*International Journal of Engineering &Technology*, 7 (4) (2018) 6140-6144

**International Journal of Engineering & Technology**

*Website: www.sciencepubco.com/index.php/IJET*
*doi: 10.14419/ijet.v7i4.23127*
***Research paper***

# Modelling of a novel cost saving automated stand fan

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## Abstract

In tropical forest countries like Malaysia where the normally temperature is 27℃ in most region it becomes very uncomfortable to live with-out a fan. Electric fan become electrical appliance that have been used widely in our daily life. By pressing switch button, we can operate ceiling fan or stand fan manually. In this research, we will develop a sensory system for detection of the presence of human and the position of human in a room. The sensory system will be embedded with stand fan. It will facilitate by automatically turn on/off the fan depends on the presence of human. Fan speed will also be controlled automatically depends on the environment temperature. Furthermore, it will also allow the fan to oscillate in a certain range depends on the motion or presence of numbers of human. The proposed automated fan will save approximate 50% operating cost by operating automatically only the presence of the subjects.

***Keywords***: *Human Position; Localize; Sensor Fusion; Fan.*

## 1. Introduction

Microcontroller have been used widely because of its feature specification. Muhammad Khairi as shown in figure 1 have proposed the system a method to control the speed of the fan according to the temperature changes automatically [1]. He also presented that the input part of the system is LM35 temperature sensor, the main controller is microcontroller MC68HC11A1 and the output part is DC motor. This temperature sensor will detect the environment temperature. There will be level 0, level 1, level 2 and level 3 for the temperature sensor level. The lowest level which is level 0 indicates that the temperature is 15℃ while the highest level which level 3 is when the temperature is 33℃. This information will be send to the microcontroller to change the speed of the fan according to the temperature and display the data through LCD as shown in Figure 1.

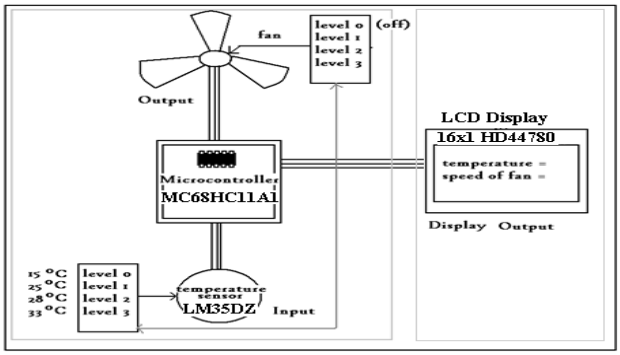



**Fig. 1:** Block Diagram of Automatic Fan System [1].

However, Tarun et. al. has also implemented automatic fan system by using different microcontroller which is 8051 microcontroller. He also used LM 35 temperature sensor to detect the temperature changes. He used ADC converter to convert the signal from analog to digital, so it can readable. Figure 2 shows the block diagram of the system.

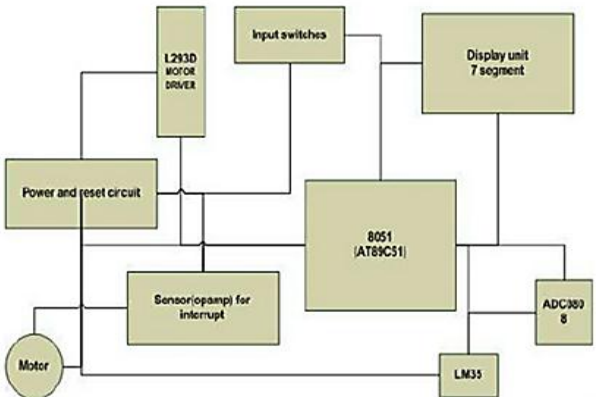



**Fig. 2:** Block Diagram of the Temperature-Controlled DC Fan [2].

Researcher used temperature sensing module to determine the environment temperature. Object locating module to detect the location of human within the specific angle of oscillation and motion detecting module is used to detect the presence of human. They used PIR sensor to detect the presence of human and to turn on the system if there is presence of human. Next, if there is presence of human, temperature sensor will sense the environment temperature. Ultrasonic sensor with the combination with servo motor also have been used to detect the human location. If there is multiple people, the ultrasonic sensor will oscillate within the people and the servo

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motor will keep moving within the specific angle. More recently, Amit Baran Roy et al. [4] have proposed ultrasonic sensor based smart fan because of the PIR sensor have its own disadvantages which is sensitivity to the light reflections and the temperature limit problems. The ultrasonic sensor is used with the 8051 microcontroller and a motor driver circuit. MLS diffusion also have been recommended to sense the maximum coordinates that can reach in a place. In this system, it can implement to the ceiling fan as it use MLS diffusion. Rahul Mishra et al. [5] have developed a system to control AC fan and room lights. The input part is temperature sensor LM 35, the controller is PIC microcontroller 16F887A and the output part is AC motor and the LCD display. Infrared sensor also will be used to control the room light. If the speed of the fan is increasing or decreasing, there will be a short beep because the buzzed is used to indicate the level of fan speed. Relay switch also will be used if the microcontroller goes high. This system also can be used for security reason in the auditorium because once there is people enter the place, the bulb will turn on. Saiprasad et. al [6] used pyroelectric infrared sensing mechanism which can display through mobile phone regarding the temperature in degree Celsius and humidity. SHT11 is used to monitor the changes in temperature and humidity. Pyroelectric detection sensor is used to detect the presences of human. The authors also state that they used the Texas Instruments MSP430G2553 as the microcontroller. Jaesok et. al [7] have also developed research by using pyroelectric infrared sensor to depend on varies factors such as speed of movement, different direction and distance of the body from the PIR sensor. As the result, this experiment is detectable by using these different factors and identifying subjects with more than a 92%recognition accuracy using the raw data set collected from single PIR sensor of each of the three based PIR modules. However, by using pyroelectric infrared sensor, it just can cover within certain area. Kharangate [8] used MATLAB for human tracking. MATLAB will issue command to the microcontroller and to the motor. PIR sensor also used to turn on the system once detect the presence of human. In the same time, temperature sensor LM35 also will sense the temperature surrounding to control the speed of the fan. PC webcam sensor will detect the presence of human then send the information to the ATmega32 microcontroller and the result of the data will display through the LCD. As the MATLAB provide graphical user interface for user interface development, GUI will take webcam as the input part and display the real time video on the GUI screen for two times. The first frame will display normal real time video. Second frame will show the difference of position of the person from its previous position. This data will send to the microcontroller and command the DC motor to rotate according to the program. Sang Hoon Lee et. al [9] have been working on development by using Matlab based Graphical User Interface with hardware component. An experiment regarding light refraction have been conducted. Matlab have been used to demonstrate the signal processing. The PIC will used the program to control the position of servo motor. PIC will turn on the light source. GUIs have been used to change and control commands, acquire the data from sensory, perform online data processing and by using virtual instruments, it can visualize data to realistic. Zairi et. al. [10] have presented an innovative circuit with hardware implementation. Sensor, fans and light emitting diodes have been used to develop this design. This circuit can be function as a detector which can be an alarm signal when there is an emergency. PIC have been used because very fast compare to other microcontroller. However, it is very huge for the length of the program since it uses RISC Architecture. This circuit will turn on when the DC battery is supplied with 9V. IC regulator circuit have been connected for 5V stable voltage. Then, LM35 sensor will measure the changes of temperature. All of this operation is operate by using PIC microcontroller. LCD, fans and buzzer have been used as output part where it will work with the program in PIC. The buzzer will used as emergency signal if the temperature is unstable.

## 2. Modeling of the smart fan system

This project is an attempt to design cost saving automated stand fan. With these kind of technologies, it can make humans life easier because nowadays, internet has become a part in our life. In this project, the development of the system including selection of controllers, sensors. This system includes motion detection, temperature and human location detection that will implement in the prayer hall. Figure 3 shows the overview system in sequences.

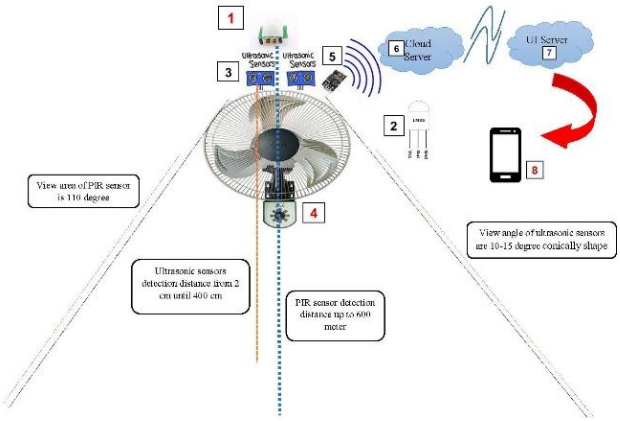



**Fig. 3:** Overall System That Will Be Implement in the Prayer Hall.

The design of the fan (see Figures 4, 5) is based on the ordinary table fan which consist of guard, base, motor housing and blade. However, ordinary fan does not have automation system, human location detection and temperature detection. The main component of this project is passive infrared sensor. Passive infrared sensor will turn on the system if there is motion or presence of human. If there is no presence of human, the system will not turn on. The details on how the sensor works will be discussed through the subtopic. The function of the human location detection is by using ultrasonic sensor and servo motor. The fan will not turn on if there is no presence of human. It will also allow the fan to oscillate in certain range depends the human location.

In addition, the temperature sensor is used to detect the temperature changes so that the fan will be controlled automatically depends on the environment temperature. The speed of fan can be regulated through several conditions.

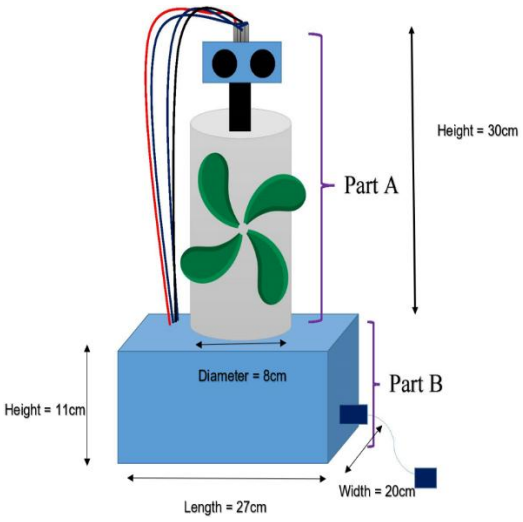



**Fig. 4:** Design of the Prototype.

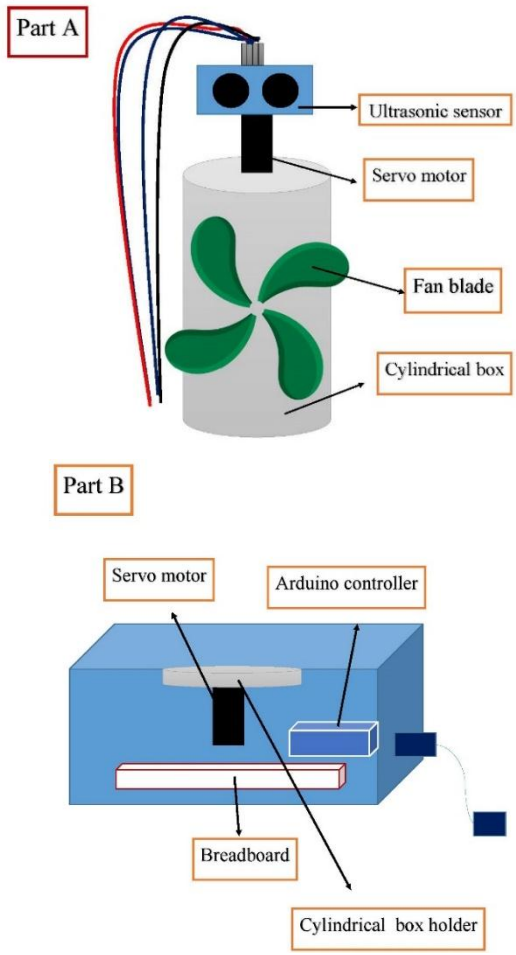



**Fig. 5:** Overview Design of the Prototype: (A) Part A, (B) Part B.

Figure 6 show the prototype that have been developed. The prototype is attached with one ultrasonic sensor which rotates by attaching a servo motor. A fan is attached at the bottom part of the tower of system as shown in Figure 6.



**Fig. 6:** Developed Prototype.

Ultrasonic sensor will detect the presence of human within the range 2 centimeter until 400℃. Ultrasonic sensor with the combination of servo motor will start the oscillation from 0˚ until 180˚ and back to its initial degree. For the first servo motor, it is designed to detect single human. Once there is one person located in front of the ultrasonic sensor, the ultrasonic sensor will keep oscillate to the person with specific angle. Figure 7 shows the drawing of the area of the location will be oscillated.

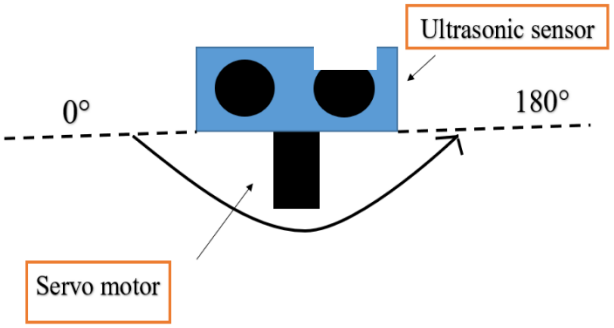



**Fig. 7:** Shows the Area of the Location That Will Be Oscillated.

The second servo motor also will rotate from 0 degree until 180 degree and return to its initial position. This second servo will use to detect multiple people and oscillate within the range. The second ultrasonic sensor will detect the first human as minimum angle of oscillation in degree while the last human within the angle 0 degree until 180℃ will detect as maximum angle of oscillation in degree. If there is another human located between location X and Z (see Figure 8). The degree of human location Y will not take as maximum or minimum value because the initial human location is human location X and the last human location is human location Z. Besides, human location Y is still within the range of X and Z. So, the fan will oscillate from human location X until human location Z and return to its initial angle of oscillation with the presence of human.

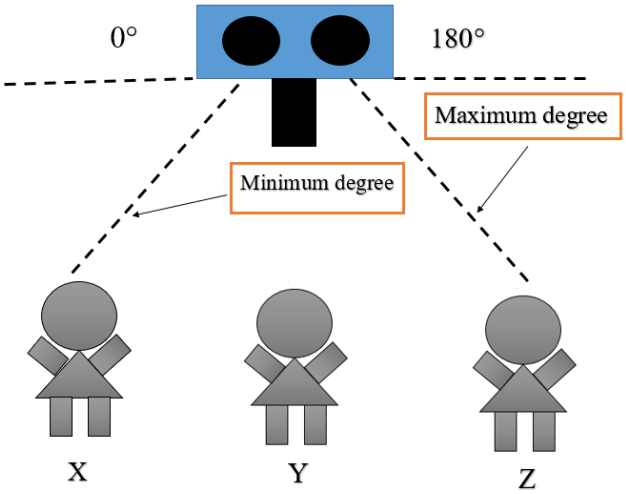
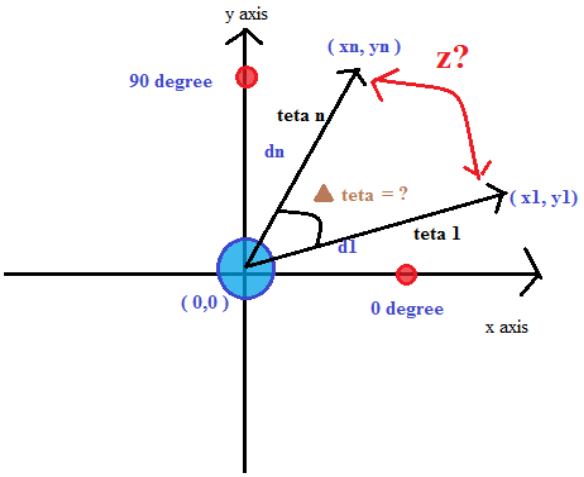



**Fig. 8:** System for Location Detection.

In Figure 9, X axis is considered as reference axis. The origin for this XY plane is (0, 0). X axis is 0 degree and Y axis is 90˚. Here is the example for human which located within 0 degree until 90˚. From here, angle is labelled as (a), distance is labelled as (b).
There are 3 steps to detect the human location:
1. As the servo rotate anticlockwise, the servo will detect human at location (x1, y1) initially and consider first object is ($x_1$, $y_1$). The degree of X is taken as initial angle of oscillation. However, this servo will rotate from 0˚ until 90˚ according to this situation. As it keeps rotating, there is another human detected at other location ($x_n$, $y_n$). The value of X is set as minimum degree angle of oscillation. Furthermore, distance of both θ which known as d1 and dn can be calculated. By using ultrasonic sensor, distance from sensor to the object can be calculated and the calculation can be uploaded in Arduino software. Besides, angle of oscillation for the servo motor can be measured manually by using simulator or by using Arduino software.
Thus, for the first part, we will know the distance from the sensor to the object and angle of oscillation from servo motor.

Step 2: The location at ($x_n$, $y_n$) is set as maximum degree. In this part, distance have been measured by using ultrasonic sensor and angle of oscillation have been measured by using servo motor. These outputs will be displayed in the serial monitor of Arduino software.

Step 3: There is another human location Z which is within the location ($x_n$, $y_n$) and ($x_1$, $y_1$). Human location Z will not take as minimum or maximum value of angle oscillation because it is within the range of location ($x_n$, $y_n$) and ($x_1$, $y_1$). However, difference angle of minimum degree of human and maximum degree of human location, $\Delta\theta$ can be calculated.




Last object angle, $\theta n$

First object angle, $\theta 1$

To get the z, we can subtract $\theta 1$ from $\theta n$

$$\Delta\theta = \theta n - \theta 1$$

**Fig. 9:** Calculation for Detect the Human Location.

## 3. Results and discussions

Figure 10 shows the results of experiment. The graph consists of angle of the ultrasonic sensor in degree and the distance of ultrasonic sensor from the object. It can be seen (see figure 10) the angle in degree is from 1 degree until 177 degrees according to the x axis while the distance is from 0 centimeter until 200 centimeter according to the y axis. There are 3 circles that have been circled in the data representation. The first circle labelled as A is angle of oscillation for servo motor at 1 degree, the second circle labelled as B is angle of oscillation for servo motor from 17˚ until 57˚ and the third circle labelled as C is 105˚ until 153˚. These data have been selected because they show the distance less than 10 centimeter respectively. This is because the object that have been detected by the ultrasonic sensor is placed in front of the sensor which is less than 10 centimeter. This show that the human location detection is accurate.

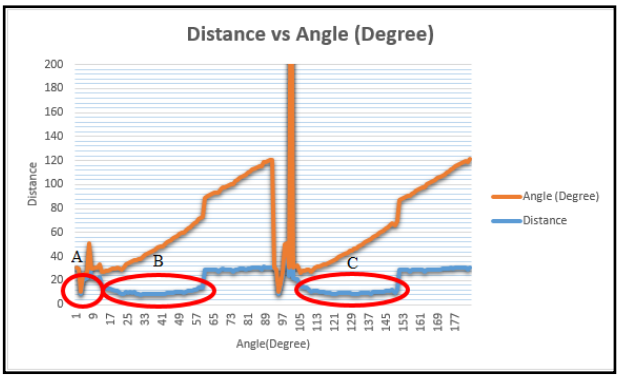
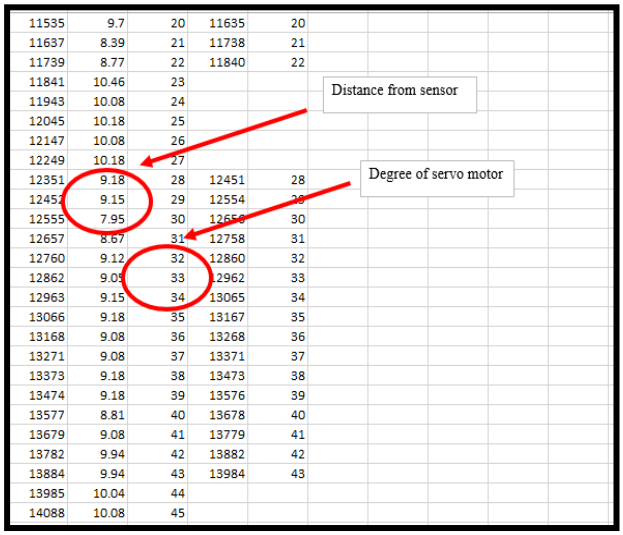



**Fig. 10:** Graphical Representation of Human Location Detection.

Figure 11 shows the data representation. From this data, there are five columns. The first columns are time in milliseconds, the second column is the distance from the sensor, the third column is the angle of oscillation from 0 degree until 180 degree, the forth column is time in millisecond for the fan and the last column is the angle of oscillation in degree for the fan. There is tolerance in time for the oscillation from ultrasonic sensor and the fan because it takes time to send data to the fan as the fan is received data from the first ultrasonic sensor to oscillate. However, the angle of oscillation for the fan is fixed. For this situation, angle in oscillation for the fan will measure by using protractor and the percentage error will calculate later. The first circle has been labelled as distance from sensor and the second circle have been labelled as degree of servo motor. These data have been selected because they show the results of distance from sensor to the object detection is less than 10 cm and the range of the servo motor is within 28 degrees until 43 degrees. However, to ensure the human location detection system is accurate the servo motor need to put delays. If the servo motor oscillates faster, it cannot detect the object accurately.




| | | | | |
|---|---|---|---|---|
| 11535 | 9.7 | 20 | 11635 | 20 |
| 11637 | 8.39 | 21 | 11738 | 21 |
| 11739 | 8.77 | 22 | 11840 | 22 |
| 11841 | 10.46 | 23 | | |
| 11943 | 10.08 | 24 | | |
| 12045 | 10.18 | 25 | | |
| 12147 | 10.08 | 26 | | |
| 12249 | 10.18 | 27 | | |
| 12351 | 9.18 | 28 | 12451 | 28 |
| 12452 | 9.15 | 29 | 12554 | 29 |
| 12555 | 7.95 | 30 | 12656 | 30 |
| 12657 | 8.67 | 31 | 12758 | 31 |
| 12760 | 9.12 | 32 | 12860 | 32 |
| 12862 | 9.09 | 33 | 12962 | 33 |
| 12963 | 9.15 | 34 | 13065 | 34 |
| 13066 | 9.18 | 35 | 13167 | 35 |
| 13168 | 9.08 | 36 | 13268 | 36 |
| 13271 | 9.08 | 37 | 13371 | 37 |
| 13373 | 9.18 | 38 | 13473 | 38 |
| 13474 | 9.18 | 39 | 13576 | 39 |
| 13577 | 8.81 | 40 | 13678 | 40 |
| 13679 | 9.08 | 41 | 13779 | 41 |
| 13782 | 9.94 | 42 | 13882 | 42 |
| 13884 | 9.94 | 43 | 13984 | 43 |
| 13985 | 10.04 | 44 | | |
| 14088 | 10.08 | 45 | | |

**Fig. 11:** Data Representation.

Automated stand fan with Internet of Things application is a cost saving stand fan with automation system, human location detection and temperature detection. This system uses passive infrared sensor, temperature sensor LM35, ultrasonic sensor for sensory system that make different with all the existing motion sensing device. Plus, this system also integrates with internet of Things application by using cloud server and user interface server to send the data through Wi-Fi connection. The data that have been measured including temperature measurement, presence of human, human location detection and the angle of oscillation which can be monitored by the user through Cloud with availability of the internet. Besides, this system also a cost saving because it can save energy up to 50% approximately.

## 4. Conclusion

In this paper, modelling of automated fan has been briefly described. The prototype has been built successfully. The prototype was built and tested according to our proposed system. A few sensors including temperature sensor, PIR sensor and ultrasonic sensor also have been described as well as with the Arduino microcontroller and Wi-Fi module. Results have been presented by using graphical representation and data representation and have been described briefly. The initial results and testing of the proposed prototype is acceptable in terms of fan oscillation between human presence. The automatic fan system has reduced cost and energy up to 50% approximately.

## Acknowledgement

The authors would like to thank UniKL BMI for generous support in completing the project.

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