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Intelligent Home Automation System for Disabled People

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Abstract: ***This paper presents the intelligent Home Automation System (HAS) for disabled people, since still now facilities for disabled people are insufficient around the world. Numerous researchers developed different technologies considering Bluetooth technology, ZigBee system, and Wifi technology. However, these topologies lack efficient support for disabled people. Therefore, to engage the disabled people with the modern technology and make their life safe, secure and comfortable, authors have introduced the Rasberry Pi 3 Model B with Blynk application which is able to control the home appliances from their smart android phone. In this research, the motion of the intruder has been considered as the key parameters and HOG method is used to detect the motion. Experimental validation of the proposed model implies that this process is more secure and user-friendly for disabled people compare to other existing technology. Therefore, the main contribution of this research is to develop a secured automated system, which will enable the disabled people to control the home appliances and thus overcome the limitation of the existing technology.***

Keywords: HOG, Blynk, Disabled People, Raspberry

I. INTRODUCTION

From the last few decades, with the advancement of technology, automation has been playing an important role to make the life easier and comfortable for the people. Generally, home automation system able to control the devices from remote area and provide various benefits such as increasing the comfort, safety, and security. One of the greatest benefits of the home automation system is that it can be controlled and managed easily from an array of devices such as a smartphone, tablets, desktop, and laptop [1]. Common features for HAS is the appliances control, remote control lighting, and live video surveillance and monitor security camera. To control the appliances of the home appliances, there are two types of communication i.e. wired and wireless.

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In wired communication, copper wired used meanwhile in wireless communication, the signal transmitted wirelessly [2] like using Wi-Fi to achieve for remote control. Home automation is a convenient home setup where the appliances and electronic devices automatically control remotely from any internet-connected place by using a smartphone or another network device. BasiGenerally, HAS is used to control HVAC (Heating, Ventilation and Air-Conditioning) as well as fire safety and security, controlled by the central computer [3]. With the improvement of the modern technologies of home automation system, it includes the different features for lighting, interfaces, security, software and access control. The technologies such as Bluetooth, Zigbee, and Wireless Fidelity (Wi-Fi) [4] have been proposed to support the remote data transfer, the sensing and the control [5] of the home automation system. Authors [6] presented a new generic framework for a smart home system as shown in Fig. 1. Here, to communicate with the objects the Wi-Fi network is required to enroll with the authentication. The communication protocol sends or receives data, control information to and from connected objects and take care of the interoperability issues. Auto monitoring and control module work to monitor the status and health and controls automatically based on the context [7]. The objects access control is used to prevent and protect data from the unauthorized user. For remote access, the computers or smartphone are equipped with the internet facility. The function of the context-aware adoption scheme is to control the operating devices, and the data analysis and visualization provides the data service.

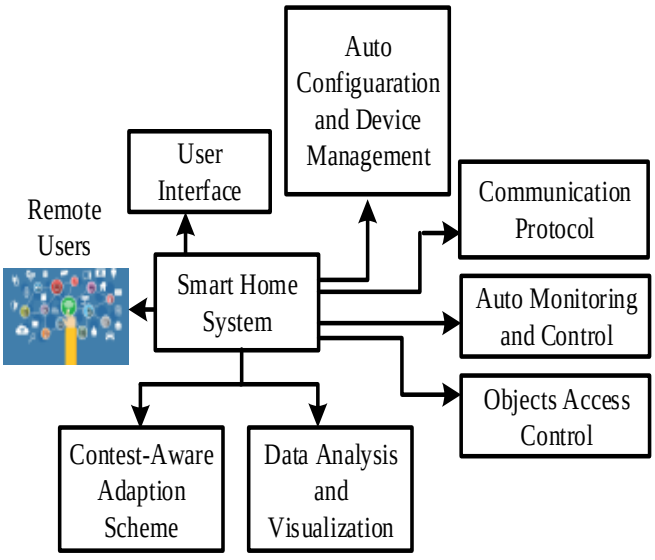

Fig. 1 Generic framework of the smart HAS

Study shows that, in Malaysia, facilities for the disabled people are not enough and disabled-friendly [8]. In Malaysia, as many as 443,541 disabled persons have registered with the Social Welfare Department as of October, 2017 [9], which has not reached the target of accumulating the total disabled population declared by the World Health Organization (WHO). However, to encourage the disabled people to be independent, it is mandatory to create a system or facilities to help them in giving the best quality of life, which can encourage enthusiasm to carry out their daily lives. Addressing these issues, this paper aims to develop an intelligent home automation system for disabled people using raspberry pi. Although various home automation system exists by using Bluetooth, ZigBee and Wi-Fi module, among all the alternatives raspberry pi is now more useful to handle the web traffic with low cost. In this research, external Wi-Fi module has been installed to connect the web server and smart phone with the raspberry pi model.

External Wi-Fi will allow the system more secure and less complex, as it can be changed whenever it is required, rather to change the overall model. Overall model is verified with experimental work and has been found satisfactory to overcome the problems of the mentioned disabled people.

II. EXISTING HAS TECHNOLOGY

Bluetooth Technology

In [10] the appliances controlled by PIC microcontroller, PIC16F877A via Bluetooth by triggering the relays that connected to the microcontroller. To transfer data, the Bluetooth transceiver is connected to the Bluetooth module and the triggering of relays is controlled by the relay driver. When the relay gets energized then it allows the switching of AC circuit to trigger. Authors of [11][12] [13] proposed a low cost, flexible and wireless solution by using the smartphone and Arduino Board to communicate with the Bluetooth. The appliances are controlled by the user via the smartphone and to protect the system, the password can be used by the authorized user only. Study shows that, Bluetooth is one of the technology that simple to use, low cost , easy to install in the house and easy to switch between devices or find and connect to any new devices [14]. Besides, Bluetooth was chosen over Wi-Fi primarily because of the lower power drain on the mobile devices [15]. However, the major problems of blutooth technology is the scope of limited connection and short range (100m) of operating region.

ZigBee Technology

Researchers in [16] proposed the home automation system by using ZigBee to control and monitor the loads and appliances. The performance of the system has been analyzed by using the Latency, Received Signal Strength Indicator (RSSI) and Round Trip Delay (RTD). ZigBee is ideal for communication in home networks due to secure networking, low power, an small size. Compared with Bluetooth, ZigBee is much cheaper and simpler. However, the shortcomings of ZigBee is the lackings of signal compatibility with any mainstream computing device. Likwise, Bluetooth, the ZigBee also has limited range which is less than 10 meters for each node. Another problem of ZigBee is the requirement of different frequency for different countries. Therfore, managing the users' own network is quite hard and hassle according to [17].

Wi-Fi Technology

Authors in [18] designed a home automation system to monitor and give an alert for disabled people. The system used main controller board with wireless Centrino board for internet connectivity. In [19] the author presented the system to control and monitor the house by using the Internet of Things (IoT) with low cost and flexible. The high rate of data rate is one of the advantages of Wi-Fi and this is one of the reasons why the users of the home automation system preferred using Wi-Fi instead of Bluetooth and ZigBee. It can range from 2.4GHz with a data rate of 2-54Mbps to 5GHz with a data rate of 54Mbps [17]. The biggest flaw of Wi-Fi in home automation is the high consumption of power.

Image Processing for Human Detection

Histograms of Oriented Gradients (HOG) descriptor is used to detect the faces in [20]. Positive loads with facial features such as nose, mouth, and eyes are marked completely to envision a face. The algorithm used persistently recognize the face from +90° to -90° rotations even for impeded countenances with high recognition rate.

To improve the visual impact, the image is modified by changing the pixel brightness values, which is called image enhancement technique. Some of the enhancement techniques are histogram modification, contrast stretching, and noise filtering. Next stage is image segmentation which is the process that subdivides an image into its constituent parts or objects [21]. For image segmentation, the technique of image thresholding used. Thresholding defined as a mapping of the grayscale into the binary set {0,1}:

$$S(x,y) = \begin{cases} 0, \text{if } g(x,y) < T(x,y) \\ 1, \text{if } g(x,y) \geq T(x,y) \end{cases} \quad \textbf{(1)}$$

where S(x, y) is the value of the segmented image, T(x, y) is the thresholding value at the coordinates (x,y) and g(x, y) is the gray level of the pixel.

Authors in [22] proposed a systematical video analysis architecture which provides the rich source of information about the home condition. In [23], the Haar-feature classifier is utilized to extract the background interface data. Motion detection algorithm is used with some alarming features in for monitoring system. According to in [24], the surveillance system incorporates five phases that is object tracking, object detection, understanding and description of behaviours, object classification and human identification. However, the main challenge is to send the commands from software to turn ON/OFF [11] [25][26][27]. To comprehend this issue, the topology requires to demonstrate the gadget's genuine status after it gets the order to ON/OFF from the mobile phone. Different types of Bluetooth causes the software of the gadget to update to implement this in the house.

III.METHODOLOGICAL FRAMEWORK

The complete procedure is separated into 3 phases. Stepwise description has been illustrated below.

Phase 1: This phase focused on the development and design of the idea for the home automation system. Since disabled people always left alone at home which can cause dangerous for them, the camera surveillance installed outside of the house to prevent from the intruders. To control the home appliances such as light and fan, Wi-Fi are chosen as it has a wider distance range. Android smartphone is used as a remote controller to control the appliances.

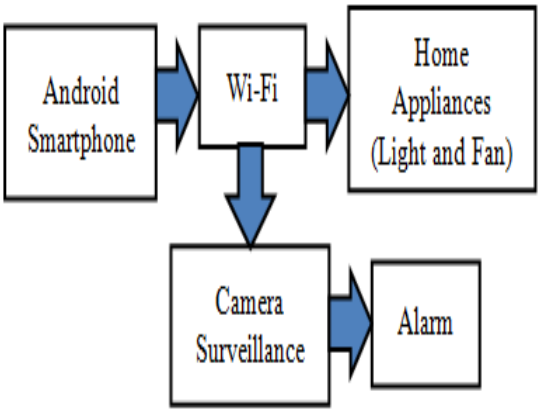

Fig. 2 The block diagram of the system

Phase 2: Second phase focused on the identification and selection of the microcontroller used to construct the home automation system. Here, Raspberry Pi 3 Model B is used which is faster and more capable than other models of raspberry. The new board is equipped for playing 1080p MP4 video at 60 frames for every second (with a bit rateof about 54000Kbps), boosting the Pi's media focus accreditations. The language used is Python.The 16G SD Card with NOOBS (New Out Of Box Software) used as it is a simple operating system for the Raspberry Pi.The Passive Infrared Sensor (PIR Sensor) is used to detect the motion. The camera is used to capture the image when the presence of intruder outside of the house. The sensor itself has a resolution of 5 megapixels and has a settled center focal point installed. The piezo buzzer activates once the PIR Sensor detects the human motion. This gave alert the user so that the user can take the action. 5mm Light Emitting Diodes (LED) are used to represent the appliances such as light and fan in this project. The smartphone used to turn on and turn off the appliances and sensor. In this project, Android Smartphone chosen as the application of Blynk required to install and this application is free to download at the Play Store.

Phase 3: Third phase is about the working system after all the microcontroller and components selected. In this phase, the Blynk Application with the Android Smartphone enable the user to control the switch "ON" or "OFF" of the appliances and alarm. Figure 3 showed the architecture of the proposed system in this research. Figure. 4 showed the block diagram of the intelligent home automation system.

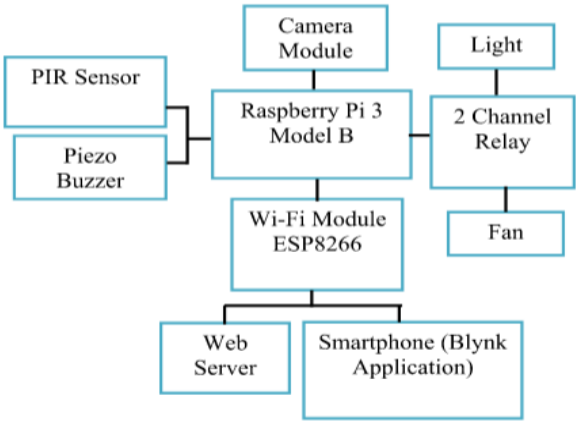

Fig. 3 Complete architecture of the operating system

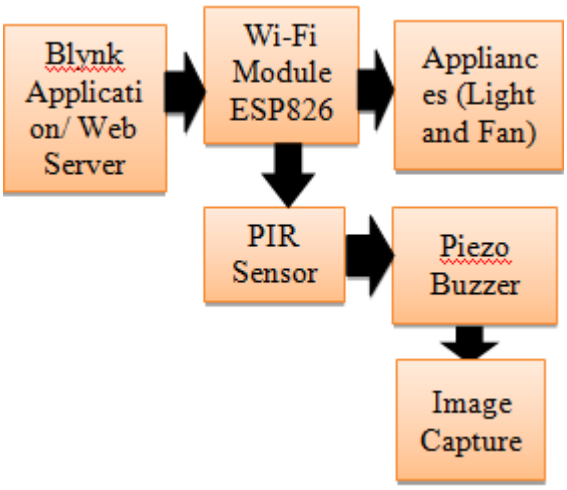

Fig. 4 Block diagram of HAS

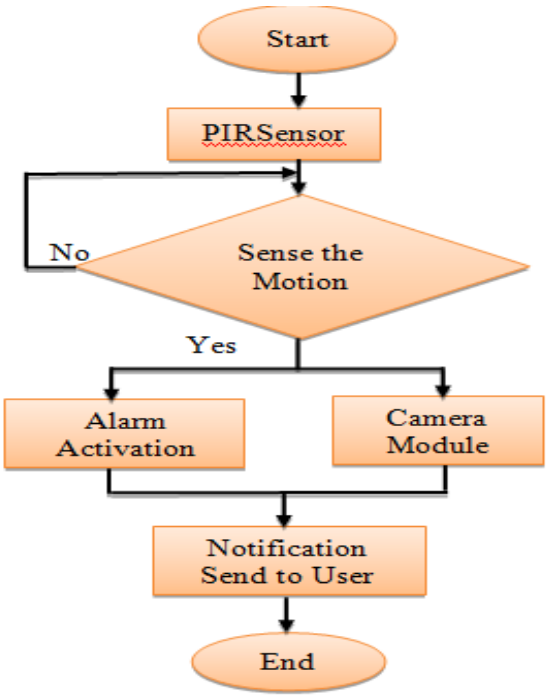

Fig. 5 Flow chart of the sensing section

The whole system can be modelled into three sections.

Step 1: First section is the sensing section where the PIR sensor senses the motion and causes the piezo buzzer trigger and activate the alarm. At the point when an intruder walks into the detector's field of vision, the detector views a sharp increase in IR energy.The camera surveillance automatically captures the image of the intruder after the alarm activation. The image of the intruder will be uploaded and send to the user through the smartphone. Figure 5 show the flow chart of the sensing section.

Step 2: The second section is for controlling the appliances. The user can control the appliances and sensor through the smartphone by using the Blynk application or through the web server. The ESP8266 Wi-Fi module is used to communicate with the Android smartphone. The user needs to tap the "ON" or "OFF" button to control the appliances and sensor on the devices. Figure 6 show the flow chart for controlling section.

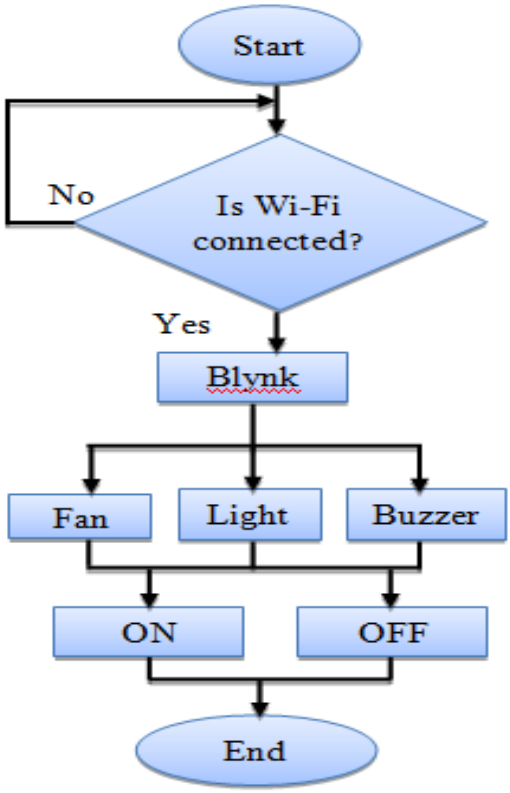

Fig. 6 Flow chart of the controlling section

Step 3: The third is for the detection section to capture the image of the intruder. The surveillance camera is installed at the outside of the house and automatically on to capture the images of the intruder and upload them to the user. The alarm is activated when intruder has been detected by the sensor. The user can decide to download or ignore the image of the intruder. Figure 7 shows the flow chart of the detection section.

IV.PROPOSED HOG METHOD FOR FACE DETECTION

When the significant movement is recognized beyond the threshold the application jumps to face recognition method. In this method, 64 × 128-pixel window is separated by 8 × 8pixel cell, framing 8 × 16 = 128. The slope segments of every pixel (x,y) in horizontal and vertical directions are determined by the equation (2) and (3), and for each pixel point of gradient magnitude (4) and gradient direction (5) as below:

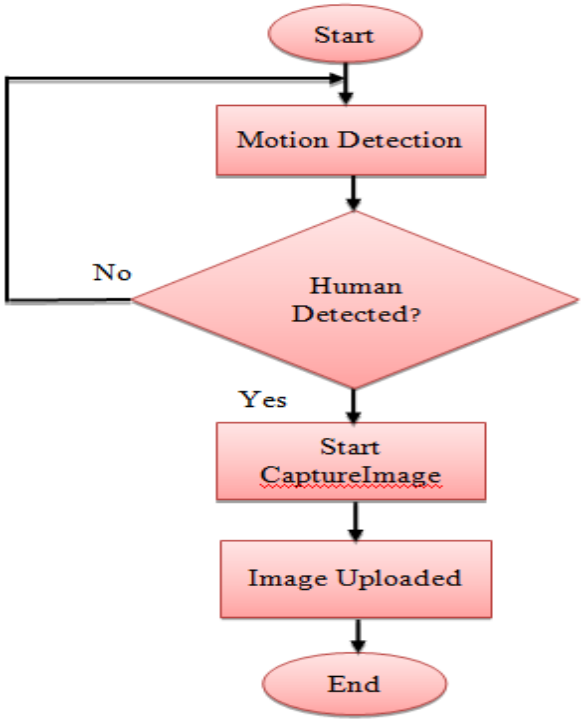

Fig. 7 Flow chart of the detection section

$$Gx(x,y) = I(x+1,y) - I(x-1,y) \textbf{(2)}$$
$$Gy(x,y) = I(x,y+1) - I(x,y-1) \textbf{(3)}$$
$$m(x,y) = \lceil (Gx(x,y))^2 + (Gy(x,y))^2 \rceil^{1/2} \textbf{(4)}$$
$$\theta(x,y) = \arctan \frac{Gy(x,y)}{Gx(x,y)} \textbf{(5)}$$

The block of 16 × 16 pixels is made from 2 × 2 = 4 cells, and 7 × 15 = 105 blocks are created. The block advance since of 8 pixels, the quantity of blocks in the level horizontal direction is $\frac{(64-16)}{8} + 1 = 7$, and the quantity of blocks in the vertical direction is $\frac{(128-16)}{8} + 1 = 15$.

The histogram of 9 gradient directions for every cell is taking where is the block has 4 × 9 = 36 features vectors, and after that 105 block of feature vectors are associated in arrangement to a shape of image of 36 × 105 = 3780 HOG features. The PCA algorithm is enhanced by utilizing fast-PCA method to comprehend the eigenvalues and eigenvectors of the sample matrix due to the HOG feature dimensions is higher than the sample of numbers.

$$z = \frac{X-\mu}{\sigma} \textbf{(6)}$$
$$P^{-1} \times (Z \times Z') \times P = S \textbf{(7)}$$
$$P^{-1} \times (Z')^{-1} \times Z' \times Z \times Z' \times P = S \textbf{(8)}$$
$$(P \times Z')^{-1} \times Z' \times Z \times (Z' \times P) = S \textbf{(9)}$$

Where, X denotes the sample matrix, μ is the mean of the sample, σ is standard deviation of sample, Z normalized sample matrix, Z = row of matrix, Z′ × Z = Z′ ×P = eigenvector matrix, Z′× Z = Z ×Z′= eigenvectors.

Let V1 is the first k of eigenvectors of Z ×Z′, Z′ × V1 is equal to Z′× P. Thus,

$$V = Z' \times V1 \textbf{(10)}$$

V.EXPERIMENTAL VALIDATION

The complete experimental setup is shown in Fig.8. The PIR sensor has three pin that are VCC, Digital OUT (Data) and Ground (GND). GND pin is connected to the pin number 39 (GND), VCC to pin 4 (5V power) and Digital OUT pin is connected to the pin 16 (GPIO23) on the Raspberry Pi 3 Model B. The piezo buzzer is connected to the pin number 18 (GPIO24) and pin number 34 (GND) on the Raspberry Pi 3 Model B. Two LEDs are used to represent the light and fan in this project. 220ohm resistors are used to connect the LEDs. To enable Raspberry Pi 3 Model B communicate with the Blynk Application the Wi-Fi module ESP8266 required. The ESP8266 has eight pins namely Rx, VCC, GPIO 0, RESET, CH_PD, GPIO 2, Tx and GND. On the Raspberry Pi 3 Model B, the Rx pin is connected at the pin number 10, VCC at pin number 1, Tx at the pin number 8, GND at pin number 6 meanwhile GPIO 0 and GPIO 2 is ignore. Finally, the Raspberry Pi 3 Model B is powered with 5V supply.

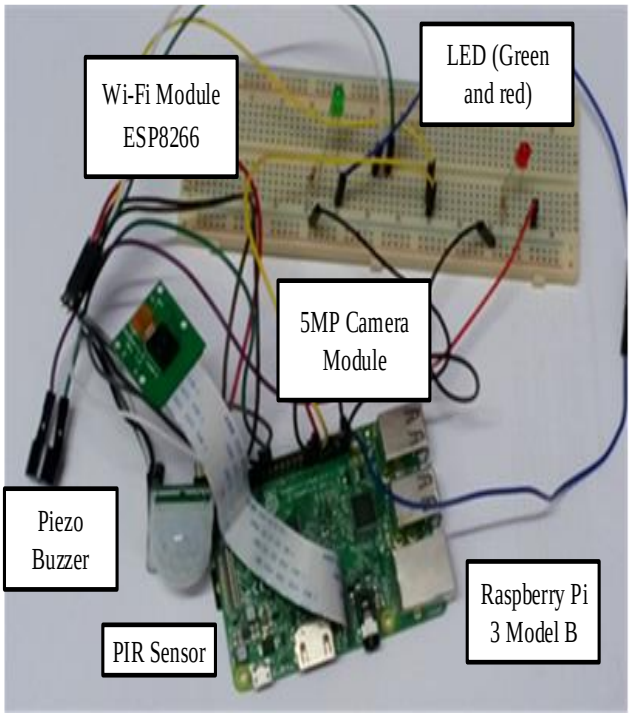

Fig. 8 Experiment set up

VI.RESULT AND ANALYSIS

When the motion is detected, PIR sensor triggers and if the motion detected, the alarm is activated automatically which is controlled by the Blynk application. The user needs to tap on the “OFF” button once the alarm activates to off the alarm otherwise the alarm keep activated. Subsequently, the camera automatically ON and start to capture the image of the intruder. Fig. 9 shows that the fan is controlled by using the Blynk application via the ESP8266 Wi-Fi module. When fan is ON it displays the value of 1 and when the fan is OFF it shows the value of 0. Similar analysis is true for the lamp.

To adjust the sensitivity, we have adjusted the trim pot at the back of the sensor by turn it in the anticlockwise. This can decrease the sensitivity of the motion at the short range. This testing experiment start from the 15 meters away from the PIR sensor to detect whether it sense any motion which can causes the alarm to activate. The alarm is activated, and the sensor manages to detect the motion when the people at the 5 meters from the PIR sensor range. To control the fan, lamp, and alarm the Blynk application is required to allow the user to communicate and allow the alarm to send notification to the user. Table 1 reveals the range of the motion detected after decreased the sensitivity and testing of the Blynk is done before implementing it in the system.

According to table 1, when the internet connection is not stable all the appliances and alarm cannot be controlled by using the Blynk. However, it becomes unstable when the testing is repeat at the third times until the eight timesand become stable back at the ninth and ten times. After several testing, with stable internet connection, complete control of the lamp, fan and alarm by using the Blynk become successful.

In the proposed system 5MP Camera is used to capture the image when the light is available. To confirm this statement, the experimental procedure operates for 24 hours starting from 7am to 6am in normal days and 7AM to 7PM in rainy days. two different days. The image is captured after every 2 and 1 hours for normal and rainy days respectively. Obtained result shows that, even the image is in low quality, the alarm is still activated, and the user able to control through the Blynk application.

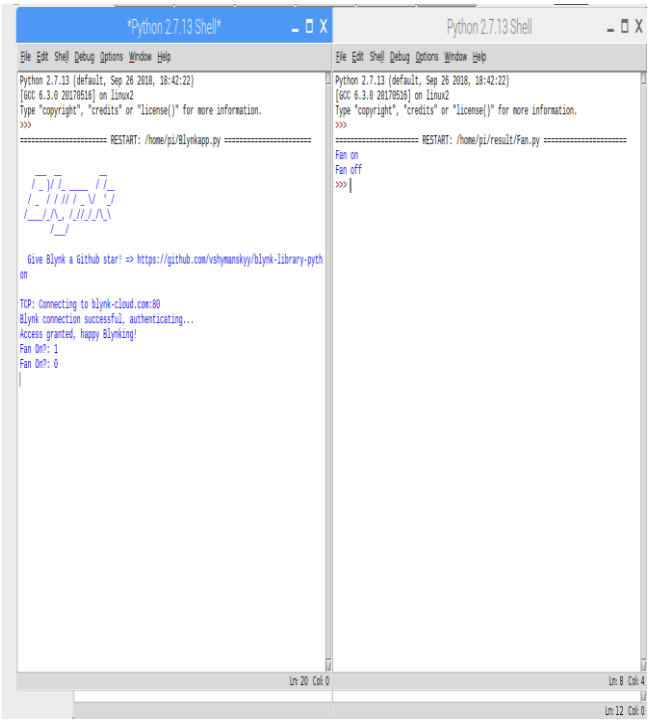

Fig. 9 The fan is ON and OFF by the user

Table. 1 The appliances and alarm testing using Blynk

Number of Testing	Distance detected after sensitivity of the sensor adjusted			The appliances and alarm testing using Blynk		
	The Distance from the PIR sensor (m)	Alarm Activate	Motion Detected	Lamp	Fan	Alarm
1	15	No	No	Yes	Yes	Yes
2	13	No	No	Yes	Yes	Yes
3	11	No	No	Yes	No	No
4	9	No	No	Yes	No	Yes
5	7	No	No	No	No	No
6	5	Yes	Yes	No	Yes	No
7	3	Yes	Yes	No	No	Yes
8	1	Yes	Yes	No	Yes	Yes

Table. 2 The quality of the image after capturing at the different hour at Normal Day and Rainy Day

Time (24Hour)		Alarm Activated		Blynk Application On		Quality of Image	
Normal	Rainy Day	Normal	Rainy Day	Normal	Rainy Day	Normal	Rainy Day
0700	0700	Yes	Yes	Yes	Yes	High Quality	High Quality
0900	0800	Yes	Yes	Yes	Yes	High Quality	High Quality
1100	0900	Yes	Yes	Yes	Yes	High Quality	High Quality
1300	1000	Yes	Yes	Yes	Yes	High Quality	High Quality
1500	1100	Yes	Yes	Yes	Yes	High Quality	Low Quality
1700	1200	Yes	Yes	Yes	Yes	High Quality	Low Quality
1900	1300	Yes	Yes	Yes	Yes	Low Quality	Low Quality
2100	1400	Yes	Yes	Yes	Yes	Low Quality	High Quality
2300	1500	Yes	Yes	Yes	Yes	Low Quality	High Quality
0100	1600	Yes	Yes	Yes	Yes	Low Quality	High Quality
0300	1700	Yes	Yes	Yes	Yes	Low Quality	High Quality
0500	1800	Yes	Yes	Yes	Yes	Low Quality	High Quality
0600	0700	Yes	Yes	Yes	Yes	Low Quality	High Quality

From table 2, the image is in low quality at 11am until 1pm due to the heavy rain. However, after 1pm the image captured is of high quality due to the presence of the sunlight. Overall cost of the hardware components has been calculated as 161 RM. Therefore, from the economic point of view, though the overall cost is somewhat more than the existing Bluetooth and ZigBee model, performance of the proposed raspberry pi model has been improved in different season of the year. Moreover, with the increasing technology, problem of pre-installed Wi-Fi can be solved, and costs of the raspberry pi board also will decrease, which will significantly reduce the total cost of the system.

VII.CONCLUSIONS

In this paper, HAS for disabled people has been introduced considering the intruder motion. The experiment has been conducted for two different durations, from 7AM to 6AM for normal day and 7AM to 7PM for rainy day. Histogram of Oriented Gradient (HOG) method is used to detect the motion. The outcome of the proposed system proved its efficiency to let the disabled people to move independently. Here, the alarm is activated based on the motion sensed thorough PIR sensor. Python is used as the coding language to develop the algorithm. Finally, ESP8266 is introduced to enable the user to communicate and control the fan, lamp and alarm through Blynk applications. The complete operation can be monitored from the user smart phone. Therefore, obtained result from the Rasberry model in both normal and rainy day can effectively help disabled people to help them in controlling the appliances. However, to improve the quality of images, a high configuration camera can be used to make the image recognition more accurately. Therefore, the novel and significant contribution of the research is to develop a model for disabled people to control the home appliances, which has outperformed the limitation of scope of limited application and range of operation of existing Bluetooth, ZigBee and Wi-Fi technology.

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