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# Connecting Physical Infrastructure to the Cyber Space using the Internet of Things (IoT) Devices

[1]Haider A. Alwzwazy, [2]Ruaa Hameed Ahmed, [3]Younes Alwan, [4]Laith Alzubaidi and [5]Hayder M. Albeahdili
[1]Department of H&C-IT, Missan Oil Company, Missan, Iraq
It.hfd@moc.oil.gov.iq, +9647711407460
[2]Department of Scholarships and Cultural Relations, Ministry of Higher Education and Scientific Research, Baghdad, Iraq ruaa.hameed@yahoo.com, +9647708176138
[3]Department of Electromechanical Engineering, University of Samarra, Samarra, Iraq
younes.alwan@gmail.com, +9647733781520
[4]Faculty of Science and Engineering, Queensland University of Technology, Brisbane, Australia
laith.alzubaidi@hdr.qut.edu.au, +61421933812
[5]Department of D&G-IT, Missan Oil Company, Missan, Iraq Hedereng@yahoo.com, +9647715718122

**Abstract:** Internet of Things (IoT) is considered to revolutionize the way internet works and bring together the concepts such as Machine to Machine (M2M) communication, big data, artificial intelligence, etc., all working under a same umbrella such that cyber physical systems and human are more intertwined and thus, ubiquitous. In this study, we implement Internet of Things (IoT) project for three different modules. In the first part, we design a remote robot car which can be controlled remotely from web interface anyplace around the world. In the second part, motion detection system is designed. It detects any object that radiates infrared such as humans and animals. After detecting, the Arduino Yun takes picture and uploads it to a Dropbox account which also can be monitored from anywhere for safety issue. Finally, humidity, temperature and light sensor detector is implemented to detect and upload all reading results to the Google Docs as real time monitoring. In the second part, we implemented data analysis using Hadoop.

**Key words:** IoT, big data, data monitoring, human and animaals, safety, hadoop

## INTRODUCTION

One emergence term in technology is the Internet of Thing (IoT) (Xia *et al*., 2012; Madakam *et al*., 2015; Fleisch, 2010). It is entirely a new concept and a big movement. Recently, the internet of thing has been growing rapidly. It reaches about nine billion devices globally. This trend means that the things can connect to each other without the interaction of the human. Having sensors and software enables the devices to connect through the network and exchange data. The sensors are used to collect data and react on them. However, connecting the devices and incorporating the data from different sources need an efficient administrating system.

IoT can solve many problems Farhan *et al*. (2018). First, connecting things together around the world makes it easier to access, share information and makes the world a smart world. Cloud computing with its massive storage and computing ability gives the power to the IoT (Fan, 2013). The cloud allows the apps to perform anytime, to go anywhere. That is why the cloud computing becomes the fundament of the IoT and everything will connect via. cloud. Furthermore, IoT will bring a new opportunity for application developer to build different applications for internet-enabled devices and turn our lives easier (Seneviratne, 2015 Stackowiak *et al*., 2015; Atzori *et al*., 2010) Moreover, IoT provides decision of sensor-driven analytics, optimization, optimized resource consumption, lower costs, improving system reliability, instant control and response in complex autonomous systems and data-driven systems are being built into the infrastructure.

In this study, we would measure data, monitor home by distance utilizing a USB camera and create a WiFi controlled mobilizing robot. All the process will be done automatically using sensors and connecting to the internet, so, the data will be available at the cloud and can be accessed anywhere. Without IoT the data needs to be measured with the human interaction and it will be saved and accessed locally only. In general, our study helps to monitor home remotely and discover any motion that

**Corresponding Author:** Haider A. Alwzwazy, Department of H&C-IT, Missan Oil Company, Missan, Iraq
It.hfd@moc.oil.gov.iq, +9647711407460

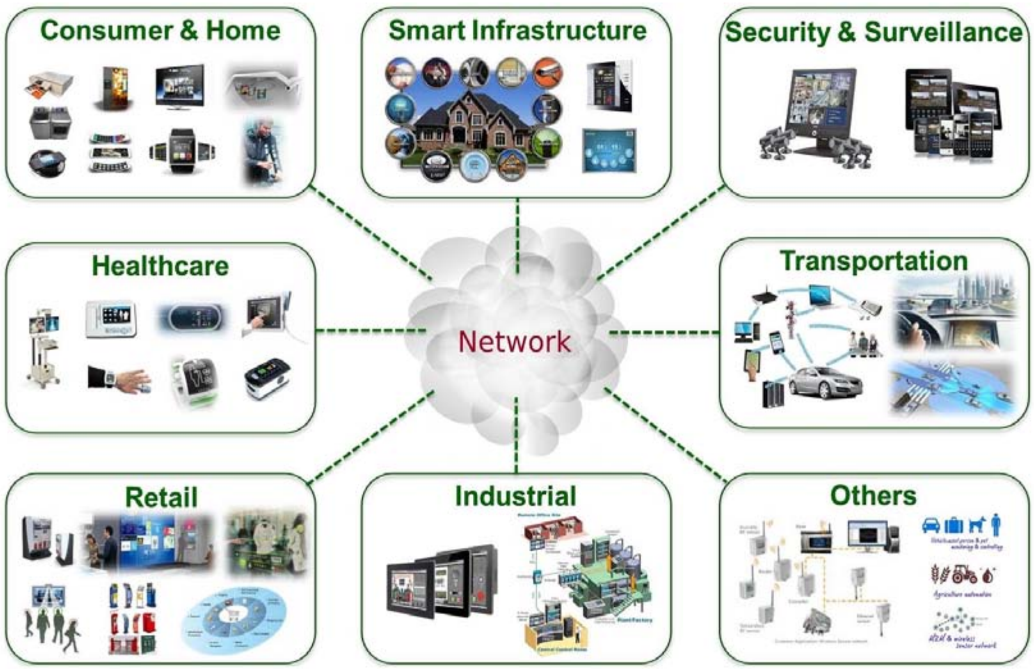


Fig. 1: IoT applications

might happen. In addition, it helps to measure the temperature, the light level and other factors then saving the data in the cloud in addition, to the mobile robot car.

The technology involved in this study is the Arduino with Arduino IDE and the sub-camera along with different types of sensors. The Arduino Yun has a WiFi, Linux and an SD card slot. Further, we used Dropbox and Google Docs to save the images and the data. Also, we used the Temboo which acts as an interface between the Dropbox or Google Docs and the Arduino. However, we will explain the details about these technologies.

The wireless security cameras can take a picture when a motion is detected. However, theses cameras have an interface unit that can be pre-customized by the producer, since, it has limited features. In this study, we will build and customize our camera depending on our needs. The same thing is true for the weather station and the mobile robot car. The limitation of current IoT are compatibility, complexity and privacy/security.

**Objective:** The objective of this study is to connect the physical infrastructure to the cyber space using the IoT devices, sensors and software. In addition, to provide a way to access the data remotely using cloud computing technology. This study gives a guideline to design IoT and use it in a daily life for home security, data measurement and control. It also provides a basic knowledge for the IoT trend (Fig. 1).

**System requirements and use cases:** We took a case for the IoT the motion detection, mobile robot car and weather station. Our study solves the problem of recording any motion and weather data automatically. Also, to control the robot using Arduino Yun, sensors and other devices.

The feature of our system is that it can be used for security. For example, it can be used to monitor the home from the work place, so, it can discover any threat happening there. It uses keys of the application in Dropbox and Temboo to assure the secure access to the data. The output data is images belonging to security camera and it is numbers representing the temperature and the light level for the weather station.

## MATERIALS AND METHODS

We used three applications for the IoT using the Arduino platform (Ferdoush and Li, 2014). We learned how data are measured, how to monitor a place distantly by a USB camera and build a mobile robot with WiFi control.

**Weather station connected to the cloud:** The first application in our study is to manufacture a prototype atmosphere station that sends measurements into the cloud utilizing the web-shaped service, Temboo which


Fig. 2: Arduino Yun

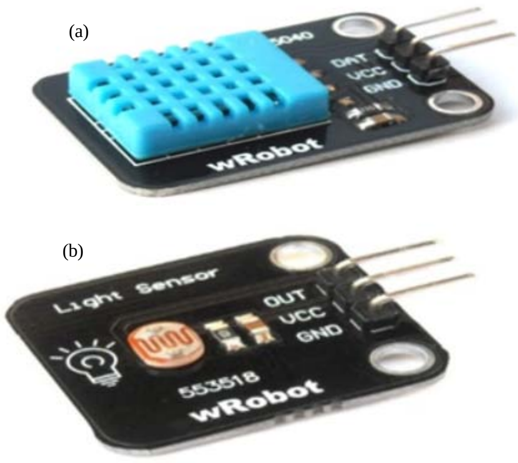


Fig. 3: a, b) DHT11 sensor

costs money, although, we have free 250 calls for Temboo per month. Our Research focuses on linking sensors measuring humidity, temperature and light level to the Arduino (Schwartz, 2014). We tested the sensors to assure that the hardware linkages, we conducted were accurate.

After, we used the libraries of Temboo Arduino to transfer measurement data into the cloud-web and multi-web facilities. As a result, they were logged in remotely nevertheless of where we are. Temboo is defined as a web-structured facility which permits us to link different websites composed and provides built-in libraries to Arduino Yun. In this experiment, we used the components.

**Arduino Yun:** The first Arduino Yun is a combination of the Leonardo board and an on-board WiFi module (Fig. 2).

**DHT11 sensor:** It is used to measure moisture and contains a photocell to measure light intensities. The first, Arduino Yun is a combination of the leonardo board and an on-board Wi-Fi module. Sensors were used to measure moisture and has a simple photocell to measure intensities of light (Fig. 3).

Fig. 4: USB camera

**Cloud-connected camera:** Our second application is for building a surveillance camera which robotically uploads pictures and data to the website. Then, a camera is connected to the Arduino Yun Kit and utilize a new means to easily control the camera and upload images to the website. We would create a system that is able to sense gesture and is able to robotically have an image and include it both on the card of the native SD that is linked to the Yun Kit and on a web of a website loading store on the Dropbox.

**What is done in this application:** We started with the hardware of the study with a PIR motion sensor, a typical USB camera and one SD card. Then, we tested the hardware connections by writing a code to check devices. We'd check the sensor of motion and have an image with the camera while linking to the Arduino Yun Kit. We would start with capturing pictures whenever a motion was detected. Then, data would be automatically stored on the SD card. The pictures wold also be uploaded to the Dropbox folder. Finally, we would connect the study to the cloud, so, we could access the Dropbox from any web browser. In this experiment, we used the components as show below.

**Arduino Yun:** We used a standardized USB web-cam that belongs to Logitech, the C900 models with an HD resolution.

**USB camera:** A standardized USB web-cam belonging to Logitech was used; C900 models with HD resolution (Fig. 4).

**PIR motion sensor:** It can notice gesture in a place from any object emitting temperature such as living creatures (Fig. 5).


Fig. 5: PIR motion sensor

**IR sensor:** This sensor is able to sense changing in position in a place by any object emitting temperature.

**WiFi-controlled mobilized robot:** We used Arduino Yun, interfaced DC motors and built our mobilized robot with Arduino Yun which is the decision stage of the robot. We also used a remoteness sensor for this robot, remote control utilizing WiFi and a modest website interface, so, we obtained a real time monitoring for the measurements taken by our robot. In that moment, the remoteness was taken ahead of the robot via. the ultrasonic sensor. In this study, we built a mobilizing robot having the Arduino Yun as its "brain" and it is completely controlled by WiFi from a computer, a tablet or a smart mobilized device. The Arduino sketch was programmed for the targeted robot, so, it would get orders, direct information back and drive a graphical interface on the computing device. We are able to build more complicated uses in the incoming time and we simply need to alter the software that runs on the computer and let the robot not manipulated. We built the robot car using some basic electrical and mechanical parts. At the bottom of the robot, we had most of the mechanical parts such as the wheels, the chassis, the ultrasonic sensor and DC motors. We had a battery at the center of the robot base. In addition, we had diverse Arduino Kits mounted on. Beginning in the lowest part, we had an Arduino Yun panel, an Arduino Uno panel, a rotating machine buffer and a prototype buffer.

For such a work, we had two Arduino boards: the Yun that would receive orders straight from the external surrounding and an Arduino Uno panel that would be joined to the motor buffer.

The next step was for building the Arduino Software which receives commands and orders from the computing device and retransmits them to the rotating machine moving the robot nearby. Till now, we were coding the portion that would conduct the remoteness data back to the computing device.

(a)

(b)

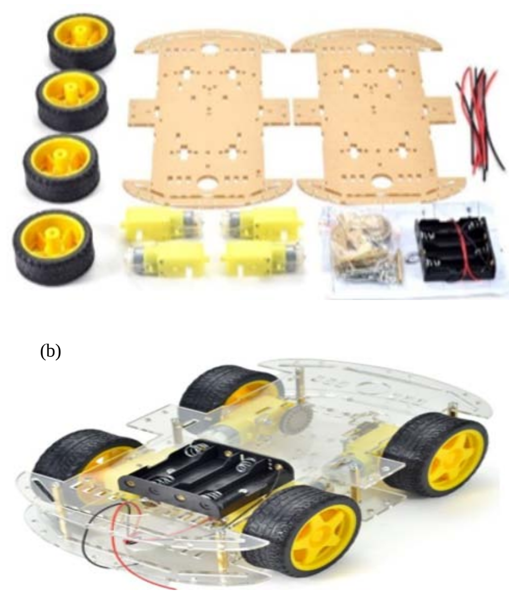

Fig. 6: a, b) Wheel robot smart car


Fig. 7: Ultrasonic sensor

Finally, we built the server-part monitoring interface on the computing device that, we could regulate the robot from the computing tool and collect data regarding the robot such as the measurements from the ultrasonic sensing device. This server-part software utilizes HTML to monitor the interface, JavaScript to deal with the users activities and PHP to send data straight to our Arduino Yun.

**In this part of our study, we would use components as shown below:** Smart wheel robot car with chassis kits and speed encoder used for the Arduino. A robot base for supporting all the components, along with four DC motors, four wheels and ultrasonic sensor at the front of the robot (Fig. 6).

**Ultrasonic sensor:** For the ultrasonic sensor, we used URM37 which is able to be interfaced through apulse in the task of Arduino (Fig. 7).

Fig. 8: Arduino Uno board

**Arduino Uno board:** We would interface the whole parts with a standardized Arduino Kit. Further more, link the Yun board to the board (Fig. 8).

**A motor shield for the Arduino:** We used a motor shield to have an interface between two DC motors and the Arduino Uno board.

**Simple prototype shield:** We added a simple prototype shield on the top of the robot to have power connections easier.

**Web interface:** We built a simple web interface to remotely control the robot. The interface was composed of several buttons to let the robot move around and display the measurement coming from the ultrasonic sensor mounted at the front of the robot.

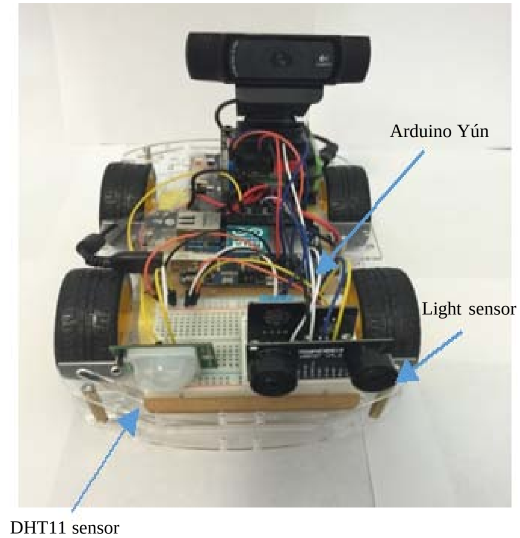


Fig. 9: Connected system parts

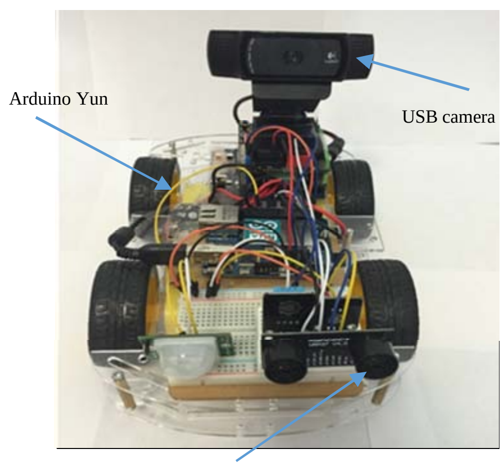


Fig. 10: Weather station connected to the cloud in robot car

## RESULTS AND DISCUSSION

**Weather stations connected to the cloud:** In this study, we describe how we monitor and detect. The required hardware connections for the study are simple. We had to connect the DHT11 sensor and then the part that is responsible for the light level measurement with the photocell by conducting the following steps (Fig. 9 and 10).

Joining the Arduino Yun board's + 5V pin to the red bar on the breadboard and the ground pin to the blue bar. Connecting pin No. (1) of the DHT11 sensor to the red bar on the breadboard and pin No. (4) to the blue bar. Also, connecting pin No. (2) of the sensing tool to pin No. (8) of the Arduino Yun panel. To achieve the DHT11 sensor linkages, we should lock the 4.7 k$\Omega$ resistor between pin No. (1 and 2) of the sensing device. Hence, we used DHT11 sensor already having a resistor. Creating and setting an account on the website facility Temboo:

- Open Temboo website at http://temboo.com/
- Enter the e-mail address to enroll and go to signing up
- After being asked to enter some basic information regarding our account and complete them, we would be prompted to create our first app

**Sending data to Google Docs:** Google Docs is appropriate and contains an online application from Microsoft. We formulate a Google Docs worksheet that would handle with the data and the measurement. We generate a new one in the descend of the Google Docs account. We would require having the identification o f the columns for the information that would be entered which are period, hotness, moisture and light strength. We upload the plot to the board of the Yun and

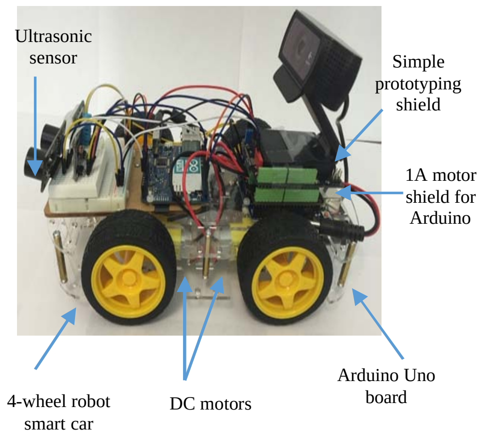


Fig. 11: Wi-Fi-controlled mobile robot car

turn the Google Docs worksheet on to watch what occurred. They are all synchronized with the Google Docs servers.

**Cloud-connected camera:** We connect theUSB camera to the Yun USB port. We link the PIR gesture sensing tool into the Yun panel. It consists of three pins: VCC, GND and SIG (signal pin). We engage VCC to the 5V pin of the Yun, GND to the earth of Yun and SIG to pin No. (8) of the same Arduino.We engage Yun to our computing machine via. a mini USB supplier or link it into a USB converter, if we wish to practice the task distantly and upload the Arduino plots utilizing WiFi. We upload the pictures taken by the camera to the Dropbox. We simply utilized the Choreos (Temboo collections) for the Yun.

**WiFi controlled mobile robot:** We engage the rotating machine protection on the uppermost of the Arduino Uno panel. We could also link the suppliers coming from the DC rotating machines to the headers of the motor protection bolt Fig. 11.

We engage the prototype protection on the upper part of the robot. The ultrasonicsensor was previously linked: the Earth goes to the Arduino Earth, VCC links to the 5V pin of the Arduino on the model protection and the pin of the signal drives to pin A0 of the Arduino panel. We built an interface, so, we could remotely control the robot from our computer or a mobile device. We created the HTML file that would be the entering socket to the robot governor. This folder contains four buttons that we would utilizing to govern the robot. The design also has CSS folder to have a better interfacing.

**Testing and validation:** We evaluated and conducted experiments as practical implementations for

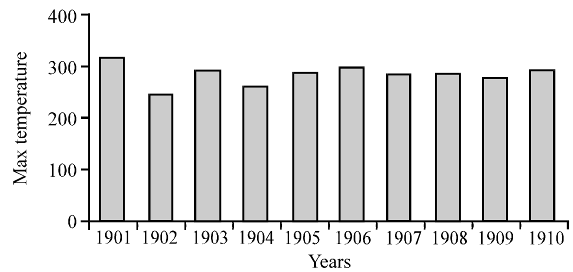


Fig. 12: Weather dataset for 10 years

the whole study parts as illustrated earlier. In addition, we attached Demos showing entire study design (Fig. 12).

**Second part:** Analysis data on Hadoop (Rathore *et al*., 2016) we used a weather dataset for 10 years and it was analyzed using Hadoop.

**User manual:** In our study, we used Arduino open source (IDE) shown in the following screenshot to upload Arduino code to use boards in our experiments. Both Arduino Yun and Uno boards are used in this study.

Since, in our experiments we used three parts represented as home security system, control remote robot car from a website and finally, a weather station, the following steps show how the code is uploaded and run on the Arduino board.

We start with the weather station used to measure temperature, humidity and light. In this part, we used only Arduino Yun to run this experiment. In all our experiments when we needed to upload the code from Arduino IDE to certain board, first, we needed to choose the Arduino board type and a port. The board type and the port were selected from tools appeared in Fig. 13.

In addition to the used code, more software is used also. For instance, Google Docs and Temboo are used here. It is worth mentioning that Temboo Software is used to transfer measurements from sensors connected to Arduino to Google Docs. Then, we can lively monitor all measurements as shown in Fig. 14.

For the rest of the part, we follow the same steps to upload codes by choosing the right board and the right port. However, we still need some supported software to run experiments. For instance, we need a Dropbox account and Temboo to run the home security paper. It is worth mentioning that as soon as we upload the code, the Arduino board then the camera start taking picture whenever sensor detector detects a motion and directly uploads to the Dropbox account and it can be seen from any place around the world. A screenshot for home security is shown in Fig. 15-19.


Fig. 13: Arduino IDE open source software

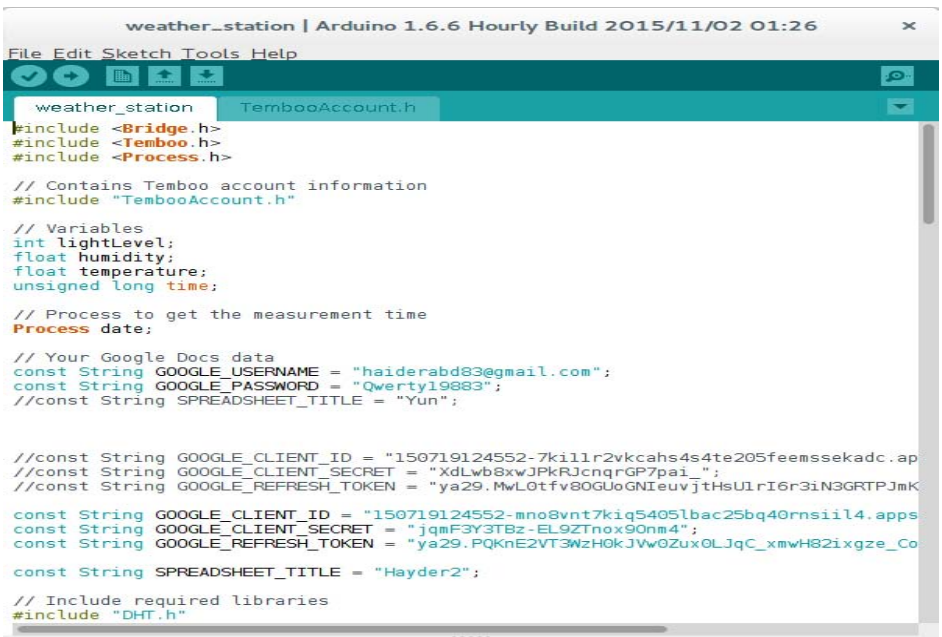


Fig. 14: Weather station code in Arduino

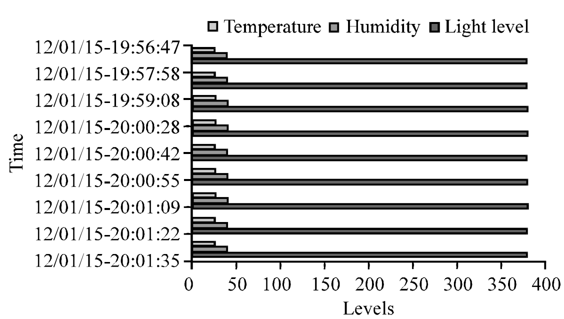


Fig. 15: Data analysis using Google Docs by date

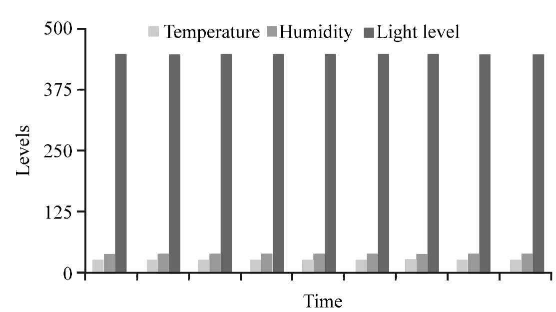


Fig. 16: Data analysis using Google Docs level

Finally, the last part of our study controls a car remotely using a website from anyplace around the world. Therefore, PHD, JavaScript and HTML are used in this experiment. The same procedure for uploading the code but in this time, we used both Arduino Yun and Uno because Arduino Uno is connected to the motor shield which controls the car wheels. Thus, two pieces of codes

Fig. 17: Data analysis for home security

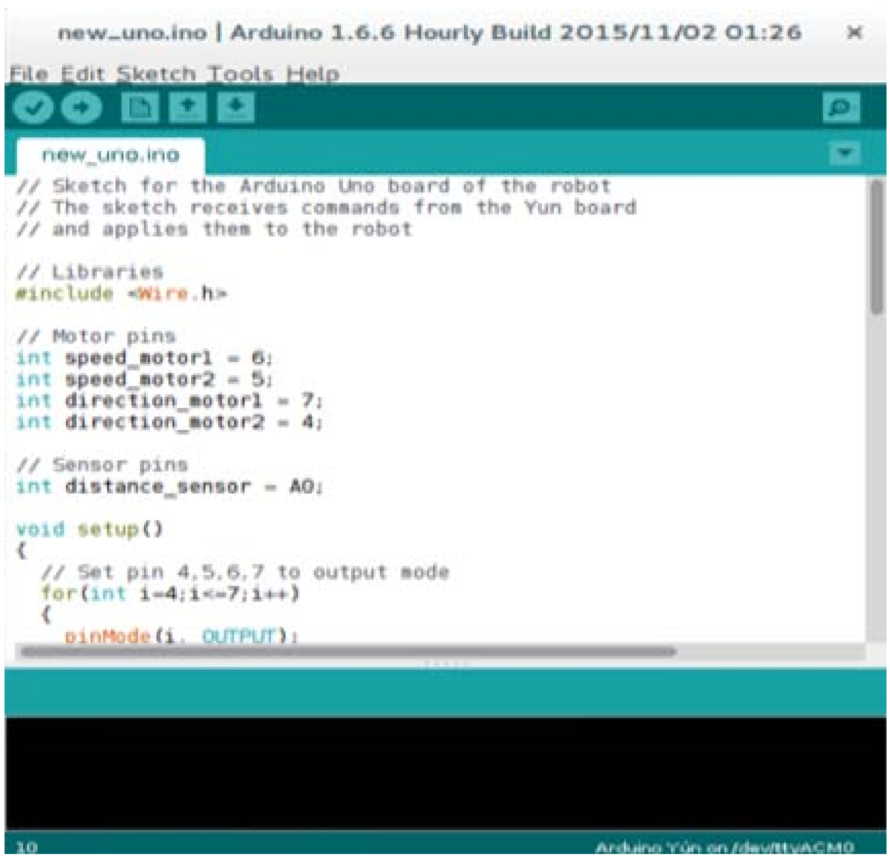


Fig. 18: Data analysis code for controls a car remotely

are used. One of them is uploaded to Arduino Yun and the other one is for Arduino Uno as shown in Fig. 5.

After finishing the coding, we go directly to our website, so, we can control the car movement.

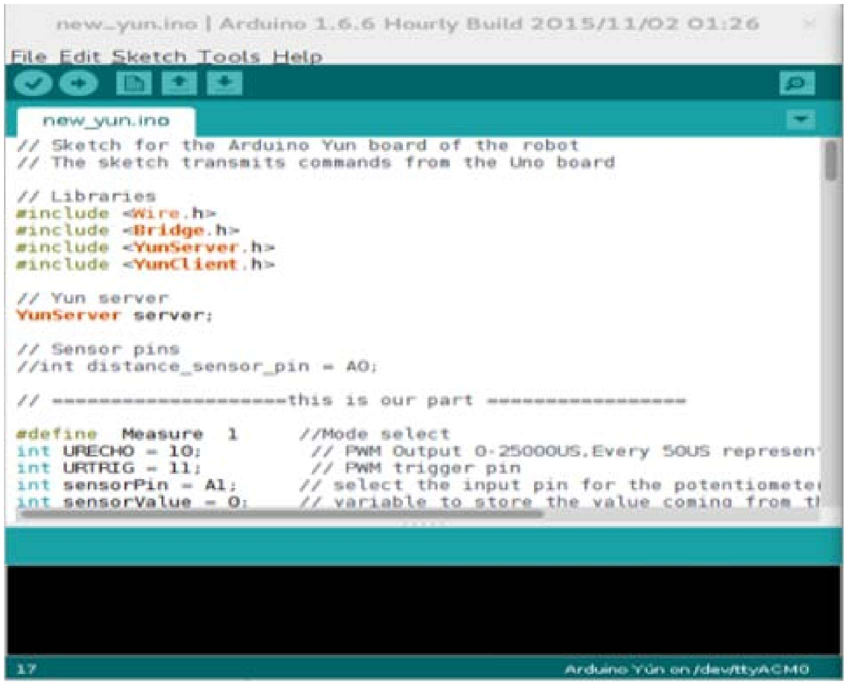


Fig. 19: Data analysis code

Furthermore, it is worth mentioning that the car is controlled to be moved forward, backward, left and right.

## CONCLUSION

In this study, we implemented Internet of Things (IoT) study for three different modules. In the first part, we designed a remote robot car which can be controlled remotely from web interface anyplace around the world. In the second part, motion detection system was designed. It detects any object that radiates infrared such as humans and animals. After detecting, the Arduino Yun takes picture and uploads it to a Dropbox account which also can be monitored from anywhere for safety issue. Finally, humidity, temperature and light sensor detector is implemented to detect and upload all reading results to the Google Docs as real time monitoring. In the second part, we implemented data analysis using Hadoop.

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