CHEMICAL ENGINEERING TRANSACTIONS
VOL. 66, 2018

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Songying Zhao, Yougang Sun, Ye Zhou

ISBN 978-88-95608-63-1; **ISSN** 2283-9216
DOI: 10.3303/CET1866156

Research on Network Remote Control of Mine Robot Based on Fusion Algorithm

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It is used to study network remote control of mine robot using fusion algorithm. With reference to relevant literature, network remote control system of mine robot is established through TCP/IP communication protocol, Visual studio C++.NET 2003, and MFC library to realize remote monitoring by using a visual interface program. As a result, in the hill climbing test, if the robot receives a command to advance in the north direction, it will autonomously and steadily go northward on the hill. At the same time, monitor screen can also be transmitted to the operation center in real time. In the hill climbing test, track robot in this article can successfully achieve autonomous navigation and screen transfer under the network remote control navigation and monitoring, thus achieving semi-automatic control.

1. Introduction

When demand for domestic coal has been continuously increasing at present, most coal companies do not take appropriate safety measures when they increase the production efforts. This has caused the recurrence of coal mine accidents in China, which has seriously threatened the safety of coal miners. Faced with this situation, Chinese government has continuously improved the relevant laws and regulations and increased the supervision of various mining areas in order to reduce the incidence of coal mine accidents, with little success. At present, research and application of robots has gradually shifted from the military field to civil use. With the rapid development of science and technology, information technology and communication technology, some domestic scholars have applied robots in the underground testing of coal mine. Based on it, it is necessary to strengthen the monitoring of various related data of coal mine, and find out the existing laws using the scientific analysis of these data so as to establish network remote control system of mine robot to ensure the safety of underground environment of coal mine. It can be said that it is of the vital practical significance for research on network remote control of mine robot based on fusion algorithm in the paper.

In order to study the network remote control of mine robot in this paper, network remote control system of mine robot is established based on fusion algorithm by using relevant literature and through TCP/IP communication protocol, Visual studio C++.NET 2003, and MFC library to realize remote monitoring by using a visual interface program.

2. Literature review

To achieve an agile and accurate motor control performance on coal mine detection robots TUT-CMDR, Fuzzy-PID control and its model building method in the Simulink environment are explored. The transfer function model of the TUT-CMDR motor transmission system is established and M-files used to ascertain the gain of the PID control are compiled. The final value of the step block is configured to a variable and parameterized quantization factors and scaling factors are proposed to solve the problem of different basic universe for different final value. Some improvement is also made on the existing fuzzy control rules. Finally, the designed controller is proved to show a better control performance (Niu and Wang, 2012). As the explosion-proof safety level of a coal mine robot has not yet reached the level of intrinsic safety “ia” and it cannot work in a dangerous gas distribution area, therefore, path planning methods for coal mine robot to avoid the dangerous area of gas are necessary.

Please cite this article as: Li J., 2018, Research on network remote control of mine robot based on fusion algorithm, Chemical Engineering Transactions, 66, 931-936 DOI:10.3303/CET1866156

In the paper, to avoid a secondary explosion when the coal mine robot passes through gas hazard zones, a path planning method is proposed with consideration of gas concentration distributions. First, with consideration of gas distribution area and obstacles, MAKLINK method is adopted to describe the working environment network diagram of the coal mine robot. Second, the initial working paths for the coal mine robot are obtained based on Dijkstra algorithm, and then the global optimal working path for the coal mine robot is obtained based on ant colony algorithm. Lastly, experiments are conducted in a roadway after an accident, and results by different path planning methods are compared, which verified the effectiveness of the proposed path planning method (Mao and Ma, 2016). The coal mine environment is complex and dangerous after gas accident; then a timely and effective rescue and relief work is necessary. Hence prediction of gas concentration in front of coal mine rescue robot is an important significance to ensure that the coal mine rescue robot carries out the exploration and search and rescue mission. In this paper, a gray neural network is proposed to predict the gas concentration 10 meters in front of the coal mine rescue robot based on the gas concentration, temperature, and wind speed of the current position and 1 meter in front.

Subsequently the quantum genetic algorithm optimization gray neural network parameters of the gas concentration prediction method are proposed to get more accurate prediction of the gas concentration in the roadway. Experimental results show that a gray neural network optimized by the quantum genetic algorithm is more accurate for predicting the gas concentration. The overall prediction error is 9.12%, and the largest forecasting error is 11.36%; compared with gray neural network, the gas concentration prediction error increases by 55.23%. This means that the proposed method can better allow the coal mine rescue robot to accurately predict the gas concentration in the coal mine roadway (Ma and Zhu, 2016). The technologies of wireless mesh network are adopted and a new remote control and communication system for intrinsically safe robot is proposed. This paper focused on the principle of its architecture, software implementation ways of remote control system and analysis of its data flow. The system has the advantages of superior range for wireless controlling and more visual data than other similar systems, which is verified by experiments and has practical value (Liu et al., 2017). Transfer function model of speed control system of TUT-CMDR motor was established. Firstly, initial weights and thresholds of BP neural network were optimized by Quantum Genetic Algorithm, and then BP neural network was designed to adjust the parameters of PID on line. Finally, the results show that the algorithm is feasible and superiority (He and Niu, 2013)

The paper presents the development and application of measurement and control devices and control information systems in coal mines with underground exploitation. The locations of units for measuring the concentration of methane, carbon monoxide and oxygen; the control of short circuits on ventilation doors; the control of main fan depression and the airflow speed are proposed. As a result of the research, the structure of control information system in Senje mine and ergonomic analysis of measurement and control devices in this mine are presented. Further modes of development of control information systems in underground mines in Serbia and solutions for their reconstruction are proposed (Marjanovic et al., 2015). The research of detecting by coal mine shaft underground explorative robot make the coal mine rescue works implements smoothly, to reduce casualties caused by mine disaster, it will be substituted for or partial substituted for emergency workers to enter the coal mine rescue. Main effect of coal mine detection robot is taking place of human to go into the post- disaster coal mine for detecting information of the environment and sending the information to the command center. Therefore, it is of great significance to research on coal mine detection robot for reducing casualties and unfolding of the saving work smoothly. Researches on the hardware design of control system of servo drive are not only the key technology of the issue, but also the guarantee on completing the detection task of coal mine detection robot (Liu, 2014). The coal mine rescue robot is the device which replaces the rescue workers to detect the environment and rescue victims in mine. And the control system is the core of the coal mine rescue robot and decides the performance of the robot. To design the control system which meets the requirement of coal mine rescue, it is firstly analyzed that requirements of the coal mine rescue robot in this study. Then, it is recommended that the control systems of coal mine robots which have been developed in China and its advantages and disadvantages are analyzed. In the end, we suggest an open control system based on ether net which meets the requirements of the coal mine rescue robot. The outdoor test shows that this control system effective and reliability for coal mine rescue robot (Liu et al., 2013).

Currently, more than 100 million anti- personnel mines are under the ground all over the world. These mines not only disturb the economic development of mine- buried nations, but also injure or kill more than 2000 people a month. As a result, the removal of landmines has become a global emergency. China as one of the largest coal production and consumption country around the world, it is also of the accident occurred frequently country such as fire damp explosion, water burst, catch on fire during the exploitation of coal mine.

3. Method

A protocol must be established before long-distance communication is carried out. The currently accepted, versatile protocol is TCP/IP protocol that is distributed hierarchically. It adopts a four-layer model concept, namely application layer, transport layer, internet layer, and network interface layer. Two protocols are used in the transport layer of TCP/IP protocol. The choice of the two protocols has direct impact on the quality of the entire communication. Therefore, advantages and disadvantages of the two are compared to determine the communication protocol that is suitable for the system.

First, TCP is a connection-based protocol, but IP is a connection-less protocol. The specific difference between TCP protocol and IP protocol is reflected in two aspects. First, TCP protocol data aims ultimately for connection, but IP protocol data is for destination port. Therefore, TCP protocol port is reusable, but IP protocol port can only be used by a program at a certain moment. Second, a connection must be established before the subsequent communication is carried out in the TCP protocol. That is to say, connectivity issues must be negotiated between two parties before connection is established, including window size, maximum data length, etc.. However, data can be directly sent and received through IP protocol. Furthermore, transmission service provided by TCP protocol is more reliable than that of IP protocol, that is, cases such as data loss, out-of-sequence, and duplication do not generally emerged during the transmission. In addition, transmission data in TCP protocol is in the form of byte stream, and transmission data in IP protocol is in the form of data block.

Reliable byte stream is adopted in the transmission of TCP protocol, which is a mechanism to ensure efficient data transmission. Therefore, it is generally used if a large amount of data is required to be reliably transmitted, such as file transfer protocols. However, if a small amount of data or a small amount of data packet is required to be transmitted in the application program, it is not suitable to use TCP protocol, for connection must be established before communication is carried out in TCP protocol, requiring a certain amount of time, which is inconvenient. In particular, even if a small number of certain data must be transmitted reliably, it is better to use TCP protocol.

Through comprehensive comparison of the advantages and disadvantages of the two described above, TCP and IP protocols are used by absorbing their advantages. That is to say, TCP protocol is used for remote command transmission to ensure the correctness and reliability of the command, preventing the robot system from malfunctioning or breakdown due to mis-operation. In order to ensure real-time video image transmission, UDP protocol must be used.

Different from the video information transmission with features of real-time capability and continuity, control command transmission has relatively long interval between two control commands. In addition, after a command is issued, the robot is not allowed to have large deviation or error. In order to improve the reliability and effectiveness of command, TCP protocol is used to achieve high-frequency sampling.

As shown in Figure 1, the whole remote monitoring delay is mainly composed of t1+t2+t3+t4, where t1 is the transmission delay of the control command, t2 is the on-site data transmission delay, and t3 is the delay for sending the command caused by the operator, as well as T4 is the delay caused by the control of the scene.

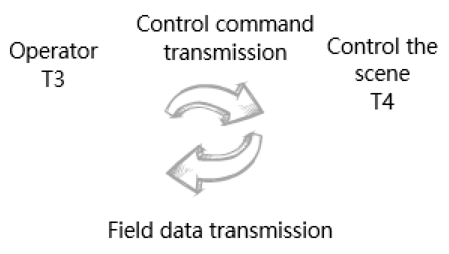

Figure 1: Remote monitoring delay

Obviously, both delays exist in the general remote monitoring system. For example, status data processing time refers to the time required for the controller to process the acquired information and status data to facilitate identification and transmission. The command processing time refers to the time required by field robot to process the commands from the remote command center so as to form a specific data format for identification of its own system.

In order to extend the communication distance, a considerable number of relay stations are added, information will be delayed in the transmission process due to the delay of network transmission, which will undermine the stability of the system. Therefore, in order to facilitate the study of the problem, this type of delay is attributed to a lagging link, as shown in Figure 2.

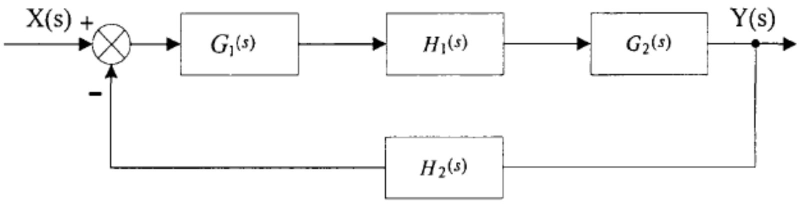

Figure 2: Block diagram of remote monitoring system that simplifies network delay as a lagging link

The transfer function is:

$$G(S) = \frac{G_1(S)G_2(S)}{1 + G_1(S)G_2(S)H_2(S)} \tag{1}$$

At present, hardware and software encodings are adopted in the video compression encoding. However, hardware video encoder cards generally have higher costs, and MPEG-4 is particularly expensive. Therefore, software encoding is generally used now. It can be seen from the previous paragraph that MPEG-4 compression method is more suitable, so video streaming is designed in this system to meet the requirements of remote monitoring for robot, and achieve good transmission in the selected communication mode.

The workflow of this solution is as follows: The video information is collected by camera, then sent to the industrial computer of robot via the USB interface for MPEG-4 encoding compression. After that, the information is transmitted to the communication network through the RTP/RTCP protocol, and received by the remote command center for decoding. Finally, the information is replayed through the display software.

Figure 3 is the video transmission module structure diagram, in which the lower-level network transmission module utilizes Winsock to perform network data transmission under the RTP/RTCP protocol, and perform compression through video encoding and decoding, and at the same time complete mode shifting recognized by the system to display the live image at the monitoring center in a real-time manner.

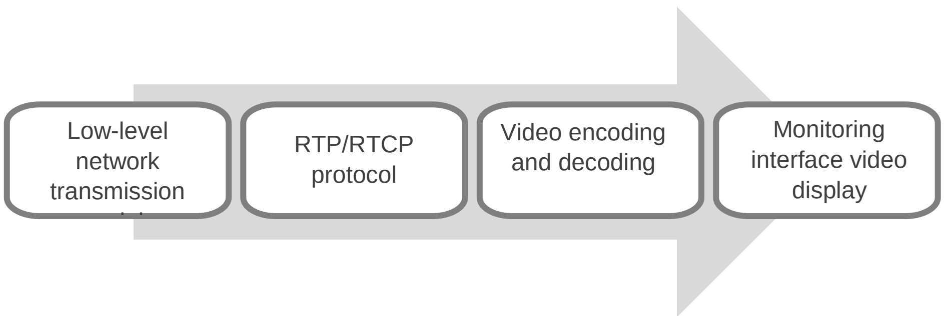

Figure 3: Video transmission module structure

4. Results and discussion

4.1 The overall design of software for remote terminal system

Based on Windows XP, The software for detecting robot studied in this paper adopts programming language of Visual studio C++.NET 2003, and foundation class Library 7.0 application framework (MFC library for short). The MFC framework defines the outline of the application and provides a standard implementation of the user interface. Programmer is responsible for filling in the outline of the specific application by the predefined interface.

In the remote monitoring system, it is also necessary to package the written application into a DLL dynamic link library so as to be well linked with the visual interface edited with VB. The visual interface must have the features of friendliness, simplicity, and ease of operation when editing. The following content will focus on the preparation and design of the remote terminal interface.

Given the high visual programming language and simple programming, the interface uses Viaual Basic in the design. Property values, ID values, and categories of button controls for several parameter variables, radio button controls, and edit controls are shown in Table 1.

Table 1: Button Controls Categories and Properties

Category	Caption	ID number
ButtonControl	go ahead	IDC-FRONT
ButtonControl	Recede	IDC-BACK
ButtonControl	Turn left	IDC-LEFT
ButtonControl	Turn right	IDC-RIGHT
ButtonControl	stop	IDC-STOP
EditControl		IDC-SPEED
EditControl		IDC-ACCE

4.2 Debugging experiment for robot motion

First, system initialization settings are made on the robot, beginning from serial port number and baud rate. The serial port number is set to COM2. After that, a wireless communication environment is created by inserting a USB wireless network card in the robot embedded industrial computer and searching wireless network from network neighborhood to set the wireless communication network of notebook and the robot with the wireless network cards in the remote computer. Then network video data is collected by clicking the button on the robot to set the corresponding remote termination address, selecting the corresponding video source, and starting the receiving service by clicking the desktop button on the remote computer to enter the IP address of the robot. Figure 4 is the video window operation of the server and client. It can be seen from the figure that the video source is correctly displayed to verify the correctness of hardware and software design.

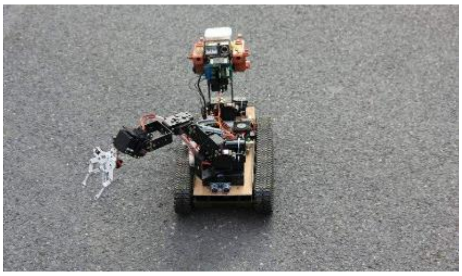

Figure 4: Acquisition of remote video information

In the fourth step, the previous several steps have made the transmission and playback of video images possible. At this point, remote control operation can be performed. For the convenience of control, rocker of track robot is used in the operation. This rocker is also called as “handle” using the USB button interface, which has good maneuverability and adaptability for the platform. It is equipped with multiple function keys, including dual throttle control keys.

The remote monitoring of the entire wireless network is carried out in accordance with the above steps. In addition, remote control test and mechanical climbing and crossing obstacle capability test are performed under different road conditions near the laboratory. As shown in Figure 5, test results for remote control of robot and video transmission acquisition several hundred meters away are satisfactory.

Figure 5: Robot Hill Climbing Test

This section is mainly involved in the design and debugging of remote terminal software system for the robot. First, software design idea and principle is analyzed in an overall manner, and then development environment based on Windows XP with programming languages of Visual Studio C++.NET 2003 is proposed. In addition, MFC library is used to process the application framework, supplemented by visual interface programming, thus realizing the design of remote monitoring interface. Its basic motion interface is taken as an example to illustrate the processing of the code and design of interface.

For TYT-CMDR detecting robot, related tests in remote monitoring system are performed. In laboratory environment, a wireless transmission network is established, and then software interface and baud rate are set. Finally, video acquisition and remote control are completed successfully.

5. Conclusion

In order to study the network remote control of mine robot in this paper, network remote control system of mine robot is established based on fusion algorithm by using relevant literature and through TCP/IP communication protocol, Visual studio C++.NET 2003, and MFC library to realize remote monitoring by using a visual interface program. The results of this paper show that in the hill climbing test, if the robot receives a command to advance in the north direction, it will autonomously and steadily go northward on the hill. At the same time, monitor screen can also be transmitted to the operation center in real time. From the results of the research, it can be seen that in the hill climbing test, track robot in this article can successfully achieve autonomous navigation and screen transfer under the network remote control navigation and monitoring, thus achieving semi-automatic control.

Although certain research results have been obtained, our research also has certain insufficiency: network remote control of mine robot in this paper will lead to navigation error under certain conditions. From the experiment process, it can be seen that control algorithm of remote control system of mine robot has some defects, leading to the semi-automatic navigation of the robot, which urgently needs to be improved.

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