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Automatic Speed Control and Turning ON/OFF for Smart Fan by Temperature and Ultrasonic Sensor

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Abstract. When it is hot, using a fan is an inexpensive choice compared to spending more on using an air conditioner especially in some areas where high temperature is naturally normal. Some problems, nonetheless, arisen such as users forget to turn off when being away, some people might get a feeling of annoyance and perhaps frustration when getting up from the seat in order to adjust the speed. These result in a rise of electricity bill from leaving the fan on when it is not in use and it may cause disasters, fire for example, when the motor get heated up. A prototype of smart fan was built in this research using ESP8266 as a microcontroller, DHT22 and HC-SR04 are used to measure temperature for speed control and detect the user for automatic on/off respectively. A group of participants used the prototype and they were interviewed to give some feedbacks, comments, and suggestions from the experiences after using it. The results show that they were satisfied from the automation; it gave the sense of staying in a modern house with an automatic wind blower. It also assisted to reduce energy consumption according to target group. Some users stated that the environment and atmosphere in the room was not too hot because the fan was working in the background. This has shown that the prototype significantly gave the participants a feeling of relaxation and comfortability and also was a part of energy and cost reduction.

1. Introduction

Fans are commonly used in places where the temperature is normally. Also the concept of Smart Home are getting popular all around the world even though the concept was known for decades [1].The problems arise when all the fan's speed are adjustable; however, this can be done manually. It means that if the user wants to change the speed, they have to move to the fan the push the button by themselves. Another drawback is that many people forget to turn the fan off after they have finished using it. They just leave the place and do not notice that the fan is left opened. This has resulted in the increase of the electricity bill and 5-10% of electricity consumed is wasted [4]. Sometimes it may cause a fire because the fan works by the rotation of a motor; if the motor keep operates for a long time, it produces the heat and the fan body is made of plastic which can be set fire quite easy. A system that is controlled by remote device such as remote control is a better idea due to the ease of non-contact to the system directly [6], [7].

The system that will be developed in this research will be called "Smart Fan". The smart fan can adjust its speed level according to the room temperature. Additionally, it starts working when the user sits in place such as on a sofa or chairs. After the user leaves the seat, the fan should stop working. This was supposed to bring the user comfortability and energy reduction consumption.

The phrase "Smart Home" has become more popular and common to the public after the research in software and hardware for decades. Technologies used nowadays provide human easier for do the living than before. Homes that are smart are expected to provide the owner automation such as automatic lighting and security system [17], [19].

2. Review

2.1. Hardware

To allow any home appliances to be intelligent, it needs a controller as its brain [4]. Microcontrollers are the control unit needed in this system and Arduino is by far the best choice [5] for development the prototype and also the price is reasonable. A smart appliance not only can make the user feel comfortable but also can assist the elderly or disabled [3]. The problem of wasted energy results in a quarter of all the causes of the greenhouse effect [6]. Some research in DHT22 and HC-SR04 were reviewed to gain knowledge about the two. The DHT22 seems to be a suitable for temperature monitoring as it produces digital output and the price is reasonable [9].

As for the motion sensor, first, passive-infrared sensor (PIR) which emit infrared signal and detect any movement that cuts through its signal. Second, ultrasonic sensor sends out a sound wave and once the wave contacts an object such as human or wall, the wave bounces back to the sensor and the time which the wave has traveled forth and back is calculated to be the distance between the sensor and the object. The difference is that if the object stays still within the infrared signal for a period of time, the sensor will understand that there is nothing within the range because there is no movement anymore [10], [11], [12], [13]. That is, PIR sensor can only detect movement when human come to the front but if the human sits still or falls asleep the PIR sensor will not detect any movement anymore and the fan is turned off. Ultrasonic sensor, in contrast, will always produce the output that there is still an object within a range because the distance is measured all the time. This allows the ultrasonic sensor to detect whether there is an object within its range or not even the object is not moving.

2.2. Literature Review

Ultrasonic sensor was more suitable than PIR sensor in the sense of human detection for the scope of this research because the sensor detect human in one direction which is in front of it but the PIR sensor detection range is in cone shape [13]. Another smart fan from T. Ishrat et al (2014) did not use a microcontroller that allowed the system to connect to the Internet for the concept of the Internet of Thing (IoT) but the prototype in this research used NodeMCU which is able to connect to the network allowing the system to be monitored for managed online for the future approach [13].

Another research from [14] used infrared signal to detect human in a museum. The microcontroller PIC16F887A [14] which could not connect to the computer network compared to NodeMCU used in this research. The fan from [14] was not described whether the fan continued to operate if a person is standing still or not. However, the prototype in this research is guaranteed to be working as long as a person is still there even when the person is sleeping.

As for the power usage monitoring, smart appliances that have a feature of automatic ON/OFF system will save electricity and time [19]. Smart fan from other research were concluded to help on energy conservation and cost reduction [13], [14].

The outstanding difference between the result in this research and the others is that there were no feedbacks, comments, and suggestions from the user. This paper provide those information gathered from participants by the method of interview which is a valuable information to make future process.
From the review, the prototype in this paper and the result had more potential in many aspect such as human existence detection, cost reduction and power conservation, and user feedbacks.

3. Methodology

Two main tasks were designed and created to obtain the result in this research, which were interview forms and the system:

3.1. Interview

The criteria of the interview consists of five main parts, which are features, usefulness, comfortability, satisfaction, and feedback. There were five participants testing the system by given the fans developed in this research. The period of using the fans by the experimental group was approximately six months. The data was collected by three interviews. The first interview was two weeks after getting the fans and the questions were about the stability and errors of the fans. The reason these questions were used because the system must perfectly function without any errors otherwise the result of the research will not be concise. This interview took place at the participants' house. The second interview was about the satisfaction from using the fans, are there any features that should or should not be added to the system. The last interview was also about the satisfaction of the user from using the fans. They were asked whether they wanted to keep using it or not.

3.2. The System Prototype

The system consists of three main logical hardware parts, the fans, the sensors and the controllers. All the parts were connected to one another by electric wires. The algorithm was designed and programed in C++. The diagram of the system can be seen in Figure 1.

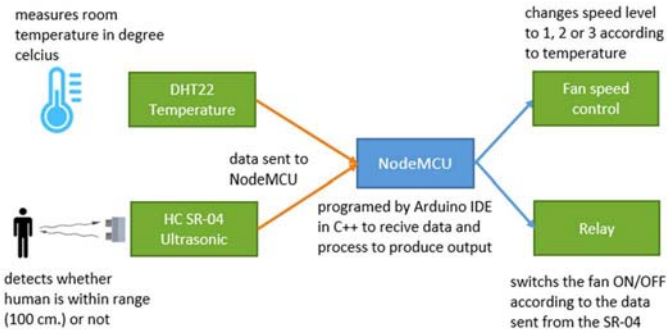

Figure 1. The System Diagram

3.2.1. Fan

Two kind of fans were used in the experiment. The first was the table fan which was placed on any table. And the second was taller and could only be placed on the floor. Both models had three speed levels consisting of four buttons, ON/OFF, speed 1 (slowest), speed 2 (medium), and speed 3 (fastest).

3.2.2. Microcontroller

ESP8266 NodeMCU was used as the controller unit. There were, at first, actually 2 microcontrollers to choose from, Arduino UNO and ESP8266. The differences between the two are the UNO does not have a built-in Wi-Fi chipset [2] and the size is about two times larger than the other one. The NodeMCU was chosen because the size mattered; it must fit inside the fans' body and the smaller circuit blue print allows the entire system to consume less power. Although the Wi-Fi was not in the requirement in this research however for the future work it is already planned to develop a step further to allow the connection of the Internet. The only disadvantage of the NodeMCU compared to the UNO is that the NodeMCU uses a micro USB as a connection port in order to connect to the computer to be programed and code embedded; the UNO, on the other hand, uses the much more stable connection which is type-b USB connection port.

The microcontroller digitally received the temperature data in degree Celsius (^{o}c) from the temperature sensor (DHT22). The level of the temperature was set to three levels. If the temperature was less than or equal to 32^{o}c, the speed was set to level 1 which is the slowest; If the temperature was less than or equal to 35^{o}c, the blade's speed was set to level 2; and if the temperature was more than 35^{o}c, the speed was set to highest level which is the fastest of the fan blade. That is, the fan blade spins

faster as it getting hotter automatically. The natural environment of the participants' house was between 30 to 38°c.

3.2.3. Sensors

DHT22 temperature sensors were used to monitor the temperature. HC-SR04 ultrasonic sensors were used to detect the users. The sensors faced at the same direction as the fan. The ultrasonic sensors emits the sound wave and it bounces back to calculate the time the wave travels and it results in the distance between the sensors and the object. The distance was set at one hundred centimeters. That is, if there is a person comes into the wave length, the sensor sends the data to the controller and the controller signals the relay to connect the AC current for the fan allowing it to start working. If the person is at the distance of less than one hundred centimeters, the fan is still working. Once the person is away from the length which more than one hundred centimeters; the fan stops working after the delay of twenty seconds.

3.2.4. Relay

The fan uses 220 AC voltage but the NodeMCU and all the sensor uses 3.3-5 DC voltage which cannot be wired up together. The relay acted as a switch for the fan when the ultrasonic sensor detected the human which was the only one task for it. A 4-channel relay was used because 3 channels were wired to connect to the 3 fan speed level switches and 1 channel was used for turning the fan ON/OFF.

3.2.5. Software

Arduino IDE was used to program all the codes and the programming language was C++.

4. Result

The result was that 100% of the participants were satisfied with the prototype. The scale were from 0 to 5 which 0 means not satisfied at all and five means most satisfied. The prototype were useful according to the result as all of the target group gave number 5 for the usefulness. As for the comfortability, 75% chose it was comfortable but 25% said that it could be difficult to say that using the prototype is comfortable or not because she did not control the fan at all as the fan controlled itself on turning on and off. This seem to be comfortable because if the user feels normal or does not feel annoyed and frustrated from the fan, it means that the fan works in a background and gives the user and feeling or comfort. The features and feedbacks will be described in the next paragraph.

The opinions from all the participants are significantly useful such as the fans should automatically stop working when the temperature drops below 26 because it means that the air conditioner is on. Two participants said that it was quite dangerous to put the plug in all the time because the fan turned on and off by itself and this made the users to forget about the plug. Keeping the plug into the wall all the time can cause a fire if the wire or the plug is in a poor condition. The feeling of the cool wind-blown automatically from the fan after sat down on the chair gave all the participants a new experience of using fans. Furthermore, the fans stopped itself when the users are away were very impressive. One participant recommended that the fan should face the users all the time; it means that some kind of user tracking system must be included into the system to allow this to work. However, this was not the scope of the research but it was a valuable opinion. Another recommendation was that there should be a portable version of the fan with battery for outdoor activities. All the participants emphasized that the system should allow the user to change from auto mode to normal mode to control the fan manually. Even though the fan is basically controlled by hand but the function was taken out because it was designed to be fully automatic. The fans are also suitable for any houses that have elderly because it requires less time to operate the fans.

The NodeMCU itself broke down very easily as twenty of them were used to build up to ten fans. This was because the connection and the program uploading issue. Another reason was that the USB port and cable were plug in and out many times during the testing process. Despite all the problems, the NodeMCU was suitable and perfectly worked because of its size and low energy consumption.

5. Conclusion

The system built in this research as a prototype is an ideal fan for many people. As they live in the world that such a system does not exist, they may not have a thought to want one; nonetheless, once they have tried it, they are satisfied and appreciated by its advantages and comfortability. Even though the hardware that was used in this research is not for enterprise level and not good enough for the market, but there are better ones and the features of the fan attracted the participants to continue using it.

Although this system does not have a database because it is just a home appliance. However, it can be put together for future work to collect data usage and analysis for any purposes such as users' behavior, energy consumption prediction and historical data usage in specific periods of time for energy consumption reduction. An alternative is using Zigbee [10] as Smart Home microcontroller because it consumes even less energy [4] than NodeMCU and can lasts for months. Also smart phones can be included in the system to virtualize data by graphs or notifications to inform the user about their usage because smart phones are things that carried with the people at almost all the time [16].

Lastly, what is learned from all the feedbacks was that any systems should be built based on the consumers' needs, preferences, and favorites in order to make the best out of it.

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