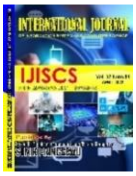
IJISCS (International Journal of Information System and Computer Science)
IJISCS, Volume 7, Number 2, August 2023
E ISSN: 2598-246X; P ISSN: 2598-0793, pp. 142-149
Accredited SINTA 4 Number 79/E/KPT/2023
https://jurnal.ftikomibn.ac.id/index.php/ijiscs

BUILDING SECURITY SYSTEM USING GP2Y0A21YK0 INFRARED SENSOR AND ARDUINO UNO

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Article history:
Received July 31, 2023
Revised August 28, 2023
Accepted August 30, 2023

Keywords:
An infrared;
control system;
security system;
sensor;
Arduino.

Abstract
The use of infrared radiation as a home security system is one of the technology improvisations that utilize physics phenomena. This research focuses on the designing of simple control systems based on Arduino Uno and GP2Y0A21YK0F infrared sensors along with other components. The working principle of this system starts when the IR sensor detects moving objects in the vicinity of the house in which infrared radiation is reflected and this gives outputs in the form of distance value from the display as well as movement and sound from servo to inform the occupants of the object's whereabouts. Data obtained from the display system showed an approximation of the real distance value. Therefore, occupants can know the distance of the moving object.

1.0 INTRODUCTION

All physical objects emit radiation respective to their typical wavelength [1]. One of the common types is known as infrared radiation. Infrared radiation is an electromagnetic emission with a range from 0.76µm to about 1000µm of wavelength [2], [3], [4]. This phenomenon was researched by humans for years, resulting in the tool called the infrared sensor, which was first made by William Herschel in 1800 [5], [6]. An infrared sensor is an electronic-based element that is used to sense characteristics of infrared radiation within its environmental condition and scope [1], [7]. This sensor is classified into two types which are for thermal as well as photon detection mechanisms [7], [8]. For the thermal type, the radiation is absorbed and converted into heat to raise the sensor component temperature. This temperature rise will be the measurement basis. Whilst in photon detection, the semiconductor part of the sensor will change along with the photon absorption, resulting in photovoltaic changes or another phenomenon according to the sensor type [9], [10].

The sensor itself has many components that are integrated into one part to receive and give output (data and information). These are transmitters, receivers, resistors, and diodes. The transmitter will emit infrared radiation which will be collected by the receiver to produce the desired results [11]. This sensor has become popular since its utilization can be found for most technology-purposed products such as facial detection in smartphones [5]. In addition, this instrument can be used for the detection of harmful gas, war field condition observation, space object analysis, and many more.

The application of infrared sensors requires sophisticated technology so that the control system can automatically produce data and information numerically for analysis purposes.

With the advancement of the industrial revolution, since countries around the world compete to manufacture the best technology, the progress for control systems has improved tremendously. The earliest usage of the control system can be seen in James Watt's steam engine in the eighteenth century. Minorsky by 1922 had produced a control system for steering ships [12]. Later, development towards control systems was further improved by Ziegler and Nichols around 1940-the 1950s and since then has been focused on system designs. Control systems have also moved towards many objectives such as the development of Human Machine Interface (HMI), Near Field Communication (NFC), and many others [13]. For this, control system has been relied on for real-time monitoring systems from LCDs or other type of monitor by many people.

One of the examples of HMI that is integrated with infrared sensors can be seen on an automatic sorting device based on a height system using Haiwell SCADA and PLC Outseal [8]. The components used in this system are an infrared sensor to detect the object height, HMI Haiwell to display the system work, PLC Outseal to save the program, a push button to start and stop the system, a conveyor to receive the given instruction to pass the object through the sensor as well as rejector to sort the appropriate object according to the height. It works when HMI is turned on to start the conveyor and the object will pass through the sensor while the rejector is sorting the objects according to the requirement [14].

Another example that uses NFC and infrared sensors is the attendance system that utilizes the AT859252 microcontroller. The research by M. Khairuddin et al shows the use of infrared sensors to detect students in schools for attendance. This will speed up the learning process for time efficiency [15]. From both examples, the infrared sensor shows potential for further improvement and usage, especially in the control system. One of the upcoming projects that are based on this is the house security system.

Many microcontroller is used to integrate the sensor. The example is Arduino microcontroller [16], [17], [18], Wemos D1 mini [19], [20], Node MCU ESP8266 [21], [22], etc. The microcontroller is a compact integrated circuit that contains a processor (CPU), memory, and input/output peripherals. It's designed to execute specific tasks in embedded systems and applications. The function of a microcontroller is to act as the "brain" of embedded systems, controlling and coordinating various tasks to achieve the desired functionality compactly and efficiently.

A house is one of the primary needs of humans. A house is a place for resting, gathering families and friends, or just simply showing the social status of the owner. However, the house function may not be completed since no security is present now. This may worry the owner whenever they are not at home or currently alone focusing on their activities without paying attention to the outer environment. With this in mind, several solutions can be recommended. One such is the use of a house security system to ensure the safety of the house owner's home.

The project of a house security system has been made by several researchers. One of the projects made by Akinwumi et al shows that using a passive infrared (PIR) sensor and a buzzer in which the working system starts when the PIR sensor detects a moving object, the sensor will be activated and send a signal to the Arduino to be processed, resulting in alarm sound from the buzzer [23]. Using this as one of the references, this project discusses the use of a control system using the infrared sensor for house security proposed beforehand. This control system will consist of two main systems that will be integrated. The system works by detecting moving objects. With infrared sensors as the distance detectors, the output will be depicted using two tools. The first tool uses LCD as the numerical display to notify the object distance while the second uses a servo motor that produces movement and sound to alert the owner about the moving object within the sensor vicinity outside the house. Both systems will rely on a microcontroller which is Arduino UNO. Arduino IDE is an open-source platform-based software as a media to make programs that can be operated in Windows, Linux, and even Mac that can be uploaded into microcontrollers such as Arduino [24], [25].

Therefore, this project focuses on the model for a simple house security control system using Arduino UNO, TM1637 display, GP2Y0A21YK0F display, servo motor, and jumper wires as the components that can be placed outside the house (such as terrace) to inform the house owner for moving object near the house. This project will be the basis for further similar and related studies that can be implemented for schools or other buildings.

2.0 METHODOLOGY

2.1. Tools and materials

The system will be designed at Universitas Multimedia Nusantara (UMN) in the laboratory. The design uses a laptop, computer, Arduino IDE, GP2Y0A21YK0F infrared sensor, Arduino UNO, jumper wire (male to male and female to male), breadboard, TM1637 display, and servo motor. The design will be based on the main purpose which is house security. The measured and sampled parameter will be the distance of the objects from the sensor.

2.2. System Design

In designing the system, some actions need to be carried out with the following steps:

1. Finding problems.
2. Determining objectives and purposes to solve the problem
3. Utilize a control system.
4. Planning and tools preparation for the control system design.
5. Tools and Arduino IDE assessment.
6. The system is designed and assessed by experimenting with a moving object within the sensor vicinity ranging from 0 to 30 cm every 0.5 cm.
7. The result will be explained further to show the system's importance.

The system will be used to produce data that will be assessed. The data will be obtained from the display based on the program made in Arduino IDE to show the distance between the object and the sensor. The data will be recorded in a table to be analyzed.

After assessing the obtained data, there is a need to process the result to analyze it to make sure the design of the system works properly. The given data will be the basis of the maximum vicinity of the object from the sensor so that the limitation is known. Data are given in number which is the distance in cm. This will be used for analysis and processing technically.

3.0 RESULTS

For the main purpose which is a house security system, the components selected (Arduino UNO as microcontroller and infrared sensor as the input sensing tools) will give an output of distance in cm from object to sensor that is displayed in LCD and movement from servo motor. The system is designed so that two Arduino Uno are used (one for infrared sensor – LCD integration and the other for infrared sensor – servo motor). Figure 1 is the infrared sensor with a servo motor system that uses an Arduino Uno. Figure 2 is the infrared sensor and the display that uses an Arduino Uno. Each system will be designed individually because of the maximum load capacity that one Arduino Uno can handle (to avoid the inefficiency of the results). The program is made based on the purpose. Thus, the results of the program are the distance displayed in the display as well as the sound movement from the servo motor every specific time the infrared radiation is reflected from the object surfaces.

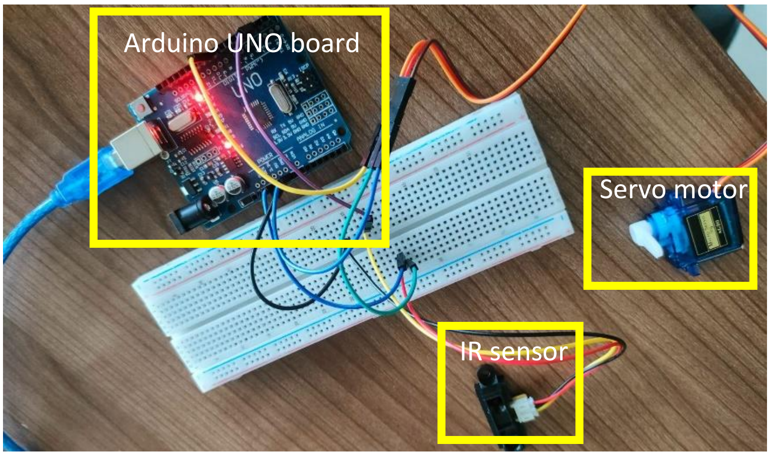

Figure 1. Infrared Sensor-Servo Motor System

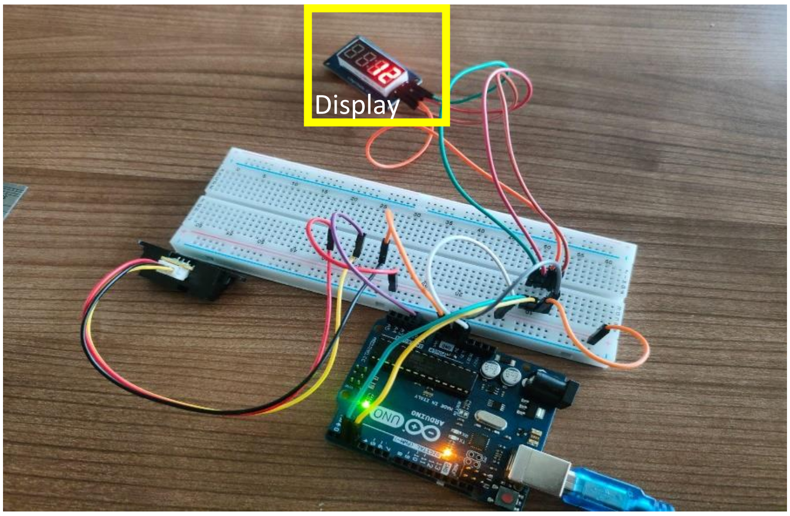

Figure 2. Infrared Sensor-Display System

After finishing the system design and integration of the two parts, the following step is to test the validity of the system by passing an object through the infrared sensor. The expected outputs are the distance shown in the display as well as the sound movement from the servo motor. The collected data can be seen in Table 1.

Table 1. Distance Data

Actual Distance (cm)	Displayed Distance (cm)
0	-
0.5	-
1	-
1.5	-
2	-
2.5	-
3	-
3.5	-
4	-
4.5	-
5	-
5.5	-
6	-
6.5	6
7	7
7.5	7
8	8
8.5	8
9	9
9.5	9
10	10
10.5	10
11	11
11.5	11
12	12
12.5	12
13	13
13.5	13
14	14
14.5	14
15	15
16	16
16.5	16
17	17
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18	18
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19	19
19.5	19
20	20
20.5	20
21	21
21.5	21
22	22
22.5	22
23	23
23.5	23
24	24
24.5	24
25	25
25.5	25
26	26
26.5	26
27	27
27.5	27
28	28
28.5	28
29	29
29.5	29
30	30

It can be seen that the data sample from 0 cm to 30 cm measured every 0.5 cm, the infrared sensor cannot detect objects below 7 cm because the result changes quickly in the display (no fixed result). Whereas from 7 cm to 30 cm, the results obtained are shown in fixed numbers (no decimal) by the round of to 1 digit below. As an example, for 5.5 cm of the actual distance from the object to the sensor, the displayed distance is 5 cm. In another example, it was tested for 3.8 cm as the actual distance and the display still shows 3 cm. Thus, the number of distances given does not include specific decimal numbers and instead is rounded off below. Yet, this result can be reliable for house owners as to shows the estimation of the moving object. It should be noted that the infrared sensor can detect the object as long as the object is the same size or bigger than the sensor (about 2.5 cm and above). In addition, the object and/or sensor tiltness can affect the distance measured and displayed which may be longer or shorter than the actual distance.

It should be noted that the infrared-display system is tested repetitively. The upper limit of the distance varies from one object to another based on their size. For smaller objects (greater than the size of a hand palm), the system can detect up to 30 cm and show the exact trend with the given table (refer to Table 1). However, for smaller objects, the distance displayed is not accurate and precise since it changes quickly. Therefore, the table results are limited to 30 cm measurements to show how the system responds to smaller objects. Other factors that have been tested to see different variable approaches are also considered. These are:

1. Movement of the object = The object's movement will critically affect the distance measured by the system. With faster movement of the object, the distance will change periodically and will not give a constant result on the display.
2. The shape of the object = If the object is huge enough, however with holes or similar shape features, the system will also not show a constant result on the display as it tries to detect a surface for the infrared to be reflected. Similarly, smaller objects with similar characteristics tend to not give constant results.
3. The angle of the surface for infrared reflection = The angle greatly influences the distance detected by the system. For example, for a book that is tilted at any degree in which the tip of the book that touches the ground is as far as 15 cm from the tip of a system that also touches the ground, the distance will be greater or lesser than the actual distance. This is because the infrared is reflected on a tilted surface. On the opposite way, if the system is tilted at any degree towards a book that is standing firmly (vertically) with the tip measuring 15 cm from the book, the results will be varied.
4. Sensitive to the environment condition = Infrared can be affected by smoke, fog, rain, dust, and many more.
5. Cannot be reflected on clear-transparent surfaces such as clear plastic and bottles.

The factors, some limitations in the system such as the small size of the infrared, limited range detection by the product, considerably low transmission data, and many more will not give accurate and precise distance on the display compared to the actual distance.

Aside from measuring the distance, it can also be seen for the reflected time from the sensor to the object and back. It is known for the infrared velocity in the air of about 2.99792458 × 10^8 m/s with the equation of light reflection (analogic to the sound reflection equation),

$$D = \frac{v\,t}{2} \qquad (1)$$

D = Distance (m)
v = Velocity (cm/s)
t = time received by the receiver since the infrared is transmitted (s)

However, in this project, no specific time can be measured since the time taken is below 1 second for the infrared transmission and reflection ranging from 30 cm and above to the object which can be categorized as high-speed movement.

The two designed systems such as in Figure 3, can be integrated into one part that can be placed in a specific location so that both can be used at the same time for the main purpose. Hence, this integrated system works when an object moves around the infrared sensor vicinity (that can be placed around the door or terrace). The sensor detects the object by sending infrared from the transmitter to it and the light is reflected to the sensor receiver. This reflection is processed by the Arduino Uno microcontroller to give outputs which are the sound movement from the servo motor and the distance measured from the object to the sensor in the display.

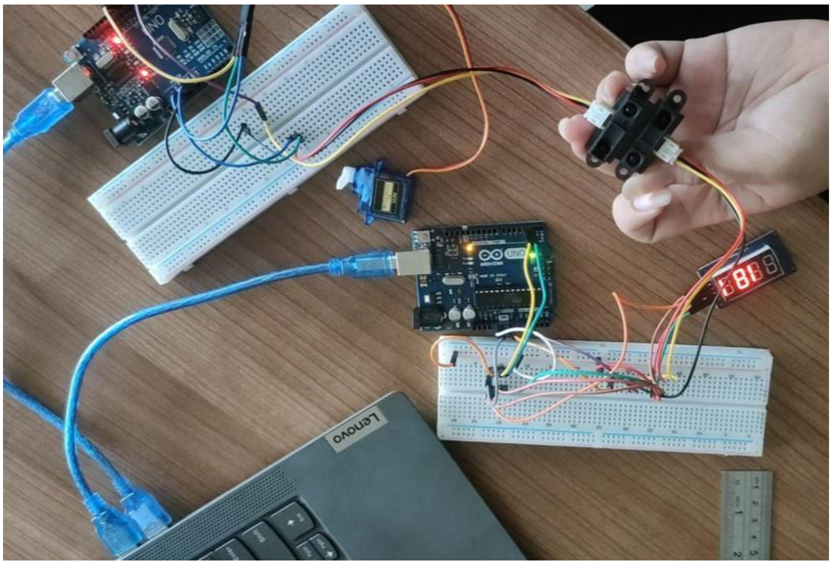

Figure 3. Integrated System

Figure 3 is the integrated system for testing to see its viability. When testing the system, both separate system is located near each other with the infrared sensor attached using additional tools such as glue and/or tape. When it is tested with similar conditions as depicted in the previous section (the system is tested repetitively with the limit of 30 cm with varied sizes and shapes of the object as well as with different approaches such as moving and steady objects), the distance displayed is shown to match the outcome from table 1 with the servo motor giving its output (movement and sound) being delayed by 1 second according to the program that has been made. This delay can be adjusted, however, to show a better result for the user of the integrated system so that when the display has shown numbers, the servo motor will quickly notify the user by its movement and sound. Similarly, with the previous section, other factors have to be considered and give effects such as:

1. Movement of the object = Moving object will make it inefficient for the sensor to detect a surface for the infrared reflection. However, the continual movement and sound by the system along with the object movement can be an advantage to alert the user more noticeably.
2. The shape of the object = For an object with a hollow section in its surface in any various shape and size, the system will not accurately give expected results such as constant distance displayed and/or continual sound and movement of servo motor. However, it still can detect the object by giving inconsistent distance results and scarce sound and movement.
3. The angle of the surface for infrared reflection = For the system not having the same output (refers to the infrared sensors that are separated), the angle will also greatly influence the results. In some cases, for example, the display can show numbers however no servo motor output is given, and vice versa. This can be caused by the different infrared being transmitted from separate sensors which end up at different surface parts of the object.
4. Sensitive to the environment condition = Infrared can be affected by smoke, fog, rain, dust, and many more.
5. Cannot be reflected on clear-transparent surfaces such as clear plastic and bottles.

With the limitations taken into account, the system will not give the expected result. Despite that, it is not restricted to not detecting a moving object of various size and shape that is tilted it still gives results that may not be consistent (changes in the distance results and occasional sound and movement of the servo motor).

4.0 CONCLUSION

The improvement in technology has made many physics-based innovations. One example is the usage of infrared sensors as a house security system. This project focuses on the designing of a house security system using a simple control system with the components consisting of Arduino Uno, GP2Y0A21YK0F infrared sensor, jumper wir (male to male and female to male), breadboard, TM1637 display as well as servo motor. The house security system consists of two separate systems the first one uses a display to show the distance between moving objects towards the sensor whereas the second uses a servo motor to make sound-movement. The whole system works by integrating both systems and placing them around the house (such as at the door or around the terrace). When a moving object is around the viscosity of the sensor, the infrared is transmitted and reflected from the object to the sensor. This signal is collected and processed by Arduino Uno and gives outputs of sound movement from the servo motor and distance measured from the object to the sensor by the display. The data collected after testing the designed system shows that objects below 7 cm cannot be measured properly whereas results above 7 cm can be shown. (The upper limit tested is 30 cm for any size object as it gives consistent results). Some factors that should also be taken into consideration are the object's movement, size, and shape, the angle of the surface from the object used for reflection, and environmental conditions, and can be transmitted on clear-transparent objects as well as separate infrared sensors for one integrated system, which will give inconsistent result on the display and momentary sound and movement from the servo motor. Thus, this project depicted that the design of a simple control system using infrared sensors can be utilized for house security systems. For further research, this project can be used as a reference for a more complex system (in regards to the limitation of the system features) that can be installed for buildings such as schools, offices, and others.

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