Journal of Engineering and Technology

ISSN 2180-3811 eISSN 2289-814X https://journal.utem.edu.my/index.php/jet/index

INTEGRATING RETROFIT IOT CONTROLLER WITH ELECTRIC POWER SYSTEM FOR MANUAL WHEELCHAIR

M. M. A. Rahim[1], A. F. Kadmin[2]*, S. F. Abd Gani[3], K. A. A. Aziz[4], R. A. Hamzah[5], A. Z. Jidin[6]
[1,2,3,4,5,6]Faculty of Electrical and Electronic Engineering Technology, Universiti Teknikal Malaysia Melaka, Malaysia
*fauzan@utem.edu.my

Article history:
Received Date: 2019-08-20
Accepted Date: 2020-06-22

Keywords: Powered wheelchair; IoT; Controller; Voice; Physical injuries; Microcontroller

Abstract— Persons with physical injuries and disability are struggling to get through places using the conventional handwheelchair The needs of many people with disabilities can be overcome with powered wheelchair, but some portion of this community is finding it difficult to operate standard powered wheelchair due to its big in size and high prize. This project developed a smatphone phone-controlled wheelchair along with three types of virtual controller which is joystick control, D-pad control and voice control through the wireless communication. It is also equipped with obstacle (ultrasonic) avoidance notification and microcontroller controls the motor that moved the direction either front, backward, left and right. The main objective of this project is to facilitate and increase the movement of people who are handicapped and the ones who are not able to move freely with the implementation of IoT platform where this platform could provide data visualization and able to analyze the wheelchair maintenance management and movement. In additional, this project analyzes distinct IoT monitoring system features, including battery level remaining and temperature control. the concept succesfully developed with integration of microcontroller in which provide desired performance control of the system to desired output with the synchronization of Internet of Thing features.

I. IMPORTANT INFORMATION

Nowadays, the Internet of Things has various applications in human services, from remote monitoring to smart sensors and medical device integration. It can possibly keep patients safe and healthy, as well as to enhance how doctors convey mind too. Bouhaï N. et al. [1] claimed that the Internet of Things (IoT) is a biological community of associated physical objects that are open through the web. The 'thing' in IoT could be a man with a heart screen or a vehicle with worked in-sensors, i.e. objects that have been allocated an IP address and can gather and exchange information over a system without manual help or intercession.

Lodhi D. et al. [2] describes the motorized wheelchair by using voice controlled wheelchair using embedded system. The system will interpret the commands and control the wheelchair accordingly via android application. Khadilkar S.U et al. [3] describe to utilize wheelchair consequently and work by utilizing voice and signal control for pushing ahead, in reverse, left and ideal by PDA. The approach enables the client to utilize human voice, signal development advanced cell and synchronize the with the development of wheelchair so they can utilize it with comfort. Leela et. al. [4] introduced work is more creative in the sense, it utilizes discourse acknowledgment framework to give guidance development control of the wheelchair. In this wheelchair, no different discourse acknowledgment circuit is utilized on the grounds that it is finished by Raspberry Pi utilizing speech acknowledgment calculations.

Nowadays, the number of elderly people has increased. Some live with their children, some live in adult foster home and some even live by themselves. The problem arises when the elderly people lose their abilities to move around [5]-[8]. Not everyone can be in the location to help them all the time. Patients involved in physical injuries and disability are struggling to get through places using the conventional hand wheelchair. A wheelchair designed to be

a replacement for walking. It is used for mobility by people for whom walking is difficult or impossible, due to illness or disability. The solution is to develop an automatic wheelchair controlled by DC motor will be develop together with IoT concepts implement on it for monitoring purpose [9]-[12].

This project aims is to develop a new retrofit multi-purposes controller that can be installed in manual wheelchair and to control the input signal and transfer the data towards cloud database. It will possess an input which is the control movement, obstacle detection and battery remaining indicator and received by microcontroller in this project used Arduino as it microcontroller, then the signal receiver will be transfer towards cloud database so that IoT platform used able to display platform.

II. METHODOLOGY

The system is designed as shown in Figure 1, there are obstacle sensor, battery level remaining and seat ergonomic attached towards wheelchair where act as transmitter to the wheelchair itself. Then, the signal received by wheelchair will be transmitted onto database by using Wi-Fi module integrated with Arduino microcontroller. Once the signal had been transmitted, the signal will be stored as data in the cloud database (using Thingspeak IoT platform). Through the Thingspeak application, all the data can be monitored on its dashboard where in this project, the aim of the WebView is to act as result monitoring. This project is divided into three developments which are; (a) Hardware development, (b)Controller development and (c) IoT Platform development.

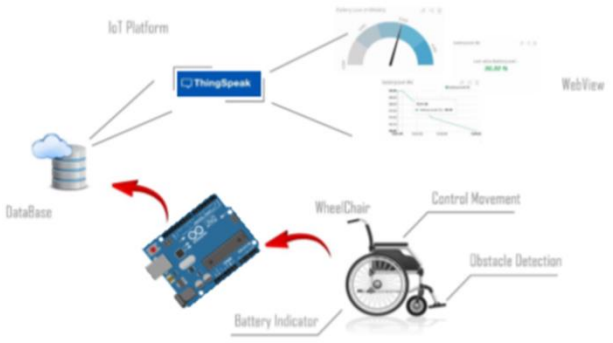


Figure 1. Project Diagram

A. Hardware Development

- Physical layer involving of sensor for sensing and gathering input information from the environment, some physical parameter or identifies other object in the environment.
- Obstacle avoidance: the obstacle sensor used for this project as shown in Figure 2 is ultrasonic sensor where this sensor interpret the echoes received from the environment respectively. The ultrasonic sensors produce high frequency sound waves and evaluate the echo which is received back by the sensor. The time interval between the sent signal and received signal is determined to measure the distance from an object.
- Temperature and humidity sensor: these sensor are capable of measuring both temperature and relative humidity and provide fully calibrated digital outputs. The purpose of this sensor is act as warning security if in case the temperature inside the microcontroller got high in temperature, the IoT data will notify user before unexpected incident happens such as the microcontroller board got burst while operating too long.
- Battery level remain: when dealing with dc motor, of course there must be a powered source attached near its. But how patient or user who in this project will be monitored the battery level in case to avoid the exhausted power consumption. The circuit used in this project is a simple two-resistor voltage divider. The circuit will take the input voltage from the battery pack and convert it to a lower volatge that can be read by a microcontroller, Arduino.

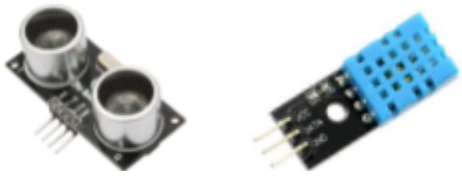


Figure 2. Sensors

B. Controller Development

- Network layer which is responsible in connecting other smart things, network devices and servers. In this stage also used for transmitting and processing all input sensor data.
- Arduino microcontroller as shown in Figure 3: All data sensor received by each sensor will be received and read by the Arduino and all this data then will be transmit over Internet through Wi-Fi Module. The microcontroller will also send a signal of Pulse Width Modulation (PWM) signal towards

the motor driver based on direction received from the smartphone application either forward, backward, left or right.

- Wi-Fi Module: The data from Arduino board will be uploaded towards Internet database to be analyze then being displayed as required by user.

Figure 3. Microcontroller

C. IoT Platform Development

- Application layer where it will responsible in controlling the wheelchair's movement and delivering application (IoT platform) specific services to the user. It defines the data visualization of wheelchair's activities in which the Internet of Things can be deployed.
- Android Apps: The Android interface design was designed using the basic4android where this interface design was proposed to act as wheelchair controller. The application offers user to use three type of input controller which is D-pad, Joystick and Voice Recognition control.
- IoT Platform Thingspeak: Figure 4 shows Thingspeak helps user to create an application that capture real-world data and turn it into meaningful actions and insights.

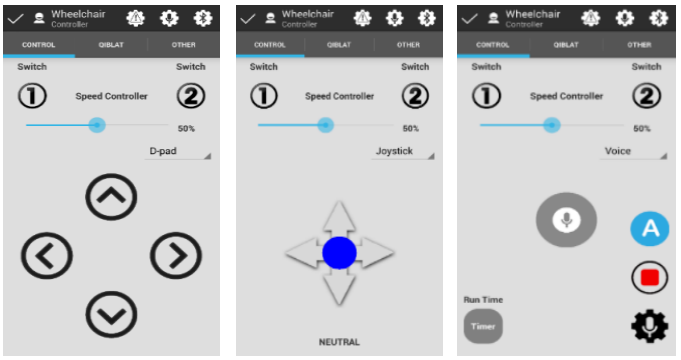
Figure 4. IoT Platform

III. RESULT AND DISCUSSION

In order to construct the purpose retrofit IoT wireless electric-powered wheelchair, the concept was developed with the making of Android application together with integration of microcontroller in which will control the system desired output also with the synchronization of Internet of Thing features.

A. Control Interface

The Android interface was designed using the Basic4Android where this interface design was proposed to act as wheelchair controller. The application offers user to use three type of input controller which is D-pad, joystick and voice recognition control. D-pad also known as directional pad is an operated four-way directional control where for this project, it is being designed to move forward, move backward, to the left and another one is to the right. Figure 5 below shows a D-pad, joystick and voice controller of wireless wheelchair controller application. Just like the real one joystick where consist of cursor stick to control the movement. However, when user releases the cursor, the application automatically returns back to the center and indicated as neutral mode.



(a) D-Pad (b) Joystick (c) Voice

Figure 5. Controller Interface App

This features are quite impressed to be implemented together with wireless wheelchair controller. The way this type of controller works is user need to set up their own voice to be acknowledge by the voice control. This recognition voice can be set up at the speech icon. In the interface itself, there is run time to shows user the time running on its. This feature is integrated with Google API key where voice is being converted into text. Qiblah direction's interface as in Figure 6 is the one of the most utilized application needed especially among Muslim user. It enables user to determine the right location or bearing of Ka'abah. In Qiblah code, the angle which is 360° is isolated into 400 divisions. On the off chance that at wherever, the north bearing is the same as the direction of the Qiblah, the difference between north and the heading of the Qiblah will be zero and turn over the wheelchair facing Qiblah.

Figure 6. Qiblah Interface

B. IoT Platform

The IoT platform used for this project is "Thingspeak" cloud since the usage from this cloud offered a variety of flexibility and customization. Thingspeak comes with one channel include up to eight fields which each fields provided data analyse from the microcontroller. However, to make it communicate with WiFi module, the transmitter port from Arduino must be connected with receiver of ESP-01 and same goes to the receiver port from Arduino port must be connected with transmitter port from ESP-01. Only then, the ESP-01 able to receiver all desired data from Arduino then being transmitted to the specific IP address to be displayed.

Figure 7 shows the "apikey" can be inserted in the command from the Thingspeak cloud itself. That is how the Thingspeak works to provide user database to the display over their service. Next, the Arduino itself have to be set up with the specific WiFi so that all the collected data from Arduino can be sent over Internet.

```
String apiKey = "Y7BQNTZMA3UJRLZQ";     // thingspeak WRITE API key

String ssid="MuhammadKim";    // Wifi network SSID
String password ="mobilecomm93";  // Wifi network password
```

Figure 7. IoT Communication Command

Thingspeak platform offers up to "8 field" per Channel. One API key only works for one Channel only and if in the future, user want to add another Channel, user have to declare first the API key in the Arduino sketch then update the Arduino to be it acknowledge and works in sending their own data to the Thingspeak as shown Figure 8.

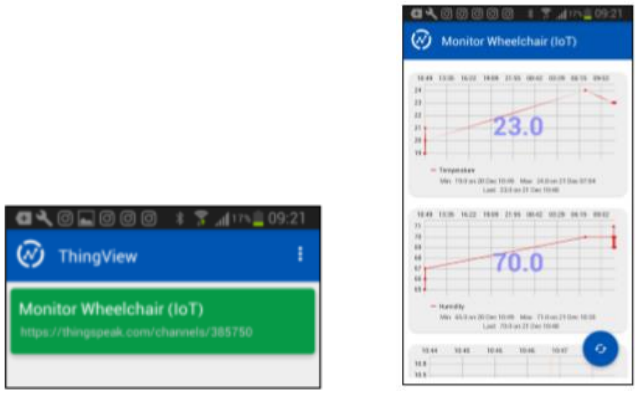


Figure 8. Data Entry in IoT Channel

C. Performance Analysis

The direct current (DC) motor is one of the main machines formulated to change over electrical power into mechanical power. Permanent magnet (PM) direct current change over electrical energy into mechanical energy through the connection of two attractive field. On the first field, is produced by a permanent magnet assembly while another field is created by an electrical current streaming in the motor windings. As this project are to be controlled by Android application, the button command for a different movement need to be configured its condition and finalize it as Table 1 where when the right condition were pressed, the left wheel will moving forward while the right wheel will moving reverse and vice versa when user want to turn the wheelchair to the left, where the left wheel will moving reverse and right wheel will moving forward. For the forward condition, both left and right wheel will move forward meanwhile for the backward condition, both left and right wheel will move reverse.

Table 1: Motor Direction

BUTTON COMMAND	LEFT WHEEL	RIGHT WHEEL	CONDITION OF WHEELCHAIR
	FORWARD	FORWARD	MOVE FORWARD
	REVERSE	REVERSE	REVERSE
	FORWARD	REVERSE	TURNING TO THE RIGHT
	REVERSE	FORWARD	TURNING TO THE LEFT
Black color is inactive button	NEUTRAL	NEUTRAL	NEUTRAL

The microcontroller will send a signal of Pulse Width Modulation (PWM) signal towards the motor driver PWM port. In the Android interface, the speed can be adjusted by

sending the PWM frequency. This designed purpose is to be able to carry any kind of weight of the user and this command setting can be seen in the Figure 9. The best way to make a battery level is by using voltage divider where the voltage divider was constructed using two series of resistor both are 12k ohm used which is the principle of voltage divider are turn the high voltage into the smaller output. The battery level monitoring also is integrated with i2c lcd display with IoT monitoring. As a result, the reading will be display over lcd also will be displayed over internet. In Figure 10 shows the result read and displayed over Thingspeak.

```
Sub SeekBar1_ValueChanged (Value As Int, UserChanged As Boolean)
      If UserChanged Then
      pwmvalue = Value/100
      lblseek.text = Value & "%"
      End If
End Sub
```

Figure 9. Command for Speed Control

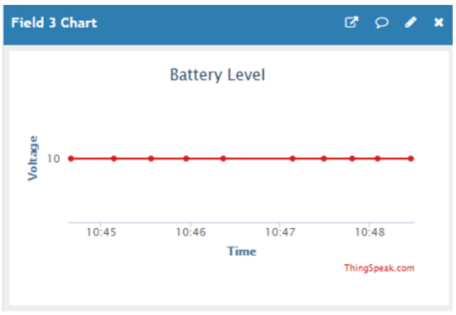


Figure 10. Battery Level Status

This analysis points out that depending on the real time taken for the battery level remain to detect exactly on how much battery left. This analysis was done to see the period would it takes for battery to detect a low voltage reading that might occur in a time after the system was installed in the wheelchair, so that an immediate action could be taken before the battery totally out. Temperature and Humidity comes in one component called as DHT11. The main purpose of this component is to make sure the temperature inside the controller box are remain as normal temperature as it can otherwise, if the temperature in the microcontroller box got high in its temperature, it will notify user before any controller in the box get burst. The command in Figure 11 below show the command used for DHT11 and in the same time, all the input reading also can be monitored from the serial monitor in the Arduino and all the input reading also is displayed over Thingspeak as in Figure 12.

```
//Read DHT11 sensor values
 float t = dht.readTemperature();
 float h = dht.readHumidity();

      if (isnan(t) || isnan(h) && isnan(v))
      {
      if (DEBUG) Serial.println("Failed to read from DHT");
    }
    else {
        if (DEBUG) Serial.println("Temp="+String(t)+"C");
        if (DEBUG) Serial.println("Humidity="+String(h)+"%");
```

Figure 11. Temperature and Humidity Sensor Command

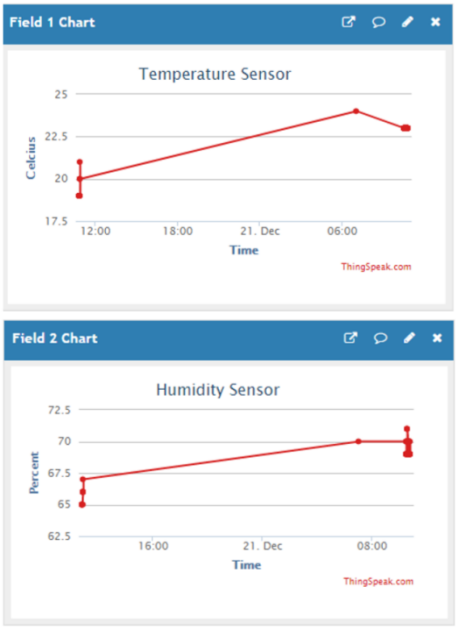


Figure 12. Temperature and Humidity Result

IV. CONCLUSION

Since world nowadays are moving forward toward IoT features, this wheelchair updated with that features in which the main focus of this IoT is to retrofit and monitor the wheelchair. Any breakdown happened, user could notify it earlier and make a move to sustain its maintenance. This enable user to move freely and independently out there without worries of drainage battery. Not only user itself could monitor this wheelchair's maintenance level, their family members also could monitor it just by log in with the provided ID Channel for this wheelchair's database. IoT features used in this project also provide the application which can be installed in Android smartphone. This also brings greater innovation towards this project.

V. ACKNOWLEDGEMENT

We are grateful to Kementerian Pengajian Tinggi Malaysia, Universiti Teknikal Malaysia Melaka (UTeM) and Centre for Research and Innovation Management (CRIM) for their kind and help for supporting financially and supplying the research components and giving their assistance to complete this project.

VI. REFERENCES

[1] Bouhaï, N. and Saleh, I., (2017). *Internet of Things*. Iso-Britannia: Wiley-ISTE.

[2] Lodhi, D., Vats, P., Varun, A., Solanki, P., Gupta, R., Pandey, M.K. and Butola, R., (2016). Smart electronic wheelchair using arduino and bluetooth module. *International Journal of Computer Science and Mobile Computing (IJCSMC)*, 5(5), 433-8.

[3] Khadilkar, S.U. and Wagdarikar, N., (2015). *Android phone controlled voice, gesture and touch screen operated smart wheelchair*. In 2015 International Conference on Pervasive Computing (ICPC), (pp. 1-4). IEEE.

[4] Leela, R.J., Joshi, A., Agasthiya, B., Aarthiee, U.K., Jameela, E. and Varshitha, S., (2017). *Android based automated wheelchair control*. In 2017 Second International Conference on Recent Trends and Challenges in Computational Models (ICRTCCM), (pp. 349-353). IEEE.

[5] Beard, J.R., Officer, A., De Carvalho, I.A., Sadana, R., Pot, A.M., Michel, J.P., Lloyd-Sherlock, P., Epping-Jordan, J.E., Peeters, G.G., Mahanani, W.R. and Thiyagarajan, J.A., (2016). The World report on ageing and health: a policy framework for healthy ageing. *The Lancet*, 387(10033), 2145-2154.

[6] Kadmin, A.F., Jidin, A.Z., Bakar, A., Aziz, K.A. and Rashid, W.A., (2016). Wireless Voice-Based Wheelchair Controller System. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 8(7), 117-122.

[7] Kadmin, A.F., Aziz, K.A.A., Soufhwee, A.R., Razak, S.A., Salehan, M.Z., Hadi, N.A., Hamzah, R.A. and Rashid, W.A., (2018). Performance Analysis of Neural Network Model for Automated Visual Inspection with Robotic Arm Controller System. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 10(2-2), 19-22.

[8] Kurita, T., Matsuo, K. and Barolli, L., (2019). *A Wheelchair Management System Using IoT Sensors and Agile-Kanban*. In International Conference on Intelligent Networking and Collaborative Systems (pp. 91-100). Springer, Cham.

[9] Nowshin, N., Rashid, M.M., Akhtar, T. and Akhtar, N., (2018). *Infrared Sensor Controlled Wheelchair for Physically Disabled People*. In Proceedings of the Future Technologies Conference (pp. 847-855). Springer, Cham.

[10] Patel, A.R., Patel, R.S., Singh, N.M. and Kazi, F.S., (2017). Vitality of Robotics in Healthcare Industry: An Internet of Things (IoT) Perspective. *In Internet of Things and Big Data Technologies for Next Generation Healthcare* (pp. 91-109). Springer, Cham.

[11] Pawar, A.B. and Ghumbre, S., (2016). *A survey on IoT applications, security challenges and counter measures*. In 2016 International Conference on Computing, Analytics and Security Trends (CAST) (pp. 294-299). IEEE.

[12] Adhikary, T., Jana, A.D., Chakrabarty, A. and Jana, S.K., (2019). *The Internet of Things (IoT) Augmentation in Healthcare: An Application Analytics*. In International Conference on Intelligent Computing and Communication Technologies (pp. 576-583). Springer, Singapore.