Integrated Surveillance System with Mobile Application

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Abstract— **In today's life with the influence and vast usage of Internet of Things (IoT), a surveillance system become an essential needs (no longer a luxury facility) to home residents, buildings and other important premises. This project deals with web-based and mobile app surveillance system using Raspberry Pi and its supporting components i.e., Pi Camera, PIR motion sensor, Ultrasonic sensor, web-based & mobile application. This proposed solution can be implemented over the internet using any computer and mobile devices from anywhere and anytime. The use of Raspberry Pi has given the ability to operate and control the motion detectors, distance of the intruders and video cameras for remote sensing and surveillance. The cameras automatically stream live video and the raspberry pi device will send an alert via email and SMS to the facility owners' computer or mobile devices. It is considered as a cost-effective solution, customizable and easy to implement by the home residents outside their home residents in comparison with other commercial surveillance system products such as CCTV, IP Camera, etc.**

Keywords— Web-based & mobile application, Surveillance System, Raspberry Pi, Pi Camera, PIR sensor, Ultrasonic sensor, Motion Detection, Live video streaming.

I. INTRODUCTION

In view of the rise of criminal cases in Malaysia, surveillance system has been considered as an important facility in today's life. The surveillance comes from a French word which denotes as "watching over" [1]. With the advancement of the evolution of the surveillance system has rapidly improved and innovated from a "Dumb camera", CCTV and now IoT (Internet of Things) system which available with low to high cost depending on the system components, its functions, and features.

There are three essential items in any visual surveillance system: the front-end video capturing tools, the central control system and the end user. Firstly, the front-end video capturing tool consists of a camera and/or digital video recorder (DVR). Secondly, after the camera captured the video footage, it sends to the central control system to compress the video setting and deliver the footage to end user. There are several types of the surveillance system in today's market, for example, Closed Circuit Television (CCTV) camera and Internet Protocol (IP) camera. The CCTV system requires continual monitoring of every action which is not at ease, makes utilization of CCTV camera are expensive. Meanwhile, the operation of IP camera is also quite costly and could cause a huge problem when it becomes open to hackers via internet while watching for the cameras [2].

The aim of this project is to design and develop a cost-effective and affordable CCTV-like surveillance system using Raspberry Pi microprocessor that manageable via an internet connection using the web-based and mobile app (application) specifically for home usage. This system is easy to implement by home owners from any laptop and mobile devices. This is because it can counter the problem of surveillance system without saving the recording video in storage but still analyzing live incident happen to them [3].

A security system designed in [4] using Arduino Uno is as its microcontroller. In this system, Arduino compatible with many sensors and hence the system can be considered as cost effective. The function of Arduino is to 33 transmit and receive data from the sensor to the serial monitor when the sensor detects movement of a human. Besides, Arduino is compatible with GSM module as a function to send and receive the message.

A smart surveillance system using PIR sensor network and gsm was developed in [5].The system used PIR sensor and video camera on peripheral interface controller (PIC). The PIC is inexpensive, easy to program and can control all the components with low computational requirement.

Technically, this surveillance system comprises Raspberry Pi microprocessor, Pi camera with mounted servo-motor, PIR motion sensor, Ultrasonic sensor, buzzer and LED. The Passive Infrared sensor (PIR) is useful in a low-cost surveillance system through which it provides infrared radiation in detecting human presence from human body temperature [5]. Besides that, this system will be programmed with a web-based and mobile app for its management and configured for internet connection.

It enables remote monitoring of homes or any other priority areas at anytime and from anywhere by controlling the movement of the camera that can detect, and then simultaneously record the image of the home intruder into the system storage and send an alert message via email and/or SMS to users [6]. Unlike commercial CCTV system, the system allows user to view the live streaming video through an application (apps) in the android which can reduce the cost of the system.

II. METHODOLOGY

A. Project Overview

The overall surveillance system components are Raspberry Pi 3 Model B, Pi Camera module 5MP, PIR sensor, Ultrasonic sensor, Piezo Buzzer, Servo motor, LED. The components were programmed to create a workable

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surveillance system. Subsequently the system was integrated with a mobile application through a dedicated website. The complete surveillance system features include an alarm unit, alert notification to users, camera movement control and data acquisition.

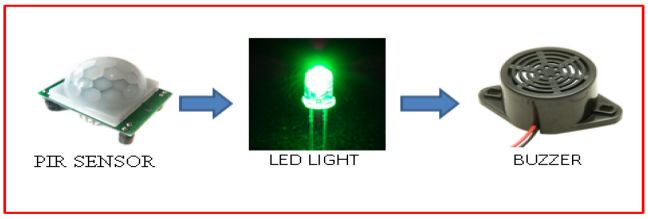


Fig. 1. Initial process in a surveillance system is to detect intruder.

The first process in a surveillance system is the alert operation (Fig. 1). The PIR sensor functions to detect any suspicious movements outside the house within a specific range usually 2 centimeters to 6 meters depending on the type of PIR sensor. When the movement of intruder detected, the LED light up and buzzer will alarm for 10 minutes.

The second stage of a surveillance system is the notification operation (Fig. 2). When PIR sensor already in the state of active (1), it automatically triggers camera to capture image of the intruder. Raspberry Pi will control the Pi camera and the whole program. The image of intruder then stores in SD card of Raspberry Pi. As for notification, SMS will notify users when the incident happened. Email emergency alert will be sent to home users say that "Intruder is detected!" with an image of the intruder as an attachment.

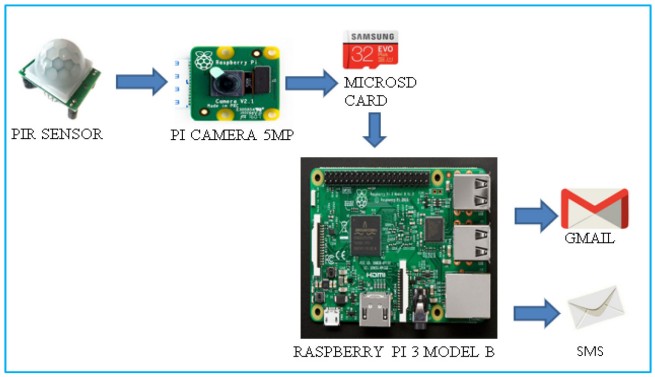


Fig. 2. Notification System to Home Users.

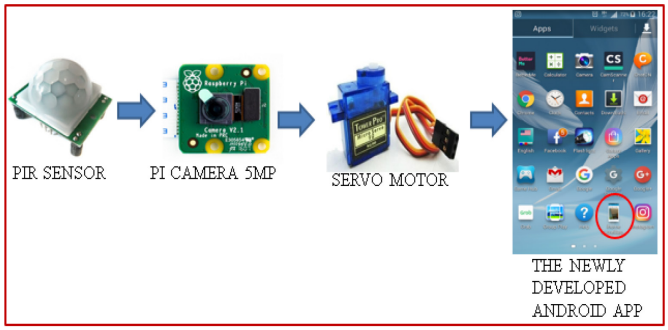


Fig. 3. The Newly Developed Mobile App System for Home Users.

This surveillance system is user-friendly when it makes the home users easier to view the live streaming video with a mobile app wherever they go straight away after getting the notification alert. Fig. 3 shows process in mobile app for home users. When the detection of intruder happened, the system will remain active for 10 minutes. During the period of time, users can remotely monitor live incident around their house with the mobile app with a feature of button for rotation left and right. Lastly is data acquisition process. In the below shows data acquisition process of the ultrasonic sensor (Fig. 4).

The ultrasonic sensor will calculate the distance between the intruder and the surveillance box. Next, data of distance is subscribed by MQTT broker and publish MQTT clients which are Node-Red and Thing Speak. In the node-red dashboard, the ultrasonic sensor distance graph will be displayed. Distance graph also can be viewed by home users through Thing Speak channel. Thus, this surveillance system provides high security for home users where it consists of many advantages to home users.

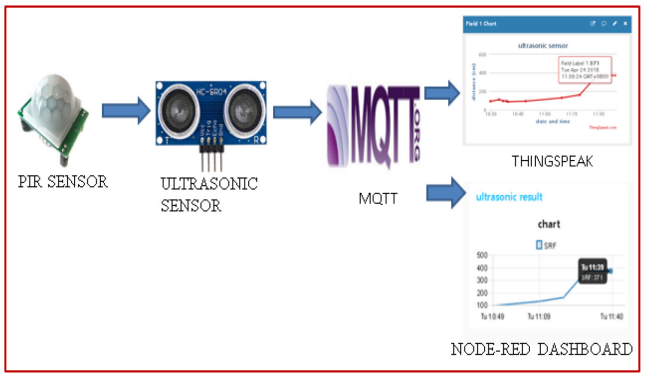


Fig. 4. Data Acquisition Process.

B. *Flow Chart*

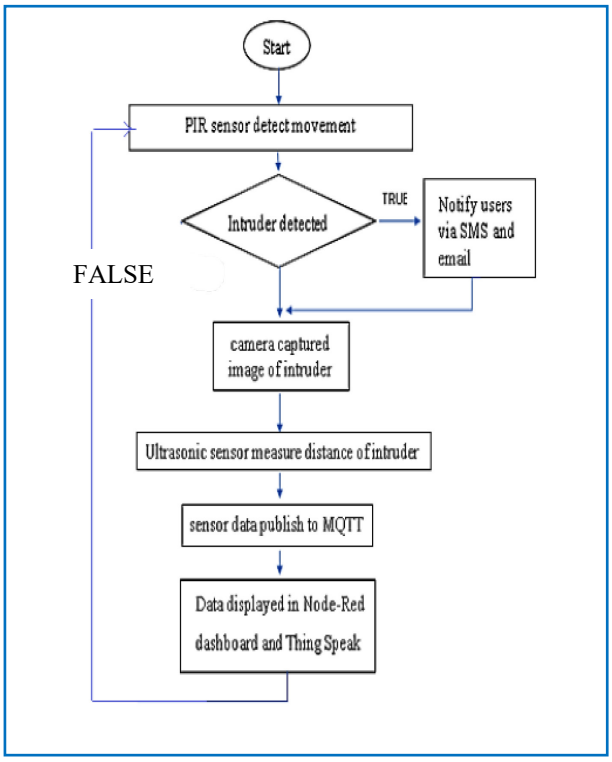


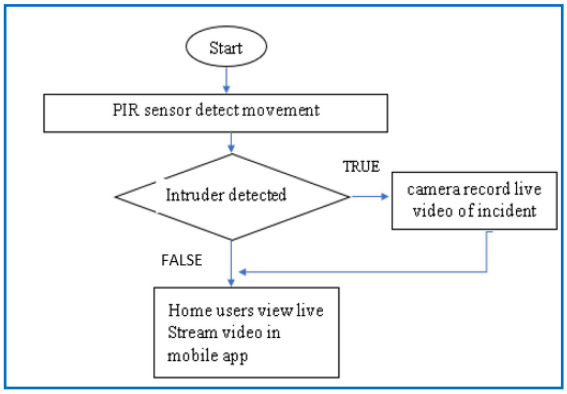
Fig. 5. Flowchart Surveillance System with Data Acquisition.

The flow chart of the designed surveillance system with data acquisition starts with sensors detection (Fig. 5). The PIR sensor will detect whether there is any movement caused by

intruder. If any movement is detected, the program will trigger the camera to capture an image of the person. The program will notify home users via SMS as well as email. The SMS will give a short alert message to the users says that intruder detected in front of their house. Meanwhile, an email will provide an attachment image of the intruder.

If the motion of intruder is detected, the camera will automatically ON and record the live streaming video. The program then will remain idle for 10 minutes in video mode until the sensor in idle mode (0). This is because the sensor is taking time restart to low mode. When the sensor in idle mode (0), it will start to sense movement again (Fig. 6).

Next, ultrasonic sensor measured the distance of intruder from the surveillance camera. The distance data will publish to the MQTT broker and sent to the MQTT client which are Thing Speak and Node-Red. Lastly, output graph will be displayed on Node-Red dashboard and Thing Speak [7-9].



C. Fig. 6: Flowchart for Mobile Application

D. Node Red Flow and MQTT Broker

Node-Red is a programming tool used to implement of the Internet of Things (IoT) [9]. It is a website-based platform that makes it easy for wiring all hardware components and have a wide range of palette node. With Node-red, a programmer could do data acquisition, monitoring, transportation, and analytics. It also has an app feature to observe home that can be developed by the developer. It also has an advantage in term of using small amount programming code and it is compatible with a variety of other platforms such as Thing Speak, MQTT, and IBM Watson.

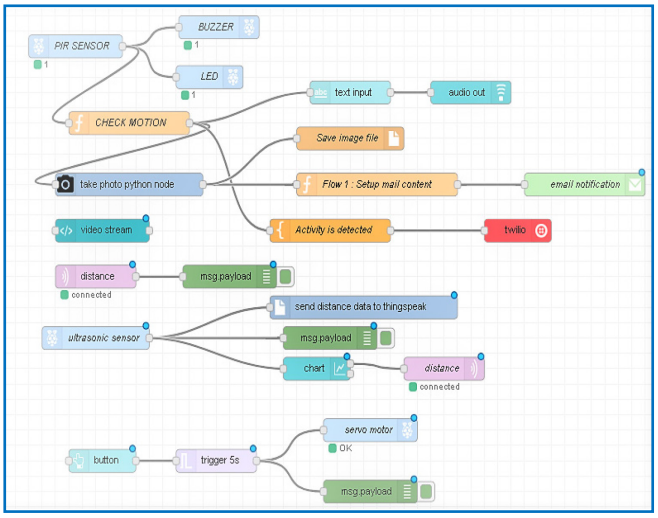


Fig. 7. Example of the Node-Red flow for the designed Surveillance System.

Following the flow chart in Fig. 6, the PIR sensor which is input is connected to output buzzer and LED in Node-Red (Fig. 7). The connection is set up using a Raspberry-Pi GPIO pin. It then linked to a function of the PIR sensor to check whether there is a movement of an intruder, PIR goes high (1), thus buzzer and LED also goes high (1). Next, function node is joined to produce an output of text which displays "intruder detected!" and output audio that present voice if motion detected. Function node also connected to the camera so that when PIR goes high (1), it automatically captures an image of the intruder and send it to email and SMS notification.

In this project, we use Twilio platform to send SMS alert. But, Twilio node need to be connected to the function of activity. Then, the image of intruder also will be saved to file in the raspberry pi SD card. As for MQTT part, the ultrasonic sensor is connected to the output in debug node, to the chart which displays in the node-red dashboard and to subscribe to input MQTT broker [7]. MQTT broker is connected to the same Wi-Fi connection as surveillance box. Next, MQTT publish node is connected to the Thing Speak channel where the channel received distance data every time there is human detection. At the same time, button node is used to trigger the rotation of servo motor. The button is to make users easily to press it when viewing live stream video. Lastly, template node is used to write functional code for live stream video.

III. RESULT AND DISCUSSION

A. Functionality Test

1) Android Application

The surveillance system can also be categorized as a portable security system which it provides mobile apps for users to monitor their home anywhere they go. The newly design mobile apps had been developed using Website 2 APK builder software tool. The newly developed mobile apps have features of live streaming video with a button on a rotation camera to left and right as well as the status of the intruder (Fig. 8).

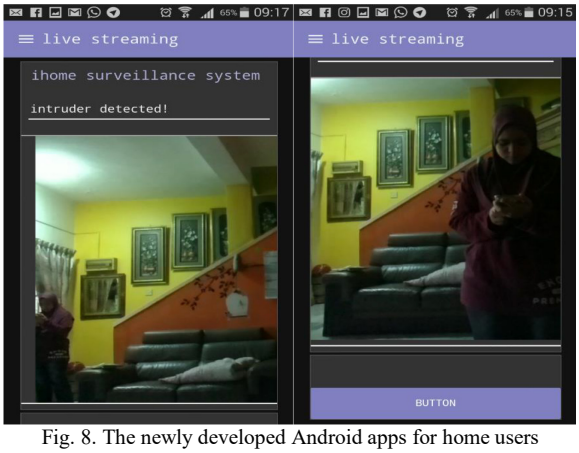


Fig. 8. The newly developed Android apps for home users

2) SMS and Email Notifications

SMS was notified to the users informing that dangerous situation happens around the user's home. The surveillance system spontaneously sent an SMS to the users when it

noticed that human detection happens in the surrounding of the house. Fig. 9 illustrates the SMS being received by home users to alert about the situation happen.

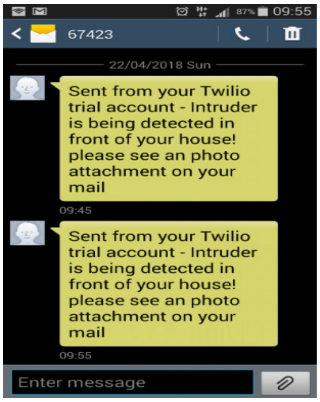


Fig. 9. SMS received by the user to be alerted of an intruder.

Besides SMS in Fig. 9, home users also received email notification immediately after intruder detected and sends an image of the intruder captured by the camera (Fig. 10).

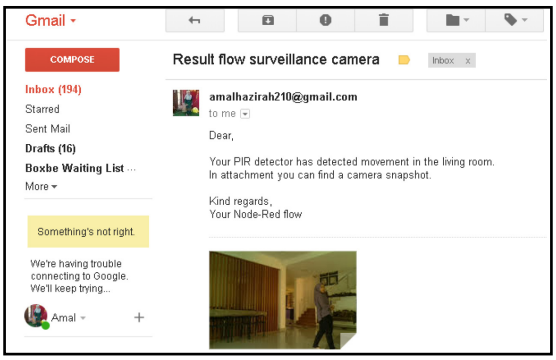


Fig. 10. Email consists of image attachment of an intruder.

B. *System Testing*

First experiment was conducted to compare distance with the actual distance (Table 1). The experiment was conducted to determine accuracy of ultrasonic sensor. Table below shows accuracy and error distance by ultrasonic sensor.

TABLE I. COMPARISON BETWEEN THE ACTUAL DISTANCE AND DISTANCE MEASURED BY ULTRASONIC SENSOR

Actual distance (m)	Ultrasonic distance (meters)	Distance Error (%)
1.00	0.93	07.0
2.00	2.09	04.5
3.00	3.77	25.7
4.00	4.97	24.3

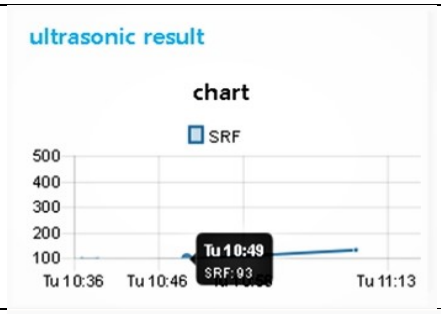
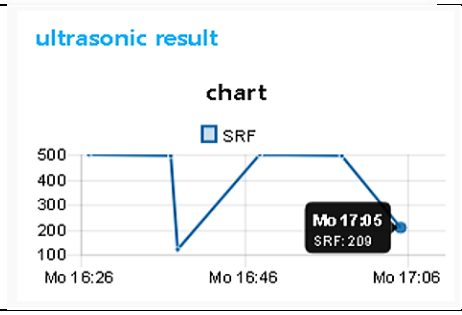
It can be inferred that there is a difference between actual distance and ultrasonic distance. This can be defined as error distance. This is because the velocity of sound of ultrasonic sensor received interference and noise from room temperature of the environment [6]. This is due to the limitation of using low-cost ultrasonic sensor. The ultrasonic sensor also has limitation to the measured distance of the movable object. Hence, it leads to distance error.

The results of measured distance were plotted in two platforms; Node Red and Thing Speak. The comparison between graph in the Node-red dashboard with the graph in Thing Speak are shown in Fig. 10 and Fig. 11 respectively. It can be observed that both platforms having the same shape of the graph. To conclude, both platforms have an advantage in IoT application [10]. From the experiment, the system notified that Node-Red is better that Thing Speak because it has a precise graph. This is because Node-Red dashboard updating the graph daily but Thing Speak continuously plotting the graph daily.

IV. CONCLUSION

The Web-Based and mobile app surveillance system objectives have been achieved. The idea of creating a cost-effective prototype IoT surveillance system which made up of electronic components and surveillance box have been successfully implemented using Node-Red and Thing Speak as the middleware. The system also has successfully made alert notification via SMS and email to notify home users on any intrusion. Lastly, this project the system can be connected to the Internet and sent data to the cloud which allows users to monitor their homes remotely.

But, this surveillance system has its limitation to differentiate the movement of object whether it is animal or human. This is because this prototype is using PIR sensor only for the purpose of detecting movement. Besides, it also has a limitation in detecting suspicious of human movement. A system that design for detecting only suspicious of human need to be added in this prototype to make it better functionality.

ctual distance (m)	The graph on the Node-Red dashboard
1.00	
2.00	

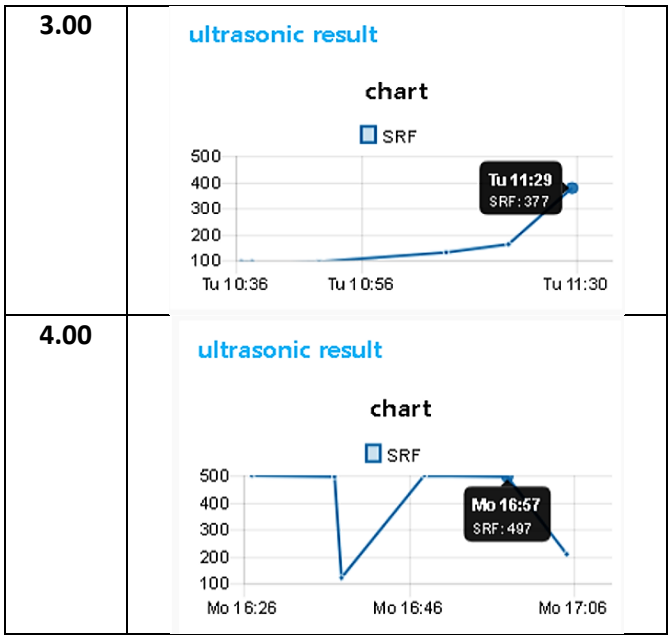
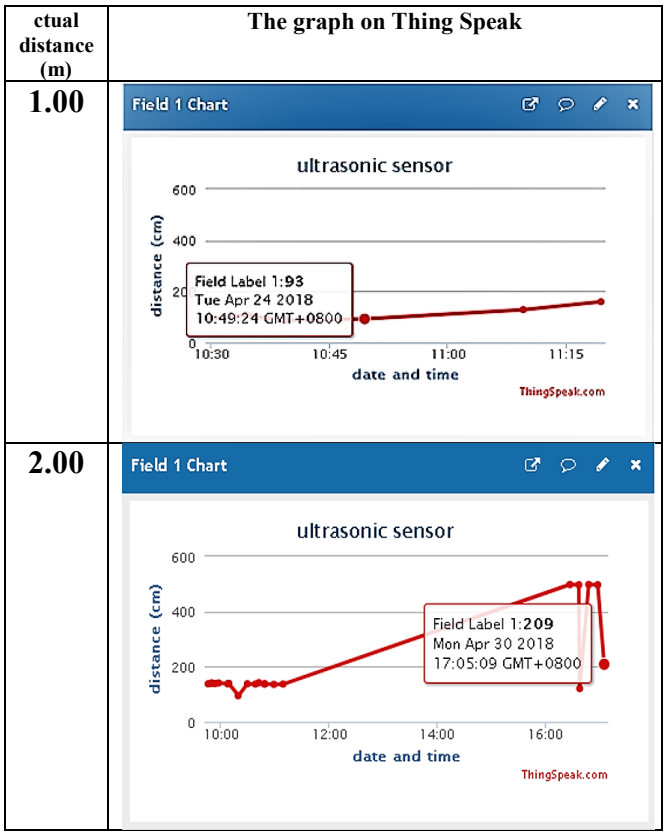


Fig. 10.Actual distant and Graph displayed in Node-Red dashboard.



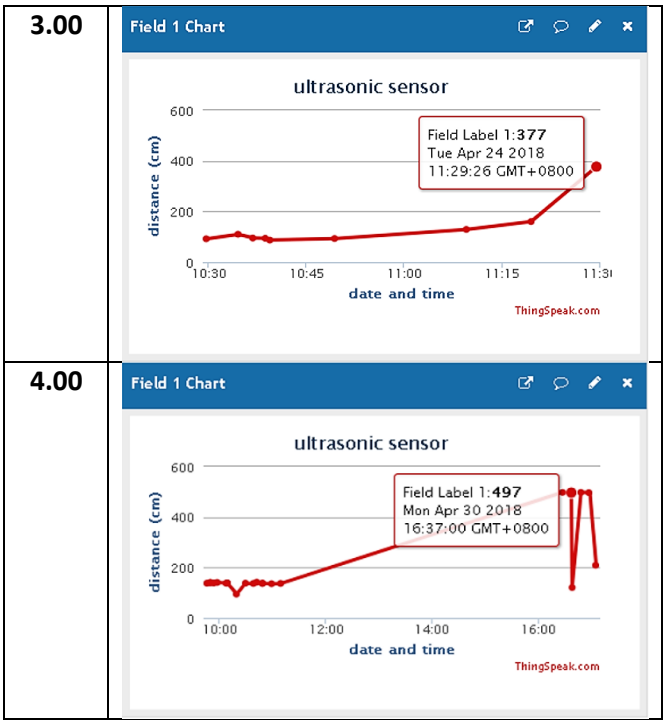


Fig. 11. Actual distance and Graph plotted in Thing Speak.

Hence, future improvements and enhancements are needed to be implemented in the Web-based and mobile app surveillance system so that it can be a very valuable product for a security system at home.

V. ACKNOWLEDGEMENT

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