The Design and Implementation of the Intelligent Warehouse Voice Control Guard System Based on Voiceprint Recognition

Lijun Yu and Kefeng Li
College of Engineering, Shanghai Second Polytechnic University, Shanghai, China
College of International Vocational Education, Shanghai Second Polytechnic University, Shanghai, China
Email: ljyu@sspu.edu.cn; kfli@sspu.edu.cn

Abstract: This design is an intelligent warehouse voice control system based on voiceprint recognition. The system consists of the following components: the first switch and the second switch connected via LAN; the voice control guard of the first circuit-connected switch, which collects voice signals on site and outputs voiceprint information; the database server of the second circuit-connected switch, which compares voiceprint information with the voiceprint samples in the database server for voiceprint recognition; the access control switch module, which receives access control commands and then opens or closes the door. Based on FPGA, infrared sensing technology, voice acquisition technology, human-computer interaction technology, and data transmission and communication technology, this design is capable of recognizing the identification of personnel and performing authentication management. This design also features convenient voice acquisition, low cost, compact size, various functions, and strong scalability.

1. Introduction
Voiceprint recognition is a biometric recognition technology, which automatically recognizes the identity of a speaker based on the physiological and behavioral characteristics of the speaker's pronunciation. Voiceprint recognition has nothing to do with the spoken language, dialect, or tone, and does not require personal contact, which is easier to accept for users. Meantime, it requires low cost to obtain voice, and only a phone/mobile phone or a microphone is required. Voiceprint is suitable for remote voice transmission and acquisition. Remote identification recognition can be achieved only over the Internet. In addition, safety provided by voiceprint recognition can match with those provided by other biometric technologies. Moreover, using voiceprint as a key has the advantages of being easy to carry and use, hard to forget, forge or be stolen, and strong security performance. By combining with access control system, this system can significantly enhances the safety and convenience of the access control system. [1]

2. Technical Features of the Intelligent Warehouse Voice Control Guard System Based on Voiceprint Recognition
Voiceprint-based access control system uses voice of the managers as the key to control and manage the access to the warehouse. The so-called voiceprint is the voice acoustic frequency spectrum, which carries voice information and is displayed on the electroacoustics instruments. We know human sound is a complex physiological process between human language center and the central organs. The vocal organs used in the speech of each person, including teeth, tongue, larynx, lung and nasal cavity, vary in size and shape significantly. Therefore, the voiceprint spectrum of each person is unique. Although voiceprint recognition has some defects in the application, for example, the same person's voice will be affected by the change of the physical condition, age, and emotion; different microphone and
interference of different external environment will influence the performance of voice recognition, but voiceprint recognition has the following obvious advantages compared with other biometric recognition technologies: 1) It is convenient and natural to obtain voiceprint, which is easy to accept by users; 2) It features low cost, which can be completed using a simple microphone or only by general communication equipment; 3) It is suitable for remote identity recognition. Only a microphone, phone, or mobile phone is required for remote login through the communication network or the Internet, telephone or mobile phone (communications network or the Internet); 4) The algorithms for voiceprint identification and verification features low complexity; 5) Through combination with other measures, such as the recognition of the content through voiceprint recognition, the accuracy rate can be improved. These advantages make the voiceprint recognition system more and more popular among developers and users. Voice recognition has taken the market share of 15.8% in the world, which takes the second position only to the biometric fingerprint and hand recognition, and the market share continues to rise. [2]

3. Work Principles of the Intelligent Warehouse Voice Control Guard System Based on Voiceprint Recognition

This design implements an intelligent warehouse voice control guard system based on voiceprint recognition and identity authentication. It uses voice to control access privileges of the warehouse so that managers can use their own voice as a key for identify recognition and authentication.

To achieve the above goals, this guard system consists of the following components: the voice control guard of the first circuit-connected switch, which resides at the access control point and collects voice signals on site and outputs voiceprint information; the database server of the second circuit-connected switch, which stores the voiceprint information of privileged persons; the management platform of the output terminal at the second circuit-connected switch, which receives voiceprint information collected on site and compares voiceprint information with the voiceprint samples in the database server for voiceprint recognition, and then sends access control commands; the access control switch module, which resides at the output terminal of the circuit-connected management platform and receives access control commands and then opens or closes the door, as shown in figure 1.

![Figure 1. Structure of the intelligent warehouse voice control guard system](image)

The guard system consists of: the main control module (FPGA), voice modules respectively circuit-connected with the main control module, infrared sensor module, cache controller, data network transmission module; audio output module respectively circuit-connected with the voice module, audio input module and cache controller. The infrared sensing module senses the on-site visitor's access and sends the trigger signal. The main control module receives the triggering signal, and controls the audio output module to send a voice to the visitor. The audio input module receives audio feedback from visitors and converts into voiceprint information via the voice module. The main control module then outputs the voiceprint information to the management platform through the data network transmission module, as shown in figure 2.
Figure 2. Circuit-connected modules of the intelligent warehouse voice control guard system

The main control module is the main control chip of the guard system. The chip model is EP2C35F672C6 of the Cyclone II series, which is made by Altera. The Cyclone II series are characterized with a lower cost, larger capacity, and more special functionalities. However, because the voice control guard system has the particularity of network data transmission, it requires EP2C35F672C6 plus data network transmission module to form NIC interface circuit, and data network transmission module uses the RTL8019 chip.

The infrared sensor module, which uses the infrared sensor ON209, senses whether visitors access in real time. By sending trigger signals to the main control module, it controls the questions for visitors and whether to collect the voiceprints of visitors.

Voice module uses the WM8751L audio chip. The audio output module adopts a loudspeaker, the audio input module adopts a microphone, and the cache module adopts the chip A2V64S40CTP. By using the loudspeaker, microphone, audio chips (WM8751L) and buffer, the voice control guard system realizes voice questioning, voice acquisition and storage.

The system uses the field programmable gate array (FPGA-EP2C35F672C6) and the RTL8019 chip to form the data network transmission module so as to communicate with the management platform in real time.

4. Implementation Methods and Procedure of the Intelligent Warehouse Voice Control Guard System Based on Voiceprint Recognition

The management platform collects the voiceprint information samples of related personnel in advance and saves them in the database server. Then, the management platform is in charge of managing user information, system maintenance, and update.

Figure 3 shows the implementation method and procedure of the intelligent warehouse voice control guard system based on voiceprint recognition.

The implementation procedure is as follows:

Step 1: The voice control guard system senses whether there is a visitor at the access control point in real time. When sensing a visitor, it triggers access control.

Step 2: The voice control guard system collects visitors' voiceprint information and transmits it through the network to the management platform.

Step 2.1: In voice control guard system, when receiving the trigger signal emitted by the infrared sensor module after sensing the visitor, the main control module controls the audio output module to send voice prompts to the visitors at the access control point through the audio module.

Step 2.2: The visitor answers questions as prompted.

Step 2.3: The audio input module receives the voice signal from the visitor's feedback and outputs
it to the audio module.

Step 2.4: The audio module converts voice signals into voiceprint information, and transmits it to the management platform via the network transmission module.

Step 3: The management platform receives on-site voiceprint information and the samples of voiceprint information stored in the database server, and then compares the on-site voiceprint information and voiceprint information stored in the database server for identity recognition.

Step 4: The management platform checks whether they match. If yes, the visitor has a valid identity and the procedure jumps to step 5; if not, the management platform further checks whether the number of onsite voiceprint information samples is greater than the preset times. If yes, the visitor does not have a valid identity and cannot pass the access control; if not, go to step 1 for re-sampling.

Step 5: The management platform checks whether the visitor with the matching voiceprint has access permission. If yes, allow the visitor to access by opening the access control module; if not, the visitor is illegal and forbid the visitor to access. [4]

Figure 3. Implementation method and procedure of the intelligent warehouse voice control guard system based on voiceprint recognition

5. Summary
Voiceprint recognition, which serves as an important aspect of human biometrics recognition and belongs to an important branch of artificial intelligence, has a wide application prospect[5]. This design implements an intelligent warehouse voice control system based on voiceprint recognition and the identity authentication method. Compared with the existing technologies of access control system, this design adopts the embedded FPGA development platform, infrared sensing technology, voice acquisition technology, human-computer interaction technology, and data transmission and
communication technology. Therefore, this design is capable of recognizing the identification of personnel and performing authentication management. This design also features convenient voice acquisition, low cost, compact size, various functions, and strong scalability.

6. Acknowledgments
This paper was supported in part by the National Natural Science Foundation of China under Grant No. 61272036, and key Disciplines of Software Engineering of Shanghai Second Polytechnic University under Grant No. XXKZD1301.

7. References
[1] Lu Yinan, Shan Baoyu and Guan Chao 2017 The status quo and application of voiceprint recognition technology [J] Information system engineering 2017 (2) p11
[2] Zheng Fang, Li Lantian and Zhang Hui 2016 Voiceprint recognition technology and application [J] Information security research 2016 (1) p44-57
[3] Ye Tiantian 2012 Voiceprint recognition system design [J] Industrial control computer 2012 (6) p88-89
[4] Li Qiuhua, Tang Jianbo and Bai Sen 2013 Network user identity authentication system based on voiceprint recognition and speech recognition [J] Information network security 2013 (12) p37-41
[5] Wu Jiapei 2016 Overview of voiceprint recognition research [J] Science and wealth 2016 (7) p865