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# *A Speech Remote Control System for Intelligent Robots by the Finite Volume Method*

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***Keywords:*** Finite Volume Method, Intelligent Robot, Voice Remote Control, Control System

***Abstract:*** Language is the unique product of highly thoughtful and conscious human activity. Language is the most direct and convenient way of human communication and the best means of human-robot communication. The aim of this paper is to investigate the design and implementation of a speech remote control system for an intelligent robot based on the finite volume method. An acoustic solver based on the finite volume method is written and implemented independently on the basis of an existing numerical simulation development platform. The program is integrated into the existing simulation program framework, and the architecture of the intelligent robot voice remote control system and the basic model of the remote control system are designed. Experiments were conducted on the system in both command-based and dictation-based voice control modes. The experimental results show that the system is able to send commands to the robot after confirmation through human-robot interaction.

## 1. Introduction

With the continuous development and widespread use of robots, people are becoming more and more accessible to robots. As a result, people want to use speech recognition and robots to handle robots in order to be able to manipulate the human manifestation of information interaction between robots in two ways: on the one hand, software development and design for easy operation of advanced robots; on the other hand, robots need information interaction in actual operation. As an advanced stage of robot development, the trend towards intelligent robots requires not only a high degree of autonomous intelligence, but also a degree of coordination between robots and humans [1-3].

The purpose of using robots is not only to help people with certain tasks, but also to expand human capabilities through robots [4-5]. To achieve this goal, Ortlieb designed and developed a remote control system based on a B/S architecture in response to the difficulty of cross-platform remote control software for service robots. To address the communication barriers caused by communication protocol differences, a gateway program is introduced for protocol conversion to enable communication between the web front-end and the on-board program. In addition, part of the business logic of the web front-end was handed over to the gateway program for implementation, thus allowing for optimised control performance [6].Sam designed a motion-centre-based remote nasal robot and proposed a voice-based robot control method. Firstly, the design of the robot based on the RCM mechanism was proposed by analysing the nasal surgery space. Based on this, the design parameters of the robot were analysed and the overall design of the robot was completed. Then, a voice-based robot control method is proposed, considering that the surgeon's hands are occupied by surgical instruments in complex surgical procedures. This method obtains the surgeon's guidance by analysing the motion of the endoscopic image. A commercial speech recognition interface is then used to implement a Chinese-English compatible offline grammar control lexicon and a general strategy for robot control is proposed [7]. Boena developed a weakly invasive framework to model the propagation of uncertainty in solutions of a general hyperbolic system of partial differential equations over a graph-connected domain with nodal coupling and boundary conditions. The method is based on the stochastic finite volume (SFV) approach and can be used to drive uncertainty quantization (UQ) of fluid flow dynamics over a transport network. The numerical format is uniquely suited to modelling the intertemporal uncertainty of time-varying boundary parameters, which cannot be characterised by strict upper and lower bounds (intervals). They describe the single-tube scenario and then present the control connection Riemann problem (JRP), which can be extended to general network structures. They demonstrated the capabilities and performance characteristics of the method using a standard benchmark test network [8]. Therefore, it is of relevance to study speech remote control systems for intelligent robots regarding the finite volume method.

In this paper, wireless network technology and speech recognition technology are applied to the motion control system of a mobile robot to achieve remote voice control of the mobile robot. By realising this theme, remote control of robots can be more convenient, user-friendly and intelligent, thus reducing workload and providing some reference value for remote control of robots, intelligent control of human-robot collaboration and migration and reuse of speech recognition technology. Remote user control of robots is achieved by combining speech recognition and remote control through DCOM components. The innovation of this paper is the combination of telephone network and computer network to achieve voice remote control of industrial robots. Its theoretical and practical results provide a new solution for human-computer interaction in information appliances and automatic industrial control systems, which is of great practical importance in the field of industrial automation.

## 2. On the Design of a Speech Remote Control System for Intelligent Robots by the Finite Volume Method

### 2.1. The Finite Volume Method and Its Acoustic Applications

(1) Finite volume method

The basic idea of the finite volume method is to divide the computational domain into non-overlapping sub-regions, i.e. control volumes, so that each node has a relatively independent control volume and the corresponding discrete equations are obtained [9-10]. The discrete equations generated by the finite volume method require integrated retention of any variable in the set of control volumes and the entire computational region is naturally satisfied, whereas other discrete methods do not achieve such natural retention [11-12]. In finite volume methods, the interpolation function is only used to calculate the integral of the control volume. If necessary, different interpolation functions can be performed for different elements of the differential equation [13].

(2) Numerical simulation of finite volume method acoustics

Unification of the linear acoustic fluctuation equations with the control equations of the acoustic high-frequency approximate Z-K model for porous media into the same form:

$$\begin{cases} A = \dfrac{\rho_0}{\gamma \rho_0}, B = 0, & \text{Linear acoustic domain} \\ A = \dfrac{k_s \rho_0}{\gamma \rho_0}, B = \dfrac{\sigma\phi}{\rho_0}, & \text{Porous media domain} \end{cases} \tag{1}$$

If only the internal nodes of the computational domain, the absolute hard boundary nodes, the absolute soft boundary nodes, and the transmission boundary nodes of the linear acoustic domain are considered. Performing volume fractionation on the above control body pairs yields:

$$\int_{\Omega} A \frac{\partial^2 \rho}{\partial t^2} d\Omega + \int_{\Omega} B \frac{\partial \rho}{\partial t} d\Omega = \int_{\Omega} \nabla^2 \rho d\Omega \tag{2}$$

In this paper, the lattice point type finite volume method is used to discrete the hyperbolic type control equations for the unified form of linear acoustics and porous media acoustics, and the type function is introduced to describe the gradient distribution of the variables inside the simple control body. The use of discrete expressions for the control bodies of the boundary units on both sides of the joint intersection interface exists in a non-physical understanding. Finally, the Heaviside function is introduced to describe the control body at the intersection and its numerical treatment is proposed as a means of simplifying and reducing the computational effort. The corresponding acoustic solver for porous media and the physical intersection processing program were written and completed [14].

## 2.2. System Architecture Design

A speech recognition-based remote control system assigns local voice control of the robot to a remote [15-16]. With the help of contemporary computer network communication technology and telephone network technology, telephone operators can operate remote robots by voice command ground as shown in Figure 1.

With the help of the system architecture diagram, we can see that voice recognition sends voice commands to the robot console via the computer network.

The host computer is based on DCOM technology and the DCOM component acts as an agent to interact with the remote operator on the one hand and the automatic operator on the other. The remote host computer acts as an independent intelligent entity that can operate and sense the environment on its own. Depending on the current state of the environment, certain tasks performed by the remote operator on the component are completed. Examples include assembly characterisation, route planning, obstacle prevention, etc. In the case of voice control, the network acts as a means of transmission for the interaction between the remote operator and the robot. The remote operator controls the automaton remotely via voice commands in order to perform the appropriate tasks and can understand how the computer uses the parameters returned by the DCOM component [17].

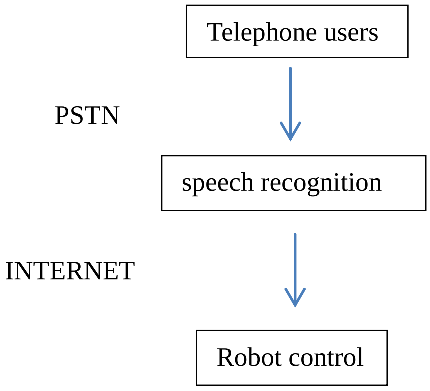


*Figure 1. System architecture diagram*

## 2.3. Basic Model of a Remote Control System

Remote control systems are advanced technologies based on communication and networking techniques [18]. Remote control usually supports the following network methods:LAN, WLAN, WAN, dial-up mode, Internet mode. In addition, some remote control programs support control of remote computers over limited distances via serial, parallel, USB and infrared ports. The basic model of the remote control system in this paper is shown in Figure 2.

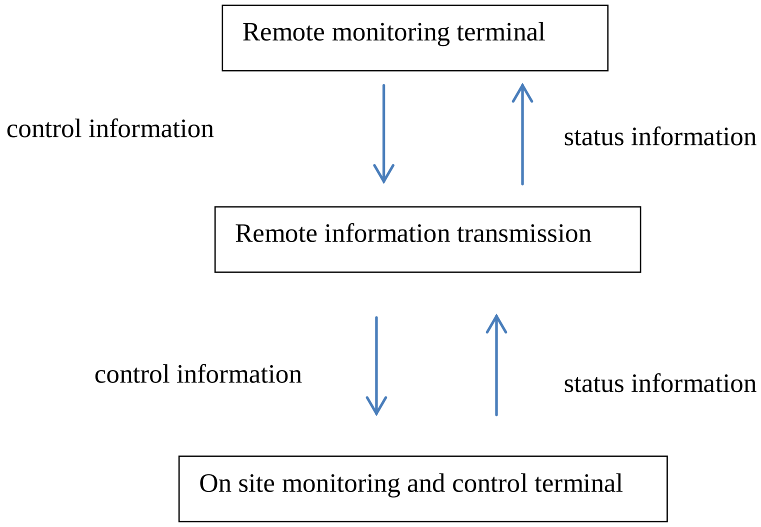


*Figure 2. Basic model of remote control system*

# 3. Experiments and Research on a Speech Remote Control System for Intelligent Robots Using the Finite Volume Method

## 3.1. Experimental Objectives

On the basis of the system design, a wireless local area network is constructed between the PC and the AGV using a wireless network card to run the client and server side programs respectively. The client (upper computer) remotely controls the movement of the AGV through voice recognition, e.g.: move forward, go 1m to the left, etc. At the same time, the images taken by the camera on the AGV (server) of the lower unit are transmitted wirelessly to the client, and the operator monitors the working status of the AGV remotely according to the images transmitted back from the remote, so as to understand the wireless remote control of the AGV. The lower unit receives the control command from the upper unit through the wireless network and feeds back the message to the upper unit in time, while the upper unit calls the speech synthesis module to interact with the operator by voice.

### 3.2. Experimental Tasks

The experiments were carried out in the key laboratory for machine building equipment at the University of Technology. The distance between the east and west sides of the laboratory is approximately 30 metres. The host computer is located on the west side of the laboratory and the AGV is located on the east side of the laboratory. Through human-machine voice interaction, the AGV's movements are controlled remotely by wireless voice.

### 3.3. Voice Remote Control Experiment

The signal-to-noise ratio of the laboratory environment is about 30dB-35dB, and the background noise mainly includes tapping the keyboard, machine running, human walking and soft talking.

The experimental procedure is as follows:

(1) Training

According to the training system prompts, five sets of speech data were collected, standard Mandarin was collected, and a period of silence was maintained before and after the speech.

(2) Test

Speech recognition test was conducted according to the test content. There were eight testers, four were male and four were female, and the testers pronounced the words clearly, but one had a slight accent.

## 4. Experimental Analysis on the Finite Volume Method of Voice Remote Control System for Intelligent Robots

### 4.1. Voice Control Based on Command Mode

In order to test the speech recognition rate of the system as well as its practicality, the experiment consisted of pre-set simple motion commands such as "forward", "backward" and "right turn". The speech recognition rate is calculated according to equation (3).

$$\text{Speech recognition rate} = \frac{\text{words or phrases successfully recognized}}{\text{words or phrases input by voice}} \text{x}100\% \tag{3}$$

The number of words or phrases to be phonetically entered in the experiment is known, and the number is added by one if the input is repeated once. The results of the experiment are shown in Table 1:

*Table 1. Command mode experiment results*

| Tester no | Recognition rate | Maximum number of repetitions | Misidentified word |
|---|---|---|---|
| 1 | 100% | 0 | |
| 2 | 93.4% | 1 | Back off |
| 3 | 100% | 0 | |
| 4 | 100% | 0 | |
| 5 | 93.4% | 1 | Turn right |
| 6 | 100% | 0 | |
| 7 | 100% | 0 | |
| 8 | 100% | 0 | |

## 4.2. Voice Control Based on Dictation Mode

For more complex task descriptions such as "turn left and go straight for 5 metres" and "pick up a person at the door", dictation-based speech control is used. The system recognition rate is based on the word recognition rate, i.e. the recognition rate can be derived by comparing the resulting word sequence with the control command to be entered. The recognition rate R is calculated as shown in equation (4):

$$R = \frac{t * N - W}{t * N} * 100\% \tag{4}$$

Where N represents the total number of words to be recognised, t represents the number of speech inputs and W represents the number of incorrectly recognised words. The experimental results are shown in Table 2 and Figure 3:

*Table 2. Results of dictation experiment*

| Tester No | Recognition rate | Maximum number of repetitions | Misidentified word |
|---|---|---|---|
| 1 | 86.7% | 2 | Back then right |
| 2 | 80% | 3 | Turn left and go straight for 5 meters |
| 3 | 100% | 0 | |
| 4 | 93.4% | 1 | 10 meters to the right |
| 5 | 86.7% | 2 | Go to the door to pick up someone |
| 6 | 100% | 0 | |
| 7 | 100% | 0 | |
| 8 | 100% | 0 | |

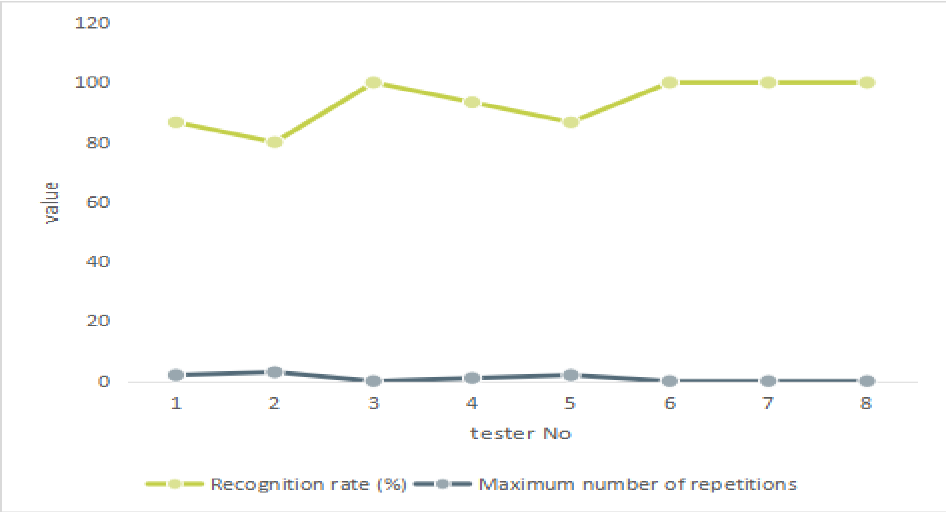


*Figure 3. System identification effect*

## 5.Conclusion

The problem of acoustic transmission has been of great interest in the fields of mathematics and physics, and is widely used in remote control, space reconnaissance, scientific imaging, geographic surveys, non-destructive testing and other fields. At the same time, the study of mathematical theory and numerical methods for acoustic wave transmission problems is of outstanding scientific value. In scientific and engineering research, it is important to establish the relevant differential equations to describe a physical phenomenon. However, it is often very difficult to obtain analytical solutions to certain differential equations, so numerical methods are used to calculate the corresponding numerical solutions. This paper focuses on the finite volume method of voice remote control system for intelligent robots, and establishes numerical simulations of the finite volume method of acoustics, but further improvements to the hardware design of intelligent robots are needed.

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## Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## Conflict of Interest

The author states that this article has no conflict of interest.

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