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Application of HOG Algorithm for Automated Room Control System

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Abstract

This study aims to develop a prototype of automated room control systems. The histograms of oriented gradients (HOG) algorithm is used to detect and count the people entering or coming out the room so that the use of electricity is more appropriate. The raspberry Pi microprocessor is used as a controller since it is efficient and can be expanded for monitoring over the web. The system testings show that the prototype can detect and count the number of incoming and outgoing people enough accurately with error rate of about 1.7%, while people entering or coming out the room not simultaneously, but can not detect and count accurately with error rate of about 43.3%, while two person walk close together through the door. Using the automated room control, the electronic equipments will be active when there are people in the room and the temperature below 20^{0}C.

Keywords*: Automated Room Control, Histograms of Oriented Gradients, People Counting, Raspberries*

1. Introduction

Energy savings have become a very important agenda recently due to the depletion of energy availability. Excessive use of energy and user negligence that allows electronic equipments remaining active when not in use causes electrical energy wasted in vain. Controlling the use of electronic equipments manually is difficult when there are many rooms in the building. The equipment should be turned off when not in use, and activated while being used according to the number of people in the room. However, sometimes users forget to turn off the equipment when leaving the room or activate excessively. Thus, it is necessary an automated room controllers that capable activating and shutting down the equipment in accordance with the number of people in the room.

Several automatic controllers of electronic devices have been developed in the previous studies, such as a Scheduled Control System for Lighting, Air Conditioner and Phone based on Microcontroller [1], a Smarthome with Wireless-Based Rasberry Using Microkontoller AVR ATMEGA328 and Fuzzy Logic [2], an Indoor Security System and Object Recognition Using Raspberry Pi for substituting the CCTV [3], an Automatic Control System of Room Lighting Using PC based on Arduino Uno Microcontroller [4], a Temperature Control and Air Humidity Monitoring System bsed on Arduino Uno Using DHT22 And Passive Infrared Sensor (PIR) [5], an Autonomous Room Air Cooler System Based on Passive Infrared Receiver [6], an Automated Air Circulation and Lighting System for Home[7], an Autonomous Room Air Cooler Using Fuzzy Logic Control System [8]. However, the activation has not been adjusted according to the number of people in the room.

In this research, the development of automated control system of electronic equipments in classroom such as lamp, computer and air cooler employing Histograms of Oriented Gradients (HOG) algorithm to detect and count the number of people in the room so that the activation of the equipment is adjusted according to the number of people. The raspberry Pi microprocessor is used as a controller because it is efficient and can be expanded for monitoring over the web.

2. Research Method

The research procedure is shown in figure 1 below.

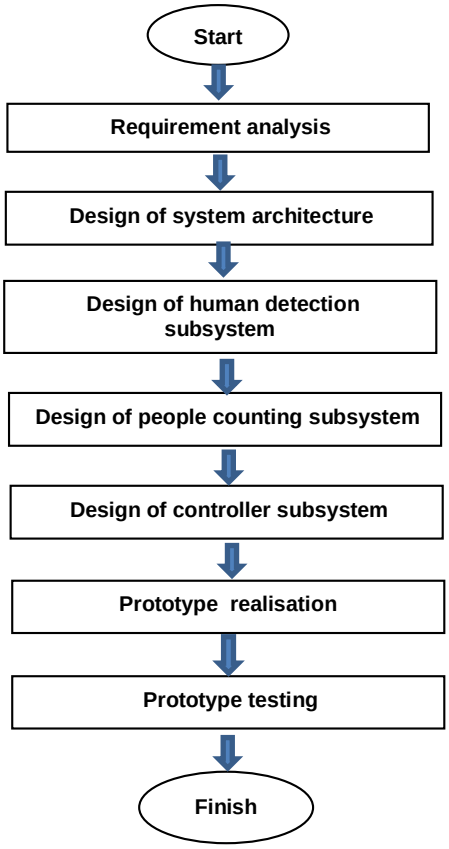

Figure 1. Research Procedure

2.1. System Architecture

The system consist of human detection subsystem which serves to receive video input from the camera and determine whether or not there are people, people counting subsystem which serves to count people entering or coming out the room and room controller which serves to activated or deactivated the electronic equipments. Figure 2 describe the system architecture.

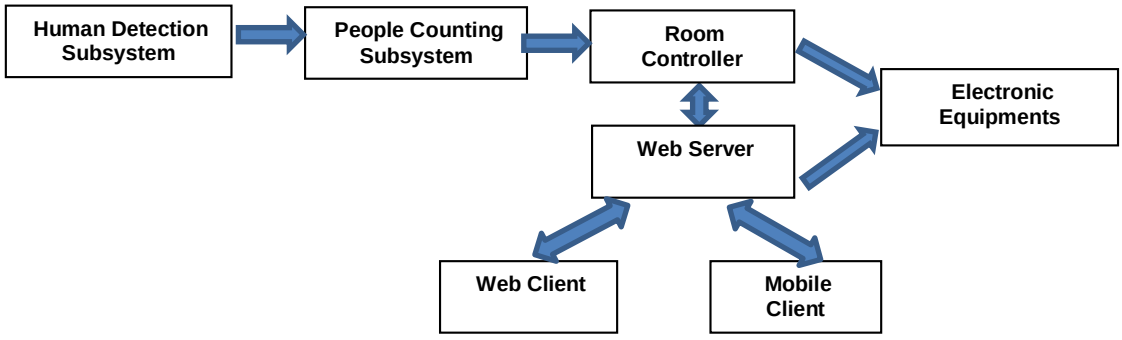

Figure 2. System Architecture

2.2. Subsystem of Human Detection

People detection in the classroom is done using Raspberry Pi camera module to get the real time video images. The camera is placed above the classroom door and facing down with the floor as its background. To find the contour of the object that passes under the camera, the contour has a radius value corresponding to the defined value of radius as human, then the contour will be marked by using BLOB. BLOB is a bubble-like circle used to mark the appropriate contours with a predetermined value as shown in figure 3. The BLOB will move along this contour which will be used to determine the direction of the object entering or coming out the room, but if the contour of the object passing under the camera has a radius value smaller or greater than the predetermined value of the object will not detect as human.

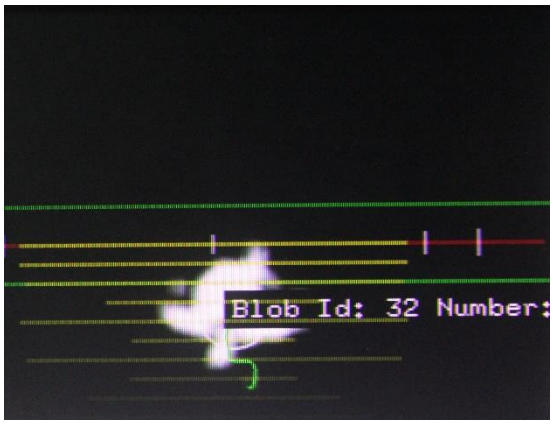

Figure 3. BLOB and direction line.

2.3. Subsystem of People Counting

Histograms of Oriented Gradients (HOG) is a method for describing the shape of an object in an Image by utilizing the local intensity of the image gradient. This is done by dividing the window from the image into sections called "cells". For better invariance of lighting, shadows, etc., it would be better to normalize locally before using it. This can be done by collecting the local histogram of all cells in a larger region called "block".

The first stage of HOG is to decorate the gradient value of the input image. The general method used to calculate the gradient is to use a filter in one or two directions, either horizontally or vertically. Then create parts called cells. Each pixel in a cell has its histogram value based on the value of the gradient calculation. The size of the cell in an image is 4x4 pixels while the block size is 2x2 cell or 8x8 pixel.

A HOG Cell can be rectangular (R-HOG) or half-circle (C-HOG). R-HOG has three parameters: the number of cells each block, the number of pixels each cell, and the number of bin each histogram. Meanwhile, C-HOG have four parameters: the number of angles and radial bin, the radius of the center bin, and the expansion factor for the additional radius of the radial bin. The structure of its HOG cell is shown in figure 4.

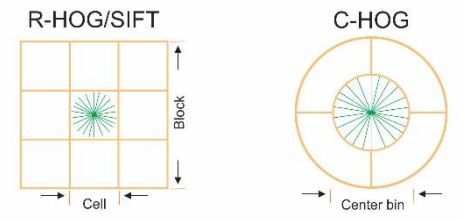

Figure 4. Structure of HOG cell

People counting is done by knowing the number of people who came out and entered the room by using a camera mounted above the door attached with a position facing to the floor using Histogram Of Oriented Gradients (HOG) method. Figure 5 shows the diagram of the HOG method.

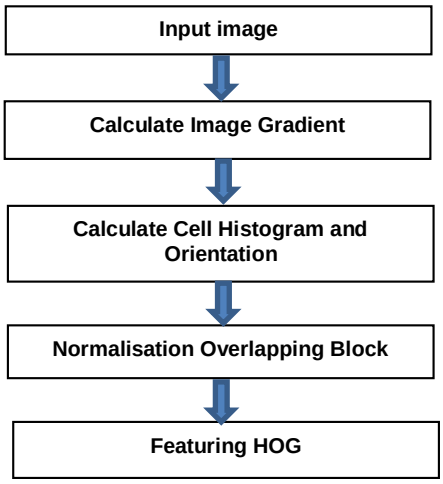

Figure 5. Algorithm of HOG

Figure 6 shows the algorithm to calculate the number of the person in the room.

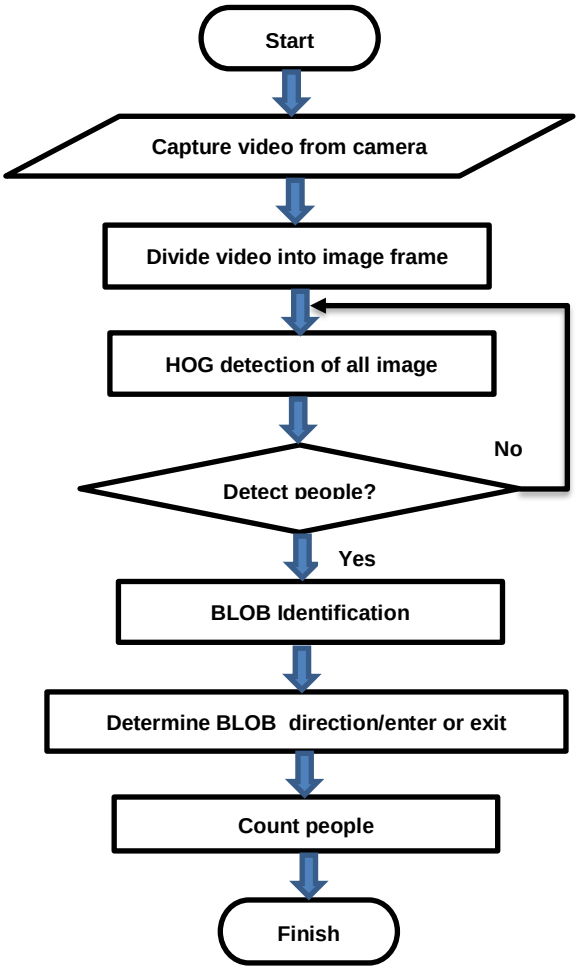

Figure 6. Algorithm of people counting

2.4. Subsystem of Room Controller

Control of electronic equipments can be done automatically and manually. Figure 7. shows the hardware architectural of the room controller.

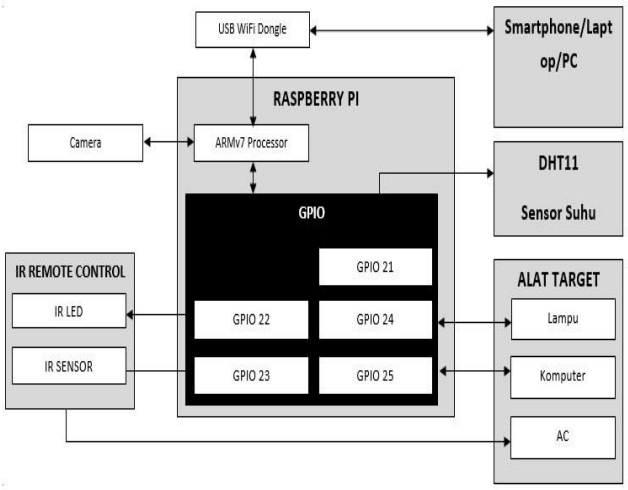

Figure 7. Hardware architecture of room controller

To run the system required software that runs the system so that it works well, Figure 8. shows the software architectural of the room controller.

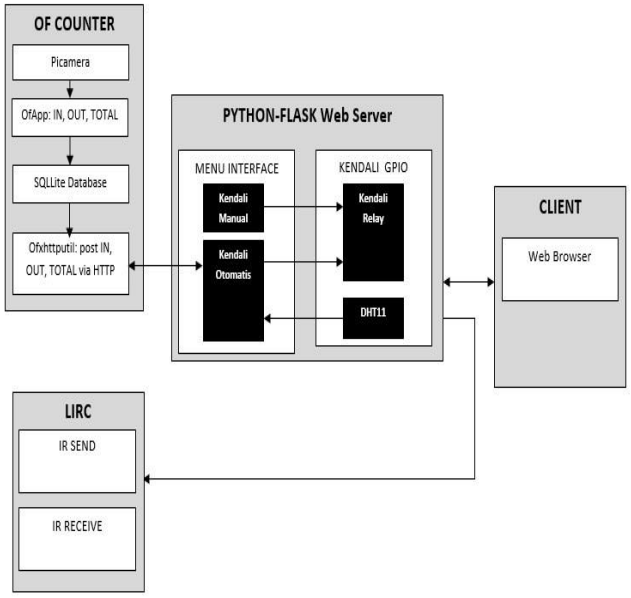

Figure 8. Software architecture of the room controller

2.4.1. Automated Room Controller

The calculation of the HOG method produces the number of people out, the number of people entering, to know the number of people in the room then the number of people who enter will be reduced the number of people who come out, all the calculation process is done in the Open Framework. In order to be read from outside the *OpenFrameworks* 0.9.3 program, the variables will be included in the SQLLite database then displayed on the web server via the OFXHTTPUtil program.

If the number of people in the classroom is equal to or more than 1 then automatically the electronic equipment in the room will be active, the equipment that only requires control on / off

is controlled by using relay, while equipment that requires remote controlling will be controlled with IR remote controler . For room temperature control using Air Conditioner added a DHT11 temperature sensor if the room temperature is below 20 ° C, then the AC will die even if there are people in the room.

2.4.2. Web Based Room Controller

In addition to the automatic way control of electronic equipment in the room can also be done manually, can be accessed using the internet after connecting with a computer or a user connected to the access point or local network. Figure 9 shows the architecture of web based room controller.

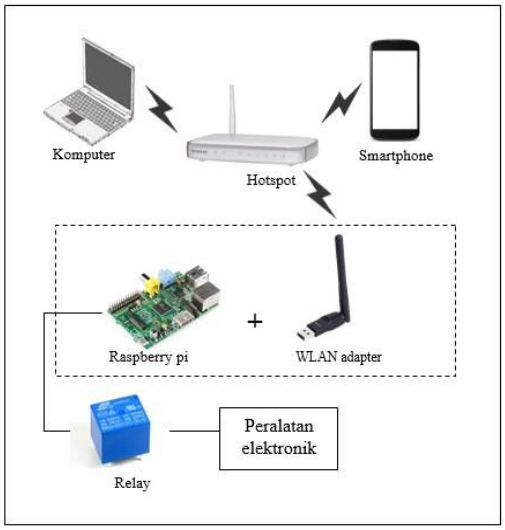

Figure 9. Architecture of web based room controller.

Basically, there are three things the system works on, receiving inputs, processing inputs and issuing response results. Input can be received either from a smartphone or laptop / computer that is connected to the internet network. The input processor is Raspberry Pi. Raspberry Pi responds to input from the web that has been given the command by the user, then Raspberry Pi activate or disable GPIO foot (General Input Output) according to the command of the user who has been connected with the circuit Relay on the load so it can be used to control On-Off electronic equipment in space class. The whole of this system can also be written in the form of a flowchart in Figure 10.

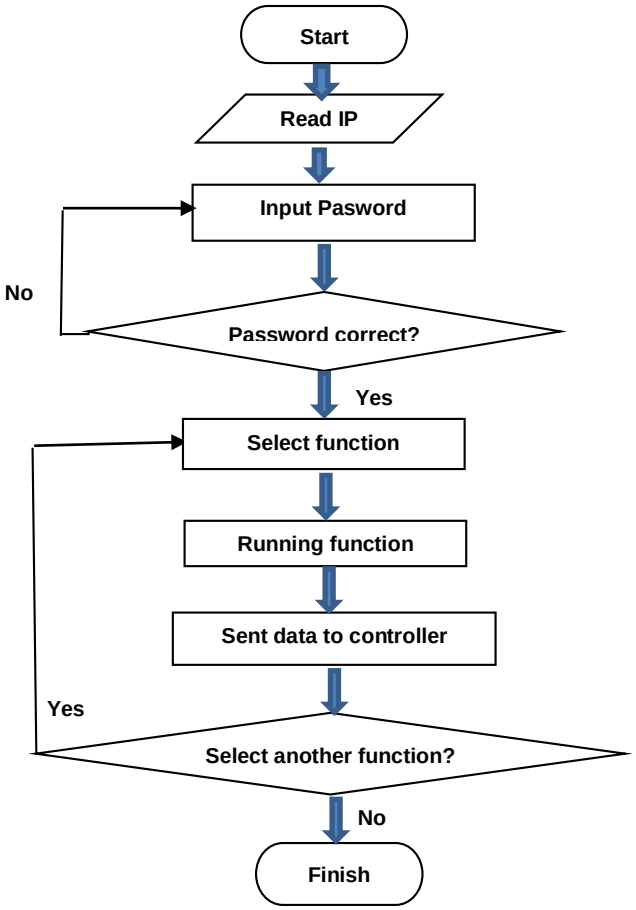

Figure 10. Algorithm of control system over the web

3. Results and Analysis

This section presents the testing results of system prototype that has been realized, namely testing of people detection and counting, and also testing of the controller either manual or automatic.

3.1. People Detection and Counting

The first testing is done to determine the presence of people entering or exiting the room. Table 1 shows the results of human detection and people counting , while only one person through the door.

Table 1. Human detection and people counting for 1 person pass by

No.	Speed	Number of People passed by		Number of Detection	
		Enter	Exit	Enter	Exit
1.	Rendah	20	20	19	19
2.	Sedang	20	20	20	20
3.	Cepat	20	20	20	20

Based on the data in table 1, it is known that the system can detect and count the number of incoming and outgoing people enough accurately with error rate of about 1.7%, while people entering or coming out the room not simultaneously.

Table 2 shows the results of human detection and people counting of people, while two person walk close together through the door.

Table 2. Human detection and people counting while two person walk close together through the door.

No.	Speed	Number of People passed by		Number of Detection	
		Enter	Exit	Enter	Exit
1.	Rendah	20	20	5	6
2.	Sedang	20	20	12	14
3.	Cepat	20	20	16	15

Based on the data in table 2, it is known that the system can not detect and count the number of incoming and outgoing people accurately with error rate of about 43.3%, while two person walk close together through the door.

Table 3 shows the results of human detection and people counting of people, while one cat through the door.

Table 3. Human detection and people counting while one cat through the door.

No.	Speed	Number of Cat passed by		Number of Detection	
		Enter	Exit	Enter	Exit
1.	Rendah	10	10	0	0

Based on the data in table 3, it is known that the system can detect cat as objects other than humans and not count as people accurately with error rate of about 0%.

3.2. Room Controller

Functional testing of the automated room controller has been done in two different room. Temperature is set below 20^0C in the first room and above 20^0C in the second room. To make room temperature below 20^0C DHT11 temperature sensor will be input into box containing ice cubes. The test results is shown in Table 4.

Table 4. Functional testing of the automated room controller

No	Initial temperature (^{0}C)	Number of people in the room	Electronic equipments		
			AC	Lighting	Computer
1	27	0	off	off	off
2	28	0	off	off	off
3	28	2	on	on	on
4	29	2	on	on	on
5	27	2	on	on	on
6	19	0	off	off	off
7	17	0	off	off	off
8	18	2	off	on	on
9	17	2	off	on	on
10	19	2	off	on	on

We can see that the electronic equipments is active when there are people in the room, and not active when there are not people in the room. AC is active when there are people in the room and the room temperature below 20^{0}C.

In addition to testing of automated control, the manual control through the web server have also been tested by using two devices namely smart phones and PC. To control the electronic equipment manually the user can use the computer device and smart phone via web server. The manual control does not require input from counter or DHT11 temperature sensor but just take input from user-instruction manually.Testing is done to find out whether the system can execute the command given to control the electronic equipment manually as shown in table 5. User interface of the manual controller are shown in figure 11-14 below.

Table 5. Functional testing of the manual room controller

No	Access device	Instruction		Response
1	Web based (PC)	Lighting	on	on
			off	off
		Computer	on	on
			off	off
		AC	on	on
			off	off
			up	temperature increase
			down	temperature decrease
2	Mobile (Smartphone)	Lighting	on	on
			off	off
		Computer	on	on
			off	off
		AC	on	on
			off	off
			up	temperature increase
			down	temperature decrease

We can see that the electronic equipments is active according the type of instruction.

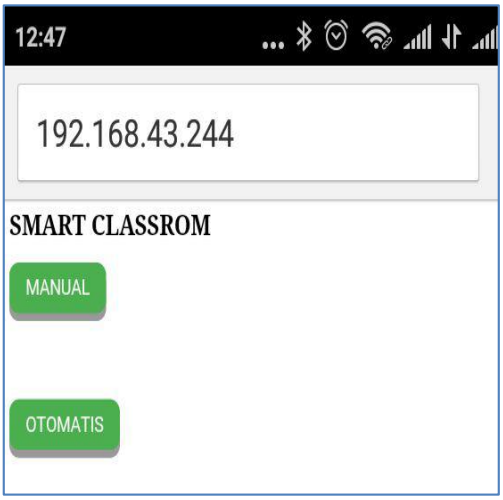

Figure 11. The main page of mobile interface on the smart phone

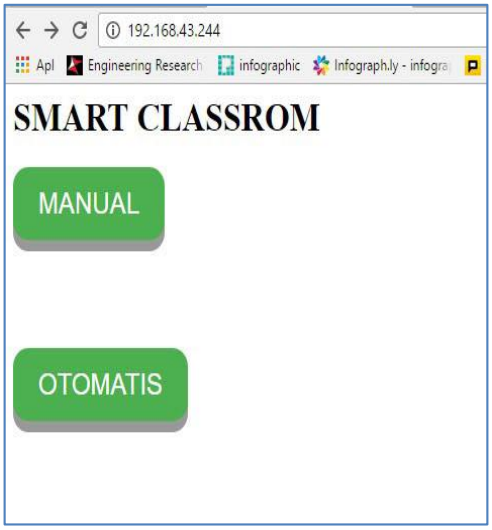

Figure 12. The main page of mobile interface on the PC

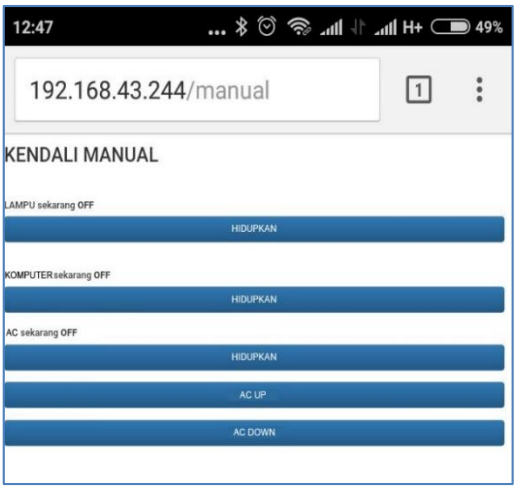

Figure 13. The control page of mobile interface on the smart phone

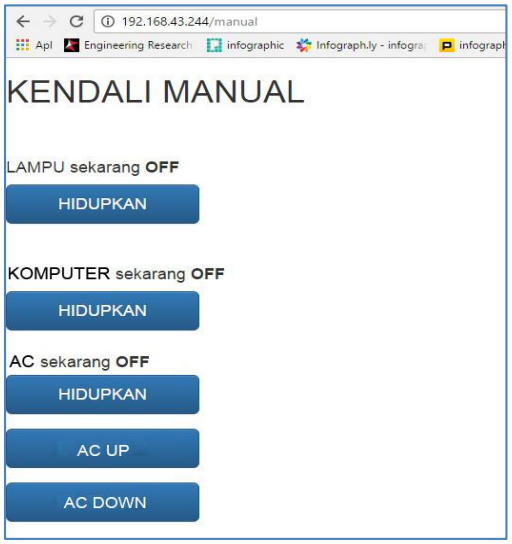

Figure 14. The control page of mobile interface on the PC

4. Conclusion

Prototype of the automated room control using HOG (Histogram of Oriented Gradient) have been realized and tested. There are several conclusions that can be taken is as follows.

a. System can detect and count the number of incoming and outgoing people enough accurately with error rate of about 1.7%, while people entering or coming out the room not simultaneously.
b. System can not detect and count the number of incoming and outgoing people accurately with error rate of about 43.3%, while two person walk close together through the door.
c. System can detect cat as objects other than humans and not count as people accurately with error rate of about 0%.
d. Using automated room control, the electronic equipments is active when there are people in the room, and not active when there are not people in the room. AC is active when there are people in the room and the room temperature below 20^0C.
e. Using web based room control the electronic equipments is active according to the type of instruction as an input.

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