often underpin home automation systems that are now easier to access and apply, whether for simple things, such as self opening doors/automatic doors or more complex applications, such as home monitoring [3][4].

An automatic bell is a feature of many home automation systems [5]. As the name implies, this bell rings automatically when it detects the presence of guests or strangers. There are various reasons behind installing automatic bells, ranging from simply making it easier for visitors (i.e. they do not have to press the buzzer) to applying them as part of an anti-theft system [6]. In the case of guests, the use of sensors to make the bell ringing eliminates the need for a traditional buzzer switch installation as the host will be notified about the guests' arrival by the automatic bell [7][8].

This type of sensor has been widely applied to detect the presence of an object as reported in previous studies; for example, such as detecting the presence of an object around the car while parking and detecting a safe distance to other vehicles when it is running [9]. As indicated in another study, using this sensor enables the detection of a certain distance or position of a person in front of the door, both horizontally and vertically, and based on that the bell rings automatically [10]. Hence, in order to function correctly, the automatic bell system must be able to detect objects in front of the door/fence.

One of the sensors that can detect these objects' presence is a passive infrared (PIR) sensor [11]. This sensor detects the presence of moving objects, so it is the type that can be applied in automating the bell function, and as mentioned above, thus eliminating the need for a buzzer switch [7][8][12]. The use of the HC-SR501 sensor is an alternative to the use of a guest bell. When the activities of the house residents are far from the front of the house, the residents would not know whether there are visitors on the house's terrace [13].

In yet another study, the HC-SR501 sensor was placed on the front porch of the house. The location of the sensor was intended to determine the presence or absence of moving objects in the area covered by the HC-SR501. As in the above examples, the purpose of the sensor was to monitor by the house residents any guests or intruders appearing on the front porch of the house [14].

In the literature review undertaken by the authors of this article, particular emphasis was placed on the recent technologies in the field of monitoring systems. Many designs and proposed methods are being used to enhance and improve various monitoring systems, especially PIR motion sensors [15][16].

In this project, the design and implementation of a simple automatic doorbell system were carried out to monitor the presence of visitors. As pointed out in other studies, that presence or movement by the visitors, can be detected by sensors placed above the front door which results in the automatic ringing of the bell [15][16].

RESEARCH METHOD

The overarching aim of this project was to develop a prototype of a waterproof doorbell using a motion sensor as an exemplification in STEAM education. This development, which is based on the studies outlined above, may also be useful for anyone interested in innovation and refinement of home security measures, and their effectiveness and up-to-datedness.

The authors adopted the developmental method of research. *Rapid application development models were also utilized in developing, testing, and evaluating the prototype* [15]. The evaluation of the waterproof doorbell's effectiveness was particularly important as the overall emphasis was on applicability and usefulness. The steps presented in Figure 1 were actually undertaken in a regency in Jawa Timur, Indonesia.

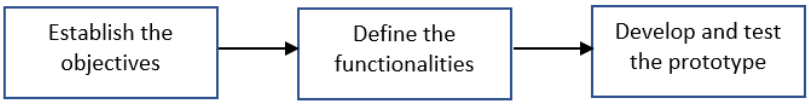

Figure 1: Flow chart of the STEAM activities.

Figure 1 also captures the main objectives of this project, which were to design, test and evaluate the performance of a waterproof doorbell using motion detection. *Functionalities include the actual transmission and reception of the signal at the time of detection* [15]. The motion sensor operation was also carefully examined concerning the interval of motion detection of object movement.

RESULTS AND DISCUSSION

Effectiveness of the Prototype of a Waterproof Doorbell Motion Sensor

The doorbell motion sensor can be used 24 hours a day. The detection of changes in the home surroundings, for example by a sensor located on a house terrace, is based on the concept of motion detection including body temperature sensors to ensure that all persons/objects with body temperature are captured. After detecting object movement, the sensor and transmitter module send a radio wave signal to the receiver. Then, *the receiver module will process the received signal by producing audible sounds* [8]. Real-time data comes from the location of the sensor, i.e. the house terrace. The task of the sensor is to recognise the presence of an object or a guest appearing on the terrace, and then transmit that information to the receiver. This arrangement is an alternative to using a traditional bell.

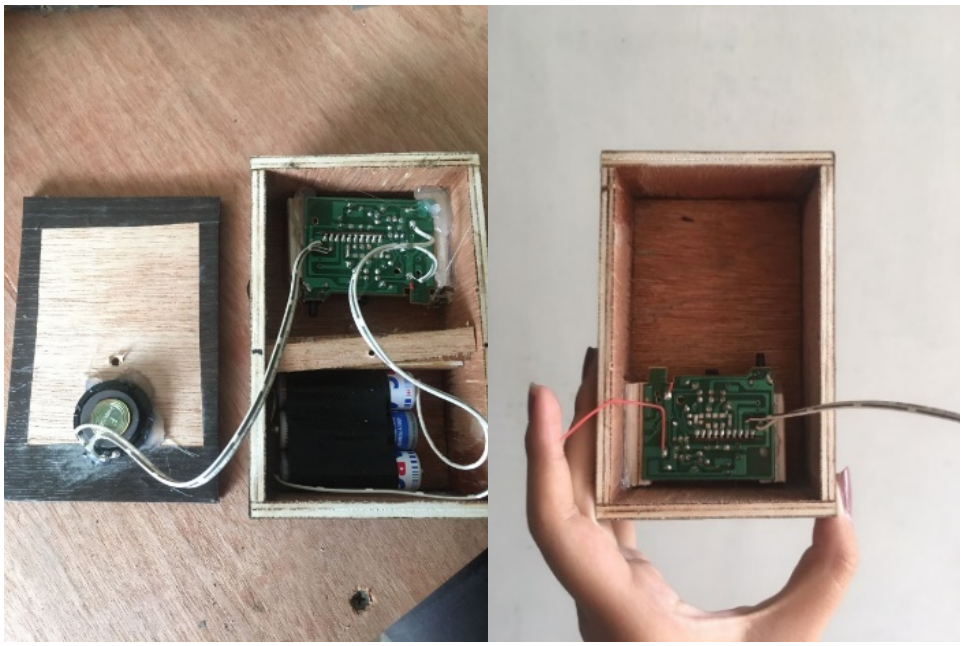

Figure 2: Set of parts.

At the initial stage, it was determined that the best location for a sensor intended to capture object movement on a house terrace would be above the door leaf - the main panel that opens. The placement of the sensor must be precise according to the motion of guests or objects close to the entrance. In this development, a wireless network was used as an example of technology applied in education. Not infrequently, it is used to send data from the application of the tool made to simplify and speed up the process. The transmitter circuit consists of a microcontroller and the transmitter's module. As already mentioned, it is a passive infrared sensor. The microcontroller here is used to automatically adjust the data received by the sensor and the data to be sent. At the same time, the sensor's function is to detect the presence of human movement in the sensor area.

Figure 3: Prototype of a waterproof doorbell motion sensor.

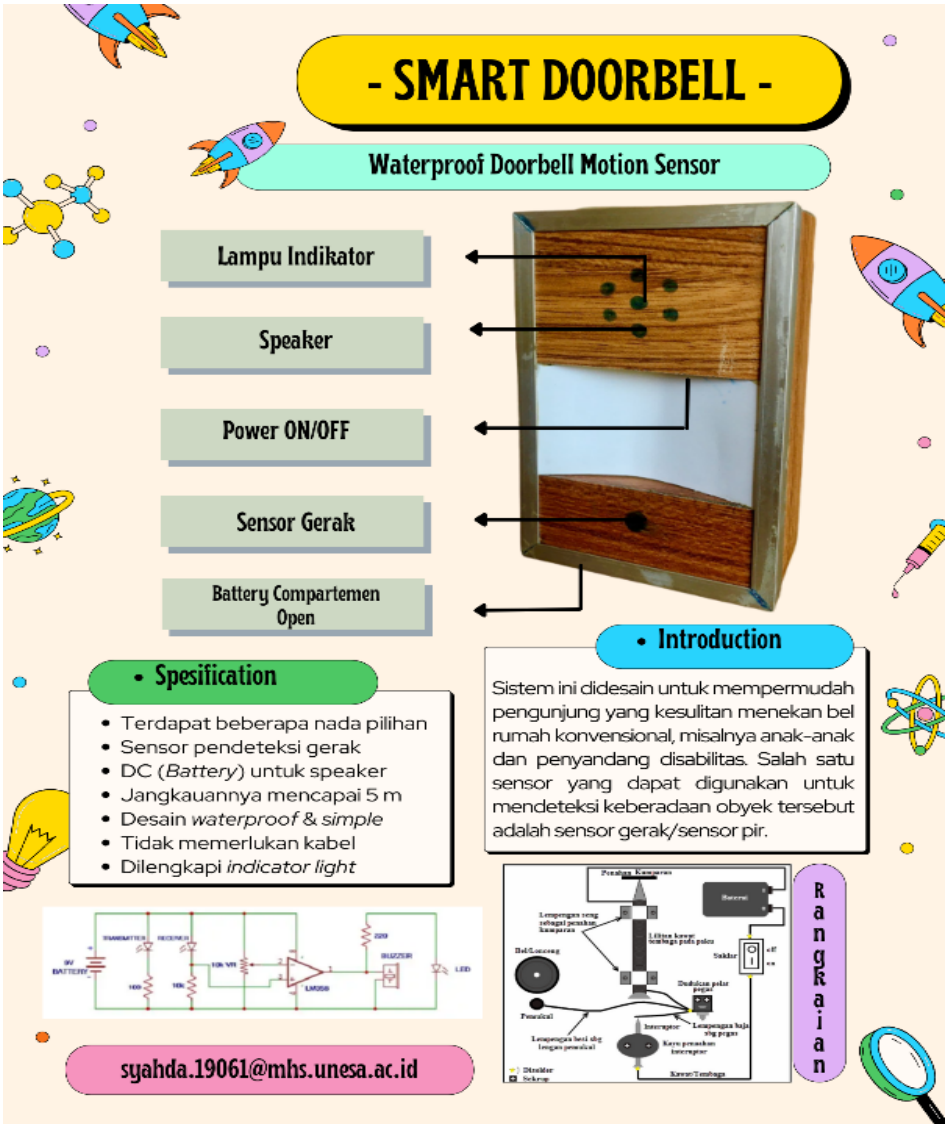

Figure 4: Prototype of a waterproof doorbell motion sensor - a poster outlining the development.

This prototype was made using simple and readily available materials. The design is minimalist, simple and waterproof. So, considering its waterproofness, the authors did not have to worry about putting it outside the house or gate. This house bell is also equipped with indicator lights and different ringtones, which can be changed according to the homeowner's taste. In addition, this bell is also practical to use without the need for electric power and cables (Figure 4). The testing results of this prototype are as follows: detection range distance from 1 to 5 meters - positive, over 5 meters - negative.

As indicated in earlier studies, the transmitter automatically sends data to the receiver when the passive infrared sensor detects the presence of humans/moving objects in the sensor area so that it gets a voltage [8][11][12]. The buzzer will automatically sound when the receiver gets the data from the transmitter coming from the passive infrared sensor that has detected some movement. As part of the prototype testing, several trials were conducted to find out if particular objects would be detected, and 95% of the total testing was successful.

Evaluation Results

This prototype is based on the idea that everybody generates heat energy from infrared rays, which are not visible to the naked human eye but can be detected using a PIR sensor (an electronic sensor). The project focuses on the detection of the motion of an intruder without any external touch. The waterproof doorbell motion sensor detects motion within its range, around five meters, of an unusual motion. The passive infrared sensor's task is to measures the infrared light radiating from objects in its field of view. These type of sensors are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications. They detect general movement but do not give information on who or what moved.

As part of the development, expert judgment was needed to evaluate the prototype of a waterproof doorbell motion sensor as a prototype in STEAM learning. Table 1 includes the evaluation results from three STEAM experts or validators. The experts were asked to rate all the components of this development within STEAM education by using a four-point Likert scale (1-4). Having considered the development from each STEAM aspect, the three experts placed the prototype mostly in the very good category (please note that in Table 1, the mode rather than the mean values have been included). After the successful evaluation, the prototype of a waterproof doorbell motion sensor can be used for future students and teachers in STEAM education [17].

Table 1: Expert judgement.

STEAM aspect	Evaluation results			Mode	Category
	Expert 1	Expert 2	Expert 3		
Science					
Accuracy of scientific concepts	4	3	4	4	Very good
Relevant to science curriculum	4	4	4	4	Very good
Technology					
Covers the principles of *do it yourself* (DIY)	4	4	4	4	Very good
Based on simple technology principles	4	4	4	4	Very good
Engineering					
Innovation in sensor type selection	4	4	3	4	Very good
Effectiveness in developing a design	3	3	4	3	Good
Art					
Pays attention to aesthetic aspects	3	4	3	3	Good
Interesting design	3	3	3	3	Good
Mathematics					
Develops visual-spatial intelligence and mathematical concepts, such as geometry	4	4	4	4	Very good
Pays attention to the components of manufacturing costs, is as efficient as possible	4	3	4	4	Very good
Total (based on mode)	4	4	4	4	Very good

*Note: rating scale from the interval 1-4

The project presented here has an impact on engineering and technology education considering its interdisciplinary approach that creates a more comprehensive framework for analysis. Another important aspect is the contribution of the T (technology) and E (engineering) component in the whole context of STEAM [17-19].

The STEAM prototype of a waterproof doorbell motion sensor illustrates the role of *simple* technology in STEAM learning. The inclusion of the prototype in the curriculum highlights the need for simple engineering approaches in grounding STEAM education. It has also been observed that implementing STEM or STEAM learning in class could trigger some innovation and creativity [20], which is yet another benefit for the students.

CONCLUSIONS

This project is an example of implementing STEAM education for students by providing a STEAM prototype of a doorbell as a tool model. While working on the project, the authors implemented a framework with PIR motion sensors to detect and determine any movement of visitors/intruders.

The advantages of this waterproof doorbell motion sensor are more numerous than any disadvantages. The main drawback of this development is that the sensor cannot detect how many persons are present in the area. Instead, it detects only the motion of the body. However, it is still a helpful model even for more significant projects, including home automation systems.

The prototype that has been developed within this study is deliberately small-scale and straightforward, so that others can understand it easily and utilise in education. It is also worth highlighting here that growing up with ever-faster developing technology may change the solution for a given problem, but the essential criteria for a problem statement and assessment may remain the same.

The content of this article is one of the outputs of a STEAM learning course. It is hoped that it can provide additional knowledge to teachers and students regarding the implementation of STEAM in physics and other classes using simple tools. The authors also hope that future researchers will be able to develop more effective and sophisticated tools to support STEAM learning.

REFERENCES

1. Anindya, S.F. and Rachmat, H.H., Implementasi sistem bel rumah otomatis berbasis sensor ultrasonik. ELKOMIKA: *J. Tek. Energi Elektrik, Tek. Telekom. and Tek. Elektronika*, 3, **1**, 64-74 (2015) (in Indonesian).
2. Susanto, R., Kristanto, Y., Ridwanto, S. and Hisnuaji, D., Perancangan dan implementasi sensor parkir pada mobil menggunakan sensor ultrasonic. *CommIT*, 1, **1**, 18-29 (2007) (in Indonesian).
3. Mustar, M.Y., Implementation of rain detection and temperature monitoring system based on real time sensor. *Semestak Teknika*, 20, **1**, 20-28 (2017).
4. Prasetya, M.A. and Aulia, R., Prototype penerangan lampu taman otomatis menggunakan arduino uno. CESS, *J. Comp. Engng., Sys. and Science*, 5, **1**, 109-113 (2020) (in Indonesian).
5. Tsauqi, A.K., Manuel, I., Hasan, V.M., Tsalsabila, A., Chandra, F., Yuliana, T. and Tarigan, P., Saklar otomatis berbasis light dependent resistor (LDR). *Proc. Sem. Nas. Fisika*, 19-24 (2016) (in Indonesian).
6. Xue, H., New integrated teaching mode for labor education course based on STEAM education. *Inter. J. of Emerging Tech. Learn*., 17, **2**, 128-142 (2022).
7. Eddi, S.C. and Triyanto, D., Sistem penerangan rumah otomatis dengan sensor cahaya berbasis mikrokontroler. *J. Coding Sistem Komp.Univ. Tanjungpura*, 1, **2**, 1-10 (2013) (in Indonesian).
8. Chaudhari, U., Gilbile, S., Bhosale, G., Chavan, N. and Wakhare, P., Smart doorbell security system using IoT. *Proc. Inter. Conf. Scie. and Tech*., 4228 (2020).
9. Syahwil, M., Panduan mudah simulasi dan praktek mikrokontroler Arduino. *Yogyakarta: Andi*, 13-19 (2013) (in Indonesian).
10. D'Angelo, M., Eggert, G., Bresler, R. and Qualitz, J., Motion sensitive anti-theft device with alarm screening. Invention with patent number US 6133830 A, United States of America (2000).
11. Dellosa, R., Development of an anti-theft device using motion detection and body temperature. *Asia Pacific. J. of Multidisciplinary Research*, 2, **6** (2014).
12. Bhaskar, P.R.G. and Rajeshwari, L., IoT based smart home automation using blynk app and security alerting system using e-mail. *Inter. J. of Recent Tech. and Engng.*, 8, **3**, 7743-7745 (2019).
13. Nazeer, M., Motion detection security alarm using Arduino. *SSRN* 3918345 (2021).
14. Alathari, B., Kadhim, M.F., Al-Khammasi, S. and Ali, N.S., A framework implementation of surveillance tracking system based on PIR motion sensors. *Indonesian J. of Electrical Engng. and Computer Science*, 13, **1**, 235-242 (2019).
15. Ismail, R., Omar, Z. and Suaibun, S., Obstacle-avoiding robot with IR and PIR motion sensors. *Proc. IOP Conf. Series: Materials Science and Engng*., 152, **1**, 012064 (2016).
16. Mouri, S.P., Sakib, S.N., Ferdous, Z. and Taher, M.A., Automatic lighting and security system design using PIR motion sensor. *J. of Institute of Infor. Tech., Jahangirnagar Univ*., 14, **8**, 1-5 (2015).
17. Anisimova, T.I., Sabirova, F.M. and Shatunova, O.V., Formation of design and research competencies in future teachers in the framework of STEAM education. *Inter. J. of Emerging Technologies in Learning*, 15, **2**, 204-217 (2020).
18. Serik, M., Akhmetova, B., Shyndaliyev, N. and Mukhambetova, M., Supervising and managing STEM projects for school students by the school-university model. *World Trans. on Engng. and Technol. Educ*., 20, **2**, 95-100 (2022).
19. Gerigk, M., Improvements to the STEAM-based teaching of architectural drawing. *World Trans. on Engng. and Technol. Educ*., 19, **2**, 163-168 (2021).
20. Li, C., Maker-based STEAM education with Scratch tools. *World Trans. on Engng. and Technol. Educ.* 14, **1**, 151-156 (2016).