Motion and Movement Detection for DIY Home Security System

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Abstract— Smart home security becomes necessary due to an increasing level of house thievery or home security breach. Previous supporting security system such as CCTV is not enough to support home security. Such system can only focus on monitoring a limited area where it is installed and it is high cost for personal use. This paper presents an Internet of Thing (IoT) system to support home security via remote and timely manner monitoring based on motion and movement detection. The IoT system uses a wireless point to multipoint technique within a node sensor (motion detector) that connects to a microcontroller. Passive Infrared (PIR) and Accelerometer GY-61 are used as the sensor to perform the detection. A web-based dashboard is then deployed to display the monitoring result in timely manner. It receives data from two (2) node sensors that is transmitted via Adafruit server. A Do-It-Yourself (DIY) sensor is then developed. Simulation shows that the sensor system works very well as it is able to detect any object within certain range and any movement of the door and window. The system is one of the practical smart home security solutions that is able to perform timely manner home monitoring based on motion and movement detection.

Keywords— Home Security, Internet of Things, Motion detection, Movement detection, DIY

I. INTRODUCTION

The needs of home security system is now paramount because family and home property needs a secure place and safe. Houses and its surroundings must be fully protected from malicious disturbances [1][14]. This is because the house owner might not always stay at home. While financial loss may be recoverable, the trauma of getting may last forever. Crime rates (theft, robbery and burglary) on household from 2013 to 2015 is extremely high. In 2015 the number of thefts with violence in households was at 1,628,634 and 140 out of 100,000 people are at risk of getting a crime [2]. In addition, FBI [3] states that 1 in 3 homes without security system falls victim to a burglary as compared to 1 in 250 homes with security system.

Several works have been professionally done on home security and they are currently considered as the best home security systems [4]. Vivint [18], ADT [19], Frontpoint [20], Protect America [21], SimpliSafe [22], Link Interactive [23], Brinks [24], Scout [25], Nest [26], and LifeShield [27] are the best home security systems. However, such systems are expensive, high fee maintenance and less support to motion detection. This paper presents a motion detection system to support smart home security. The IoT-based technology is used interconnect most of the supporting devices [5][29]. According to the results of the Juniper Research study, there has been a threefold growth of the IoT devices between 2016 and 2020. The results of this study estimated that the number of IoT devices connected to the internet is more than 46 billion up to 2020. The system requirements and design will be presented in section 2. Section 3 provides the results and some discussions. Section 4 concludes the development.

II. SYSTEM REQUIREMENTS AND DESIGN

There are requirements that is derived based on the survey on several works on home security:

1. Motion Detection
   A motion sensor (or motion detector) is the linchpin of a security system, because it is the main device that detects when someone is in a house [28]. A motion sensor uses one or multiple technologies to detect movement in an area. If a sensor is tripped, a signal is sent to a security system's control panel, which connects to a monitoring center, alerting the house owner about potential threat.
2. Continuous timely-manner monitoring
   The philosophy of security system is to monitor continuously the house and warn the owner in a timely manner in respond to any breach. Having a peace of mind is an ultimate goal of the house owner employing a security system that is able to response in timely manner.
3. Low cost
   Affordable security system is required for long term usage. Instead of renting a system from a vendor, it is better to have a Do-It-Yourself (DIY) product using alternatives items with the same function. DIY security system is not only cheap, but also expandable with less additional cost.
4. Low power consumption
   Every security system added to a house increases the electrical power bill. As a security system works 24/7, choosing the lowest power consumption items will be greatly reduce the bill.
5. Flexible implementation
   One limitation from purchasing a home security system is less flexible during implementation. The provider has certain Standard Operation Procedure (SOP) to implement their system. Sometime the implementation is less suitable with the house owner preferences.

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In this system, a home security system that is integrated with remote monitoring is developed. It is capable to continuously capture the state within an area of a house and send important notification. This system uses a wireless motion detection microcontroller as a sensor that is placed at the corner of every doors and windows in the house. The data transmitted by the sensor via the network is handled by a cloud server. A notification will be turned ON if the server receives significant distinctive signal from the detection. The signal will also be sent to a web-based monitoring system to support security monitoring.

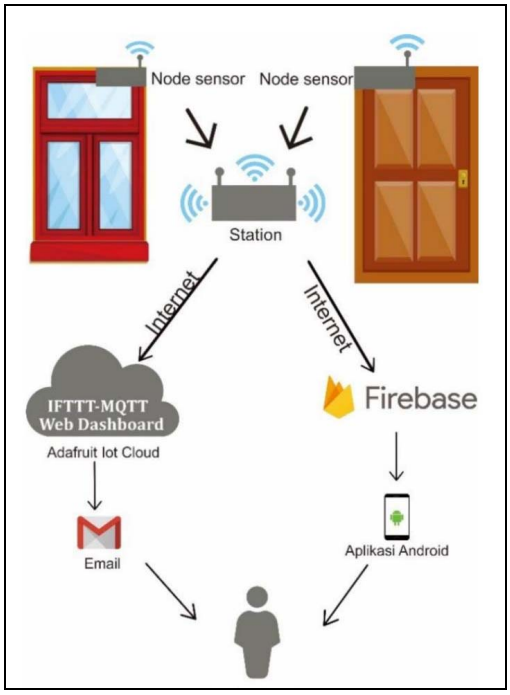

Fig. 1. Proposed System Architecture

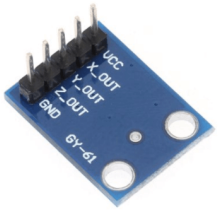

Fig. 2. Accelerometer GY-61

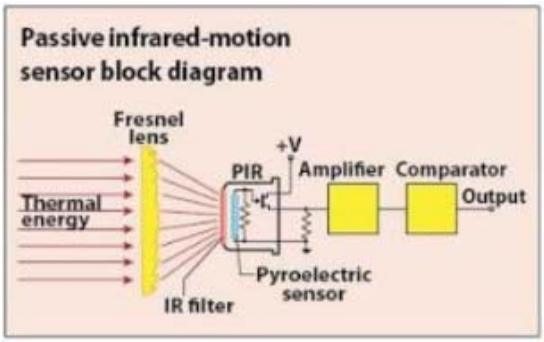

Fig. 3. PIR Diagram [17].

Fig. 1 shows the architecture of the proposed system. The system uses ESP8266 NodeMCU SoC (System on a Chip) device as a node station [7]. ESP8266 NodeMCU is a microcontroller that contains ESP8266 Arduino-like hardware as Wi-Fi module. It is suitable to support IoT devices. Such microcontroller is chosen because the price is affordable, the size is small, and it consumes only small power [8]. Users can also modify it by adding their own modules and security functions and also connect it to the internet [9][10][11] [9-11].

An accelerometer GY-61 [12][13] is added into the microcontroller, see Fig. 2. Accelerometer GY-61 is a sensor for acceleration. It can also be used to detect and measure any movement of an object. This sensor only consumes up to 5V power. The GY-61 that is connected to the microcontroller will handle and transmit the detected signal to the central microcontroller [15]. Any signal changing will lead the central microcontroller activates the buzzer and the LED light [16].

PIR (Passive Infra-Red) is also installed into the microcontroller. Passive means it does not transmit an infra-red signal, but it senses infra-red signal from any close-range object such as human-being. PIR sensor is also good at sensing movement [6]. It detects the radiation level from any human-being thermal energy. PIR is basically made of a pyro-electric sensor which generates electric current if sensing any infra-red signal. This popular sensor can distinguish if the item is human or other things within 30 meters based on radiation. Because mostly items emit a low level radiation and hotter item emits more level. The sensor output is then used as input of the microcontroller system. Most PIR modules usually use 3-5V DC input as the power. If there is no movement, output pin will stay LOW. If sensor detects motion, the output pin will go HIGH to 3.3V. See Fig. 3

Meanwhile, the central microcontroller or station also sends monitored data to the Firebase, Adafruit IoT server and IFTTT apps. Firebase is a cloud database and backend service owned by google. It provides a platform for developer to develop database application that can be connected to any smart-phone apps. Mobile apps for our work is out of scope of this paper. Meanwhile, Adafruit is a cloud platform for IoT. It has protocol for device communication called Message Queue Telemetry Transport (MQTT) to send and receive feed data. Adafruit has a web-based dashboard which shows monitoring data. Adafruit IoT becomes a supporting system to develop an IoT system. It collects data that is transmitted by the sensors and visualizes the data into certain type of charts for monitoring purposes. A web-based monitoring system is then deployed using Adafruit dashboard to show the home security status based on the motion detection sensor. If This Then That (IFTTT) apps is used to support in sending email notification to the house owner in case any security breach. IFTTT supports different types of notification such as SMS, twitter, Facebook, etc.

III. Result and Discussion

In this section the system prototype is shown. Motion detector prototype and web-based monitoring have been developed. The prototype is in the form of node sensor. There are 2 node sensor as the prototype, namely node sensor 1 that is placed in the door and node sensor 2 that is

placed in the window. Theft normally breaks into a house through the door or window. Each node sensor has GY-61 to sense any movement and PIR to sense any object within certain range. Fig. 4 shows the node sensor device that was assembled using aforementioned components and will be placed either door or window as in Fig. 5 and Fig. 6.

Fig. 7 depicts the web-based monitoring view using Adafruit dashboard. The left area of the web-view (shown in green font) is the detection notification from PIR. If there is any object within the range, the sensor will send "motion detected" signal as shown in the picture. The same case when any movement is detected by GY-61, accelerometer in the web-view will be set as 1. See Fig. 8 and Fig. 9. The combination of PIR and GY-61 during simulation supports each other in detecting an object around the door and window. Both sensors can be used to secure a house by providing the door and window status.

Fig. 4. Node sensor

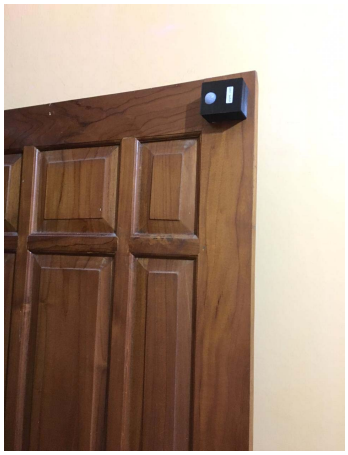

Fig. 5. The node sensor on door

Fig. 6. The node sensor on window

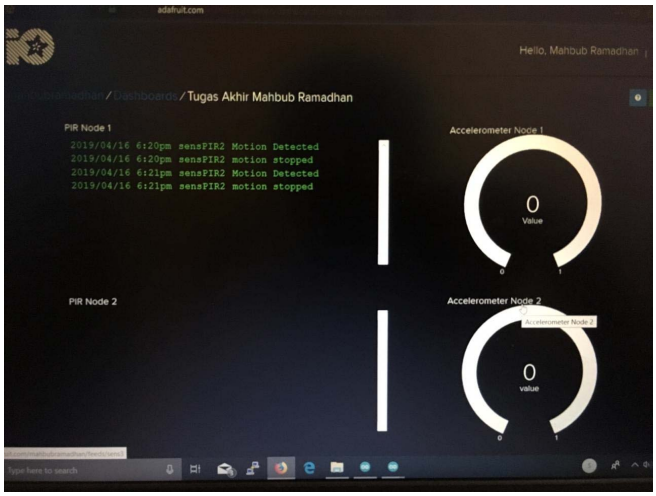

Fig. 7. Default view of web-based monitoring

Fig. 8. Web-view when motion detected by Node sensor 1

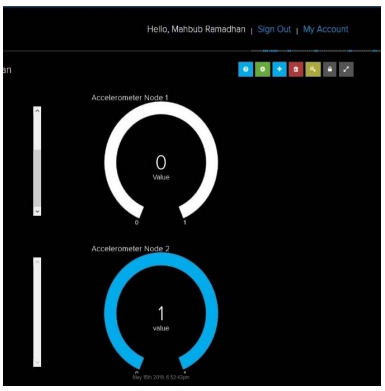

Fig. 9. Web-view when motion detected by Node sensor 2

IV. Summary

This paper presents the development of motion detection sensor for home security. IoT concept was adopted during design and deploying the sensor. The system architecture uses and implements some innovative platforms, including low cost and low power consumption components. The addition of PIR into the system that uses Accelerometer GY-61 as the movement detector makes the device able to recognize any moving object within certain range based on its thermal radiation. A web-based monitoring is deployed using Adafruit dashboard.

An email notification is under-development to notify the house owner in the case of breach. Certain measurements need to be done in order to evaluate the system capability.

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