ENTRY ALERT SYSTEM FOR THE DEAF BLIND USING THE SENSE OF SMELL

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Abstract

Most common entry alert systems use sound and/or light to give notifications when someone enters through a monitored zone. These systems are however not applicable to people who are deaf and blind, along with the elderly people who are known to suffer greatly from this problem. In this paper, we report on an entry alert system suited to assist persons with aforementioned disability by utilizing the sense of smell. The system consists of a Passive Infrared (PIR) sensor, used to detect motion of an intruder through variations in radiant heat emitted by surrounding objects. An output from a Passive Infrared (PIR) Sensor triggers an Arduino Uno based on a programmable AT Mega 328P-PU microcontroller. A program developed in an Arduino Uno IDE and installed in the Arduino, directs a digital signal to a 5v relay that switches on an actuator element which in turn causes an aerosol to release a scent which can be recognized by the deafblind alerting them of an intruder. The PIR sensor was found to have an output voltage of 3.3V and a maximum detection range of 7 meters. The sensitivity was not affected much under normal working conditions with a change of 0.8 V recorded for temperatures between 15-30^{O}C. The system response time was found to be 0.3m/s at 20^{O}C and 0.5m/s at 29^{O}C for Rose perfume, 0.19m/s at 20^{O}C and 0.25m/s at 29^{O}C for Lavender perfume. These measurements compared well with data from MQ2 gas detector. The findings offer a novel door entry alert system that enhances security and comfort for the deafblind.

Key words: Deafblind, door entry alert system, Arduino Uno, MQ2 gas detector.

1.0 Introduction

Development of smart homes has impacted greatly on the lifestyles of people (Agarwal and Nayak, 2012; Işilak, 2010; Bangali and Shaligram, 2013). Entry alert systems that use bells or light as means of indicating an intrusion have been applied notifying an occupant of an intruder and thus improving security (Shankar *et al.*, 2015; Sunil, 2014; Govinda, 2014; Anubala *et al.,* 2014). These systems are however, not applicable to persons who may be deaf and/or blind. Importantly, studies have shown that this condition also affect greatly the elderly people (Laplante *et al.,* 1992; Duquette and Baril, 2012; WHO, 2013; Kaplan, 1996; Calgaro *et al.,* 2013). For this reason, assistive technology is vital in order to supplement the service and directly assist persons with the mentioned disability (Shinohara and Wobbrock, 2011; Enders, 1991; El-Basioni *et al.,* 2014; Hui-Ching, 2010; Erin, 2007).

To this effect, there is continued development of smart home systems with the aim of assisting the elderly and the disabled. El-Basioni *et al.,* (2014) developed a Wireless Smart Home system (E/D-WSH) for assisting the elderly and disabled. The Wireless Smart Home system incorporated: an entry system, a fall detection system, RFID system, a lighting system, a speech recognition system, a sound synthesizer system, a gas leakage detection system, an electrical devices monitoring system and a home structure health system. This entire system could be controlled locally using a remote control or an application on a PC or laptop, or remotely via internet thus offering an independent living for the elderly and disabled. A smart home system reported by Ansah *et al.,* (2015) consisted of a lighting control system developed with photo sensors to regulate the external and internal lighting and a vibrating alert system to assist the deaf. With functionalities like gas leakage detection, automatic turning off and on of the gas knob, intruder detection alarms systems, ambient light controlling, remote monitoring and controlling of home devices from remote locations, the systems was found to be of great assistance to the aged and disabled. Development of portable assistive devices has also impacted great positive change on the daily lives of persons with disabilities. Bansode *et al.,* (2015) reported on a system designed to assist the blind in walking. The blind person gives the destination's name as the input to a voice recognition module. A GPS module continuously receives the latitude and longitude of the current location and compares it with the destination's latitude and longitude. The blind person receives the pronounced directions which he needs to follow to get to his destination. This system was found to be reliable thus helping the blind walk safely to their desired destination. Additionally work done by Gulati, (2011) demonstrate a GPS Based Voice Alert System for the blind. The system was realized by use of a GPS module (SR-92) and a Voice Module (APR9600) interfaced with a PIC16F877 microcontroller. The system alerts the blind person through voice alerts when he/she enters into a particular location by announcing the location name. Ultrasonic sensor systems incorporating sound and vibration have been demonstrated to alert the blind (Safaa *et al.,* 2012). The sensor had a detection range of 150 cm thus helping the blind to avoid collision with objects along the path.

The existing systems are however, not applicable to the deaf-blind (Sachter and Faaborg, 2016; Kausar *et al.,* 2012 and Hasan *et al.,* 2015). In this paper, we demonstrate an entry alert system appropriate for use by the deaf-blind persons by using an Arduino Uno system programmed to drive an actuator element to dispense perfume from an aerosol.

2.0 Materials and Methods

A HC-SR501 PIR motion sensor module was used to detect motion of a person approaching a monitored area. Once motion is detected, a signal is sent to the Arduino Uno based on AT Mega 328P-PU. An output signal is then sent to Arduino's digital pin 4 connected to the relay that turns the actuators' motor ON which in turn rotates the gear system. This pushes the pressing rod down causing pressure on the perfume aerosol top thus releasing perfume scent. Figure 1 illustrates the circuit connection, specially designed to suit the desired application. Two Light Emitting Diodes (LED) were appropriately connected in the circuit to indicate when the PIR sensor and Actuator element were active. For the purpose of data collection, two different perfumes were used; Rose and Lavender Fragrant perfumes filled in two different tightly closed aerosols.

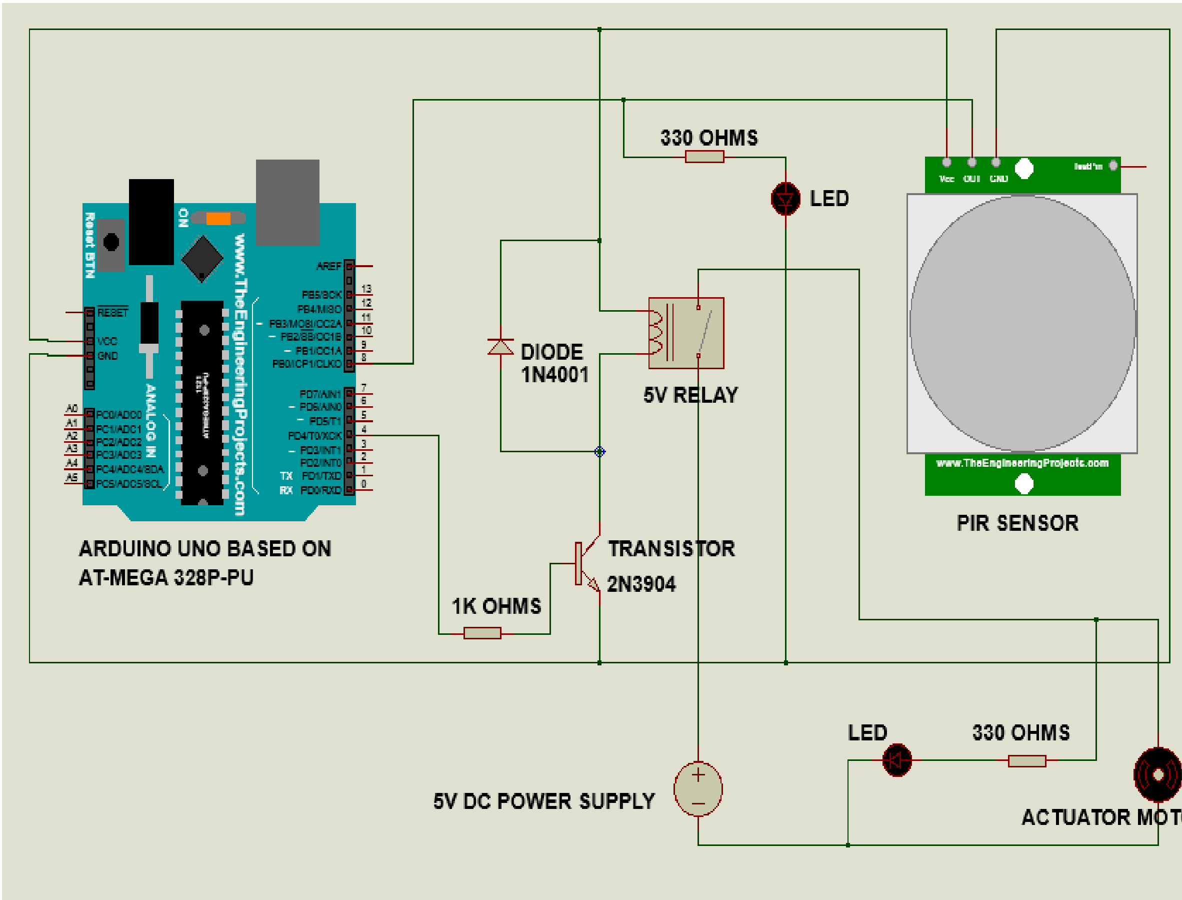

Fig. 1: Circuit diagram showing the connection of the system components making up an entry alert system for the deaf-blind.

The actuator element designed for this system is composed of 5V DC motor, a system of gears and a pressing rod, figure 2. The circuit converts electrical energy is in to a mechanical force that causes pressure onto the top outlet of the perfume aerosol thus releasing perfume. The element is powered from an external dc power source and is switched by a relay controlled by a 5V signal from the Arduino Uno. In order to facilitate proper perfume dispensation, the actuator was designed to fit the aerosol specifications.

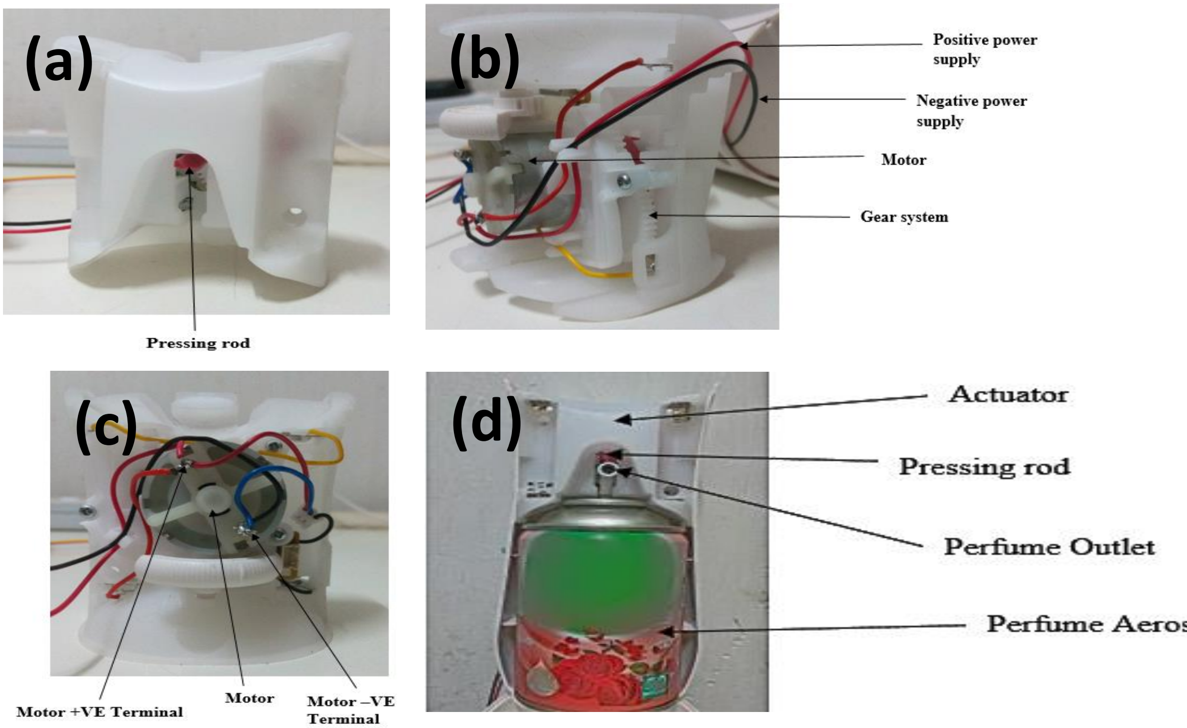

Fig. 2: (a) Front view, (b) Side view (c) Back view and (d) the actuator system and aerosol containing rose fragrant perfume fitted in the actuator element.

3.0 Results and discussions

3.1 PIR Sensor Calibration

The PIR sensor was found to have an output of 3.3 volts when motion by a person was detected. The output reduced linearly with distance as illustrated in figure 3. The sensitivity of the sensor on detection of motion was found to be affected by environmental conditions such as temperature of the surroundings and luminous intensity. We investigated the effect of temperature by repeating the measurement of sensor output versus detection range at 15 ^{0}C, 20 ^{0}C and 25 ^{0}C. A general trend is observed for the three temperatures, but with a high sensitivity for 15 ^{0}C, although the change was not huge (0.8 V change).

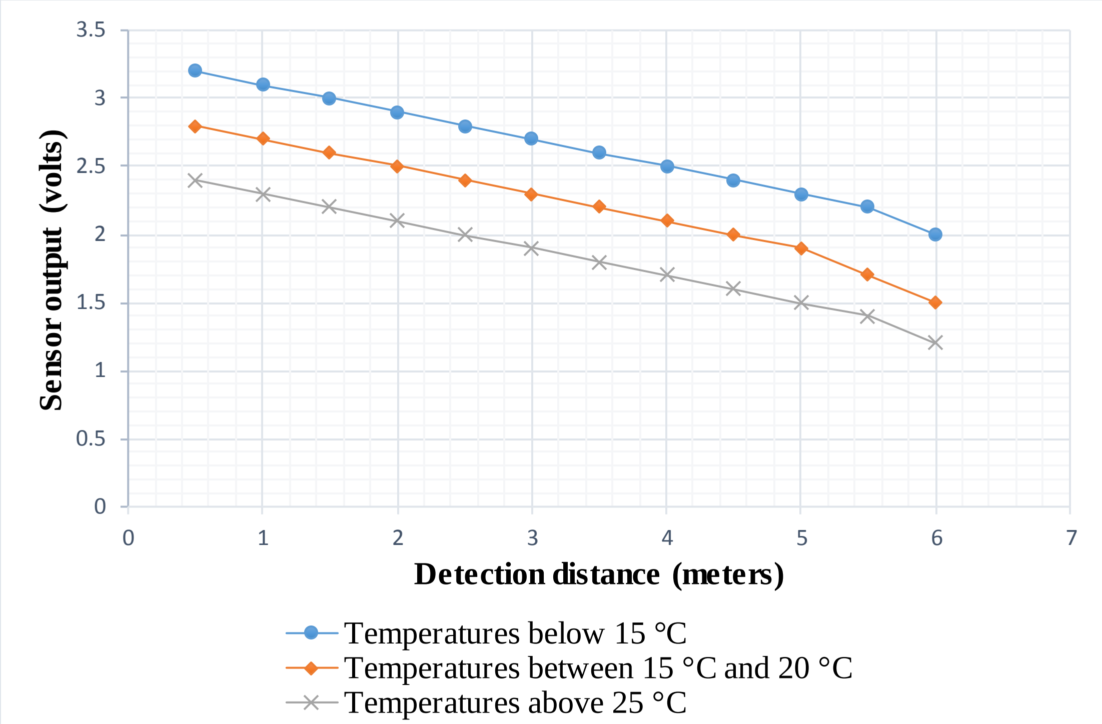

Fig. 3: A graph of sensor output against detection distance showing the inverse relationship between temperature and PIR sensor sensitivity.

At temperatures below 15 ^{O}C output voltage from the sensor was 2 V and 3.2 V at maximum distance of 6 m and at a minimum distance of 0.5 m, respectively. At temperatures between 15^{O}C and 20^{O}C the sensor output was 1.5 V and 2.8 V at maximum distance of 6 m and at a minimum distance of 0.5 m, respectively. At temperatures above 25 ^{O}C the sensor output was 1.2 V and 2.4 V at maximum distance of 6m and at a minimum distance of 0.5 m, respectively. It is observed that at reduced temperatures the sensor produced a higher output of 3.2 V as opposed to 2.4 V produced at elevated temperatures of the surroundings. The calculated sensitivity from figure 4 is -1.2 V/m, -0.8 V/m and -0.6 V/m for temperatures below 15^{O}C, between 15-20^{O}C and above 25^{O}C, respectively. The negative sign indicates an inverse relationship between the detection distance and the sensor output. The closer the specimen was to the sensor (smaller separation distance) the higher the output. Thus, as temperature increased the sensitivity of the sensor was found to decrease.

3.2 Response time for perfume detection

The time taken to detect perfume fragrance was measured with the corresponding distance of separation between the aerosol and detector. The separation distance was varied and the corresponding time measured. This procedure was done using Rose and Lavender fragrant perfumes, in order to compare the response of the two.

The experiment was carried out at two different times of the day at temperatures of 20^{O}C and 29^{O}C. Figures 4 and 5 are plots of detection distance VS time for detection depicting the response time of the system when using Rose and Lavender perfumes, respectively. It took more time to detect the perfume fragrance at greater distances as opposed to near separation distances. This was common for the two timings in the day for which measurements were done. However, in the morning at temperature (20^{O}C) it took much more time to detect the perfume. This is attributed to the kinetic energy of the perfume particles in the air medium being less at reduced temperatures and therefore particles were moving at a lower speed.

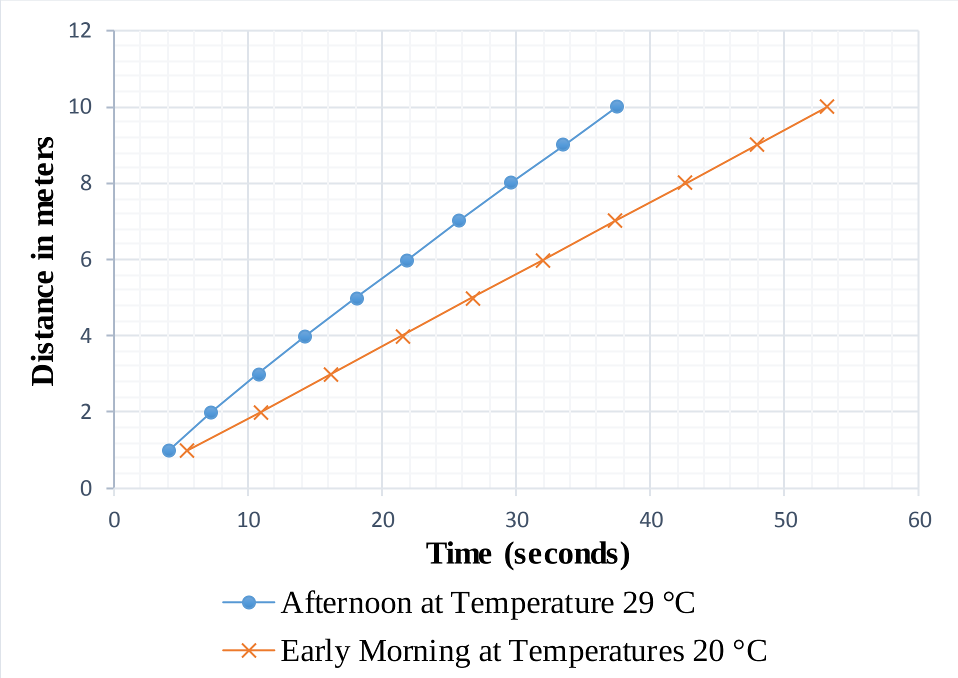

Fig. 4: A plot of distance (meters) against time (seconds) showing the response of the system when using Rose Fragrant Perfume measured at 20^{O}C and at 29^{O}C.

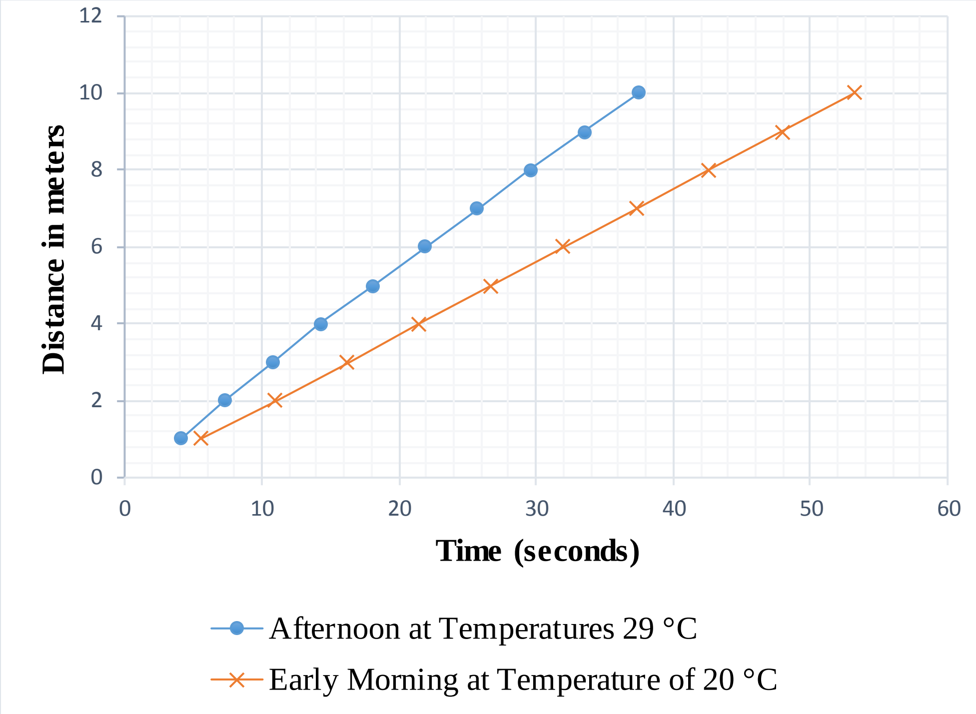

Figure 5: A plot of distance (meters) against time (seconds) showing the response of the system when using Lavender Fragrant Perfume measured at 20°C and at 29°C.

In the afternoon, temperatures rose to 29°C thus increasing the kinetic energy of the perfume particles resulting to greater speeds and quicker detection. Other physical conditions such as those of humidity, direction of air flow and pressure may have affected the speed of perfume particles and hence the attributed shapes of the plots in figures 4 and 5. By human detection the response time was found to be 0.5m/s and 0.25m/s at 29°C for Rose and Lavender, respectively and 0.3m/s and 0.19m/s at 20°C for Rose and Lavender, respectively.

3.3 Validation of detection from the entry alert system using MQ2 gas sensor

An MQ2 gas sensor module was used to detect the perfume fragrance in air and the time it took for detection was recorded. The MQ2 had a maximum output of 3.0 V whenever perfume was detected and 0 V with no detection. This gave an accurate prediction on the detection time. It was however noted that the detector had a shorter detection range of 1.3 m. Figure 6 shows the response time obtained on varying the separation distance against time for the MQ2 sensor. Measurements were done for Rose and Lavender Perfumes at temperatures of 29°C. From the graph, the response time is found to be 0.7 m/s and 0.4 m/s at 29°C for Rose and Lavender perfumes, respectively. These values of sensitivity and system response time from the MQ2 detector were slightly higher compared to measurements from the entry alert system.

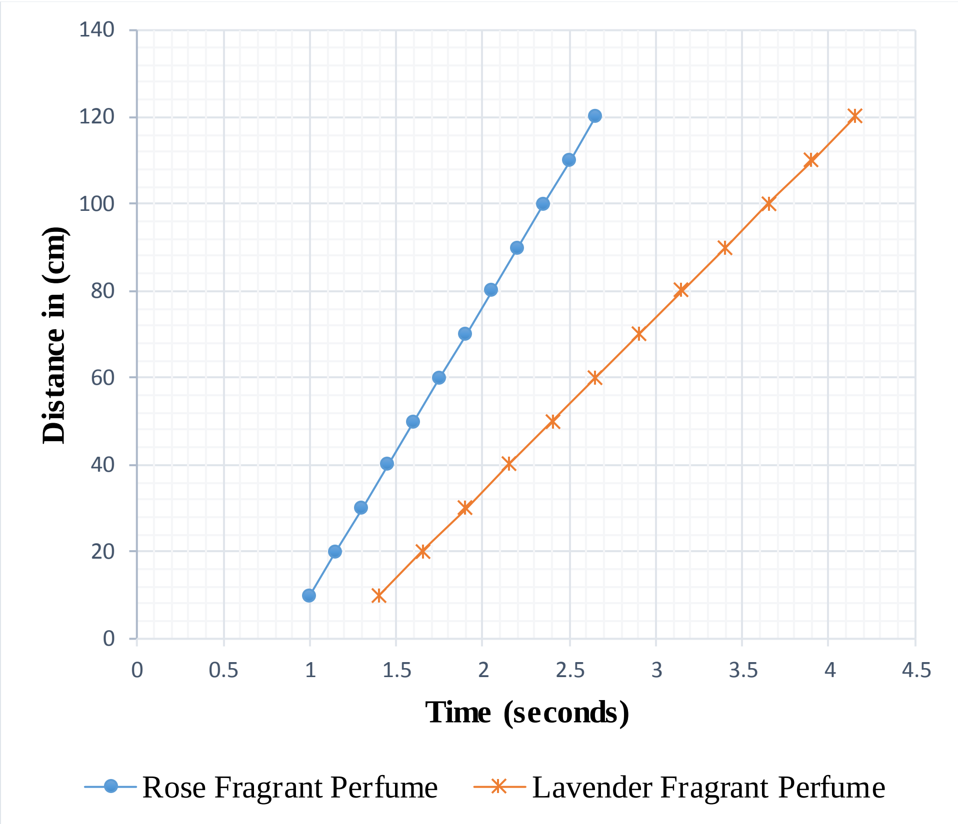

Fig. 6: A plot of distance (cm) against time (seconds) on using MQ2 Detector measured at temperatures of 29^{o}C for Rose and Lavender Fragrant Perfumes.

Both results however, demonstrate a positive relation and confirm that the system is very well applicable in alerting the deaf-blind of an intruder. Detection for Rose perfume was high for the two methods of detection compared to Lavender perfume. This is attributed to the Rose perfume being more concentrated and therefore using the Rose fragrant perfume would definitely result to a system that provides greater responses.

Conclusion

We have demonstrated an entry alert system that utilizes the sense of smell to alert the deaf-blind when an intruder approaches an entry area. The system is based on PIR motion detection and interfaced to an Arduino Uno (Atmega328P-PPU). The PIR sensor was found to operate with high sensitivity under normal temperature ranges of 15-25^{o}C change in temperature. The maximum detection range was found to be 7 m above which no motion could be detected. The response time at 29^{o}C was found to be 0.5 m/s and 0.25 m/s for Rose and Lavender perfumes, respectively.

Decreasing the temperature to $20^{O}C$ response time increased to 0.3m/s and 0.19m/s for Rose and Lavender, respectively. These measurements were confirmed by use of an MQ2 detector. Rose fragrant perfume gave a high response time due to a high concentration compared to Lavender fragrant perfume. These findings offer a novel entry alert system that enhances security and comfort to the deaf-blind.

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