

Preliminary Study of the Voice-controlled Electric Heat Radiator

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Abstract— This study presented a voice-controlled electric heat radiator which was named as “little sun”. The switch of the radiator was controlled by the input voice into the microphone. A voice recognition module connected with Arduino microcontroller which assigned the switches to turn on or off by the instructions of the user’s voice. The results presented that the little sun works. In 82 tests, 80 voice commands was successfully recognized at the first command, and 2 voice commands was successfully recognized after repeating the first commands in the condition of signal-to-voice ratios (SNR) in the range of 10 to 30 dB. Therefore, a low cost, easy to use and high performance voice controlled radiator was implemented to improve the convenience and comfortability of human life.

Keywords— electric heat radiator, voice recognition, Arduino, siren, ambulance, control

I. INTRODUCTION

When someone is busy, it is easy to turn on the electric radiator by voice commands. In case of a mother is washing her baby in bathroom. It is very possible that she is too busy to turn on any devices by hands because her baby needs her hands. Consequently, the advantage of the voice controlled is disclosed in the case of mother’s baby bathing.

Some studies proposed or employed voice control. For example, Moriyama et al. [1] proposed a voice controlled air conditioner. Browne et al. [2] explored the apparatus of voice control for lighting. Drennan [3] designed a voice activated thermostat to adjust the temperature a large space in the house. Funk et al. proposed that a home automation system controlled by voice through phone system [4]. All of these studies pointed out the convenience and advantages of the voice command to control the electric apparatuses. Lo et al. [5] proposed an electric heat radiator which connected wireless communication module, voice recognition module, rotator, heat radiator, reflector, and so on to announce an artificial intelligent heat radiator. It is a very high quality electric heat radiator.

In this study, the human voice command input into the microphone at first, then the voice was recognized by the

Arduino UNO with voice recognition module. The third step was Arduino UNO sent the instructions to the 4-way relay module to turn the power switches on or off. Finally, the power of heat radiator was controlled by the voices. Anyway, the heat radiator carries out a local area heater in the house. The function of the heat radiator is simple so the price is lower. This study added few components to keep the lower cost of the electric heat radiator.

This study included five sections. Introduction section presented the motivation and literature study of this article. Method section introduced the structure of the integrated system and its schedule of experiments. Results section presented the system integrated by the methods, and the experimental data. Discussion section showed the comparison of previous studies, and disadvantage of the system. Finally, we have a conclusion in the last section.

II. METHODS

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The reassemble of the radiator employed the devices which include an Arduino microcontroller, a voice recognition module and a 4-way relay module with some modification of the connections of the ready circuit in a commercial heat radiator. The reduced devices were individually introduced as follows,

A. Arduino microcontroller

Arduino UNO is one of the simple controllers in the family of the Arduino controller. The characteristics of Arduino UNO are [6],

- High performance and low cost 8-bit RISC microprocessor
- 32K word program memory
- 1K word E2PROM
- 2K word SRAM
- 14 digital I/O(6 pins support PWM)
- 6 analog input pins(10 bit ADC)

- Two 8-bit counter/counter
- One 16-bit counter/counter
- Range of power source: DC 1.8 - 5.5V
- Temperature range: -40°C~85°C

The structure of the microprocessor is suitable to add the external module for instruction and data communication to control the heater.

B. Voice recognition module

The voice recognition module which was produced by DFRobot is easy to use for the Chinese voice recognition. The users just code the spelling of the Chinese Characters of the commands in the program of the MCU, then that of the commands send to the voice recognition IC. The IC can contain more than 50 voice commands which can be word, phrase or sentence. The module is compatible with the Arduino UNO, and embedded with a microphone. It will occupy pins 2, 4, 9, 11, 12, and 13 of Arduino UNO for connection and communication when the module works with Arduino UNO [7].

C. 4-way relay module

The 4-way relay module supports 5, 12 and 24 V DC power supplies. It functions as the isolators with independent 4 photo-couples and can be triggered in high or low levels which can be selected by a jumper.

D. System integration

The additional devices connected with the ready circuit of the commercial radiator (Meiling Flima sun heater) to perform as a voice controlled heater. The functional block diagram was displayed in Fig. 1.

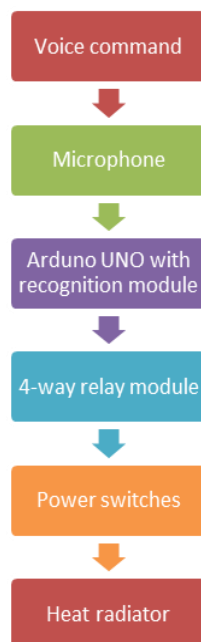


Figure 1. The functional block diagram of the system integration.

In Fig. 1, the human voice command input into the microphone at first, then the voice was recognized by the

Arduino UNO with voice recognition module. The third step was Arduino UNO sent the instructions to the 4-way relay module to turn the power switches on or off. Finally, the power of heat radiator was controlled by the voices.

E. Experimental setup

The experiment was aimed at the limitation of the integrated system. The setup of the experiment for the tests was presented in Fig. 2. In this study, mobile 1 was HONOR V10 and mobile 2 was a REDMI 9. Mobile 1 was recorded the voice commands as well as mobile 2 was download the siren of ambulance to play for the tests. The siren of ambulance is a stable voice and suitable for an example of noise. The experiment was designed by the stable voice (65~70 dB) over the variable noises (50~70 dB). The voices and siren sound was measured by a mobile application (APP) of Decibel tester [8]. The APP is popular and downloaded by 8723 times in the Application treasure.

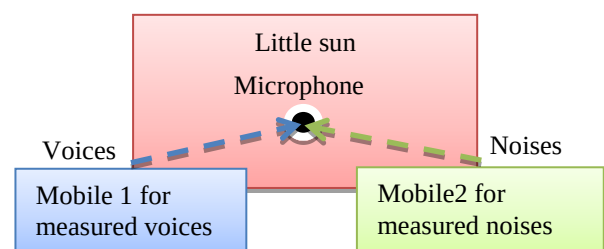


Figure 2. The setup of the experiment for tests.

III. RESULTS

Generally, the system followed the voice commands. However, the errors occurred sometimes, but can be corrected by repeating the voice commands. Anyway, the louder voice commands make the recognition perform more successfully, because of the greater signal-to-noise ratio (SNR).

The picture of the system integration was presented in Fig. 3. The external modules were integrated in a small space. Therefore, the performance of the radiator was guaranteed be the same as that of the original one's (Fig. 4).

In Table 1, the voices were limited in the range between 65 and 70 dB. Item A was the number of directive successful cases at the first voice command. Item B was the number of successful cases by repeating the first voice command. Item C was the number of failure after repeating the first voice command. Item D was the total times of the tests for the voice recognition. Item E was the successful rate 1 of Item A that was computed by Items A/D. Item F was the successful rate 1 of the sum of Items A and B that was computed by Items (A+B)/D. For the noises, the noises whose scales were measured in the range of 50 to 55, 55 to 60, 60 to 65, and 65 to 70 dB were concluded into Groups N1, N2, N3 and N4. The set $P_x = \{A, B, C, D, E, F\}$ was defined as the values of items in the Group N_x where $x = 1$ to 4.

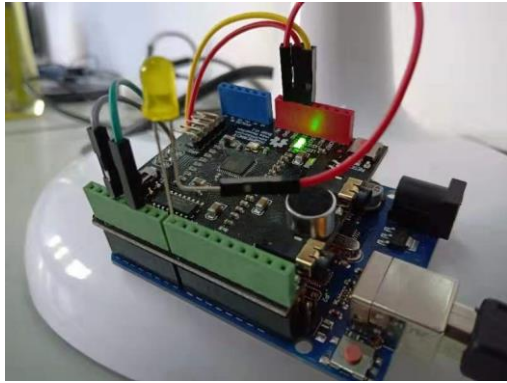


Figure 3. External system integration.



Figure 4. Total system integration.

Fortunately, in Table 1, $P1 = \{80, 2, 0, 82, 0.98, 1.00\}$, i.e. all voice commands can be successfully recognized in the condition of signal-to-noise ratios (SNR) in the range of 10 to 30 dB in Group N1.

$P2 = \{70, 17, 6, 93, 0.75, 0.94\}$, i.e. the SNRs were in the range of 5 to 15 dB. The successful rates 1 and 2 were 0.75 and 0.94 displayed an acceptable performance. $P3 = \{61, 10, 9, 80, 0.76, 0.89\}$, i.e. the SNRs were in the range of 0 to 10 dB. The successful rates 1 and 2 were 0.76 and 0.89 also disclosed an acceptable performance. Finally, $P4 = \{2, 3, 30, 35, 0.06, 0.14\}$, i.e. the SNRs were in the range of -5 to 0 dB. The successful rates 1 and 2 were 0.06 and 0.14. Certainly, the minus SNRs of the input voice did not control well. The results were concluded in Fig. 5.

IV. DISCUSSION

The findings of the successful rate of voice control presented that the SNR over 10 dB performs almost perfectly. The normal human voices are around 50 dB, however, the distance between mouth and microphone should be considered. The common environmental noise in a house is in the range of 20 to 40 dB. Therefore, it is very easy to achieve the $SNR > 10$ dB. The performance is close to the previous studies [9-11]. Consequently, the system works in general cases.

The sound or voice measurement is not easy [12] because the most of the voice are dynamic. Therefore, the ambulance siren is a good choice for the noise. The ambulance siren which was employed as the background of noise is a stable sound with higher and lower tones. Therefore, the background noises in the tests were stable. This confirmed the certainty of the results in this study.

A low cost, easy to use and high performance voice controlled radiator was implemented in this study. It can aid anyone who is too busy to use hand turning on a heater. Of cause, it also improves the comfortability of living without any placement for turning on the heater. Therefore, this study achieves the convenience for house living.

TABLE 1. TABLE 1. THE STABLE VOICE (65~70 dB) OVER THE VARIABLE NOISES (50~70 dB)

Noise	N1: 50~55dB	N2: 55~60dB	N3: 60~65dB	N4: 65~70dB
A. Success (Once)	80	70	61	2
B. Success (Repeated)	2	17	10	3
C. Fail (No response)	0	6	9	30
D. Total	82	93	80	35
E. Successful rate 1 ($E=A/D$)	0.98	0.75	0.76	0.06
F. Successful rate 2 ($F=(A+B)/D$)	1.00	0.94	0.89	0.14

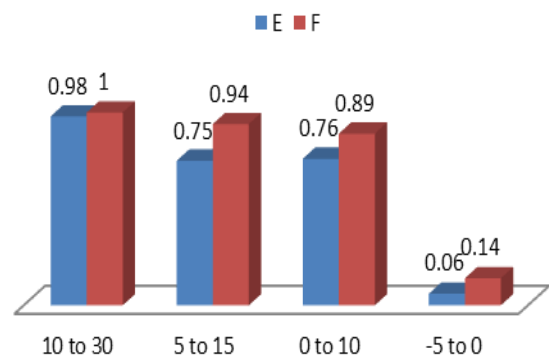


Figure 5. Successful rate vs. SNR

On the other hand, some disables are not able to use the devices smoothly, because of the unstable control of the hands. Therefore, it is not easy for a disable to make much money. Furthermore, some families who take care of the disables spend much spiritual and material cost. Some improvements for the disable's self-activation of device will encourage them to keep the work for the disables. The low cost radiator will

aid the disables for self-psychological satisfaction, because the radiator works as the disable's command.

The heat radiator owns 2 power levels in this study. Through the pulse width modulation (PWM) technology by switching the relays, it is no change of the hardware to achieve the continuous regulation of the heating power in this study. The components for the system integration are popular so it is easy to do that. The cost of the voice controlled radiator was reduced. Therefore, it is possible to push the radiator anywhere.

V. CONCLUSION

A low cost, easy to use and high performance voice controlled heat radiator was implemented to improve the convenience and comfortability of human life. The SNR of command voice in a peaceful home is usually over 10 dB, i.e. almost 100% successful rate in voice recognition. This ensures the quality of the electric heat radiator. Furthermore, it also aid some disables to realize some actions that they can not do before. The medical applications of this electric heat radiator own the potentials to expand its applications in the relative fields. Therefore, we believe the voice controlled heat radiator is available to be introduced anywhere.

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