CHEMICAL ENGINEERING TRANSACTIONS
VOL. 71, 2018

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

Guest Editors: Xiantang Zhang, Songrong Qian, Jianmin Xu

ISBN 978-88-95608-68-6; **ISSN** 2283-9216

DOI: 10.3303/CET1871221

Fault Detection Algorithm Design of Chemical Robots Based on Internet of Things and Deep Learning Feature Extraction Technology

Jian Yang, Li Yang

School of Economics and Management, Anhui University of Science and Technology Huainan, Anhui 232001, China
jianyangab812@163.com

In order to improve the fault detection effect of intelligent Chemical robots, this paper design fault detection algorithm of intelligent Chemical robots. Based on the Internet of Things and deep learning feature extraction technology, this paper combines WIFI and TCP/IP to optimize the RSSI path loss model, and obtains a path loss model with multi-path effects suitable for Chemical roadways to construct simplified model of robots. It is found that the robots could climb over vertical barriers with a height of 19 cm. It can be seen that the practicability and reliability of communication system are verified by the experiment. The stability conditions and theoretical barrier height of robots are obtained, which is significantly improved.

1. Introduction

China is the largest developing country in the world, which is rich in coal resources. According to the statistics, China's coal consumption accounts for more than half of the total energy consumption. At present, China’s industrialization degree is still high. However, there are dangers of gas explosion and water permeation in coal Chemicals. Any carelessness will result in serious casualties. Therefore, it is necessary to research and develop an intelligent Chemical robot which can detect faults effectively. Based on the Internet of Things and deep learning feature extraction technology, this paper combines WIFI and TCP/IP to optimize the RSSI path loss model, and obtains a path loss model with multi-path effects suitable for Chemical roadways to construct a simplified model of robots.

2. Literature review

In recent years, many domestic experts and scholars have put forward many concepts about the overall description of Chemical development, such as digital Chemical, Chemical integrated automation, perceptual Chemical, perceptual Chemical Internet of Things and so on, and now, intelligent coal Chemical is put forward. IBM put forward the concept of "smart earth", that is, "Internet + Internet of things = smart earth", and the concept of "smart earth" derives concepts such as perceptual Chemical, intelligent Chemical, intelligent mining, intelligent coal Chemical and so on. In fact, in 1992, Bandyopadhyay et al. put forward the plan of building intelligent Chemicals for the first time in Finland. The plan mentioned the realization of real-time control of mining process, building Chemical information network and real-time resource management (Bandyopadhyay et al., 2017). Bsoul pointed out the core content of the perceptual Chemical construction and the concept of perceptual Chemical (Bsoul, 2017). Geng et al. thought that intelligent coal Chemical was a digital intelligence body, which could collect all information of coal Chemical enterprises in real time and accurately, and transmited data through network, so as to realize intelligent service and visualization display (Geng et al., 2017). Li et al. held that intelligent coal Chemical was based on multi-network fusion technology, cloud computing, data fusion technology, Internet of Things technology, etc., through in-depth analysis of the collected massive data to achieve the automated management and control of personnel, information, equipment and so on in coal Chemical enterprises (Li et al., 2017). Liu and Wang believed that intelligent coal Chemical was the product of the new generation of information technology, such as Internet of Things, cloud computing, optical fiber network, 3G mobile Internet, and mining engineering, as well as advanced

Please cite this article as: Yang J., Yang L., 2018, Fault detection algorithm design of chemical robots based on internet of things and deep learning feature extraction technology, Chemical Engineering Transactions, 71, 1321-1326 DOI:10.3303/CET1871221

management methods, management concepts, and science and technology (Liu and Wang, 2018). Mostafa and Koroush pointed out that the goal of intelligent coal Chemical was safe, efficient and green mining, building an automated, humane and highly intelligent Chemical, and creating an unmanned production mode (Mostafa and Koroush, 2016).

With the research and development of Internet of Things, its architecture has not yet defined a standardized system. However, the framework is generally recognized by scholars and researchers as being divided into three levels: the lowest layer is the perception layer, which is used to perceive various data; the middle layer is the network transmission layer, which is used to transmit various data; and the top layer is the application layer, which is used to provide application services. As all the architecture of intelligent coal Chemical is based on the framework of Internet of Things, and built on it, so far, the architecture of intelligent coal Chemical has not yet had a clear standard system. Researchers also use the three-tier architecture of Internet of Things to design the three-tier architecture of perceptual Chemical, which is corresponding to the framework of Internet of Things: the perception layer, the transport layer and the application layer, respectively. In the research of intelligent coal Chemical system architecture, a few scholars divide it into different levels because of the difference of purposes and angles. Typically, an intelligent coal Chemical architecture composed of Internet of Things layer, Internet layer and intelligent layer is constructed, and an overall structure composed of three modules is constructed, which are intelligent information acquisition, intelligent production and operation, and intelligent management decision-making.

Intelligent coal Chemical is to realize the intelligent management and control of people, equipment, information, materials and so on in the process of Chemical production and management with the help of a variety of advanced technologies, so as to realize intelligent coal Chemical. Many experts and scholars will discuss the key technology of intelligent coal Chemical while studying its concept and system. Oshiro and Ohkohchi believed that wireless sensor network technology, anti-jamming technology, data fusion technology, multi-network fusion technology and emergency rescue and disaster recovery technology are indispensable key technologies for intelligent coal Chemicals (Oshiro and Ohkohchi, 2017). Pulver and Medina put forward intelligent coal mining key technologies from the perspective of space information technology: three-dimensional simulation and virtual reality technology, spatial information technology, cloud network integration technology, data mining technology, intelligent mining and service technology, and mining technical specifications and standards (Pulver and Medina, 2017). Wang and Zhang considered that materialization, interconnection and intellectualization were the key to realize intelligent coal Chemical, and the key technologies involved in them were studied from data acquisition and control technology, data modeling and integration technology, process integration technology, and business process service technology (Wang and Zhang, 2017). They also used SOA architecture to build intelligent coal Chemical informatization and proposed the key technologies of building intelligent coal Chemical, such as component architecture based on SOA, J2EE technology system, middleware technology, business collaborative management technology and GIS technology. Li analysed that the construction technology of intelligent coal Chemical should include: intelligent coal Chemical framework system and standard specification, Internet of Things key technology, spatial data warehouse technology, GIS Technology, virtual coal Chemical platform technology, spatial analysis technology, decision support technology, safety management technology, system platform design and development technology (Li, 2018).

In summary, the above research work mainly analyses the operation of intelligent coal Chemical robot and the design of algorithm, and concludes that it can collect all information of coal Chemical enterprise in real time and accurately, and transmit data through network, so as to realize intelligent service and visualized display. In addition, it can carry out multi-network integration technology, cloud computing, data fusion technology, Internet of Things technology, etc. Through in-depth analysis of the collected massive data, it can realize the automatic management and control of personnel, information, equipment and so on in coal Chemical enterprises. Therefore, based on the above research status, the fault detection algorithm design of intelligent coal Chemical robot based on Internet of Things and deep learning feature extraction technology is mainly studied. The Internet of Things and deep learning features are applied to extract key technical information, which is rapidly applied in today's development.

3. Principles and Methods

The fault model training method based on deep learning mainly includes supervised learning and unsupervised learning, semi-supervised learning and reinforcement learning. In the process of reinforcement learning, data is mainly from the feedback of external environment. The model must respond to these feedback data. The data are adjusted dynamically to achieve the goal of reinforcement signal, which is applicable to the system control and robots.

The fault prediction technology is divided into static and dynamic. 1) The static prediction is test by calculating quality attributes of the system and based on the prediction model according to historical fault records; 2) The dynamic prediction means to monitor the current operation state and collect important parameters of the system. The prediction is according to the safety valve of each parameter.
Based on the analysis of the coal Chemical environment, Chemical disaster information detection robots should meet certain requirements in terms of functions and performances to successfully complete the detection. The Chemical disaster information detection robots designed in this paper are mainly considered the following two aspects.
(1) Functional Requirements.
The main task of Chemical disaster information detection robots is to enter into the first scene immediately when there is a coal Chemical disaster, which requires robots to carry a variety of sensors and to possess the ability of wireless communication and a certain machine intelligence, to achieve the real-time control of robots on the ground.
(2) Performance Requirements.
At first, both the real-time control of robots and the synchronization of information and picture transmission should be ensured. The electrical part shall be in line with the explosion-proof performance of underground work and the working standard of GB3836-2000.To ensure the reliability of robots, the anti-interference performance should meet the standard of MT209-1990.
This paper develops a two-stage Chemical information detection robot based on the underground Chemical refuge chamber. Relying on the underground Chemical refuge chamber and I-beam monorail, when a coal Chemical disaster occurs, the first-stage robot (a carrying robot) will move to the disaster scene quickly from around the underground Chemical refuge chamber, along theI-beam monorail. When the robot reaches the disaster scene or is unable to move on due to the damage of monorail, the first-stage robot (a carrying robot) will be replaced by the second-stage robot. The second-stage robot continues to into the disaster scene for further information collection and detection. Figure 1 shows the overall structure of the Chemical disasters information detection robot.

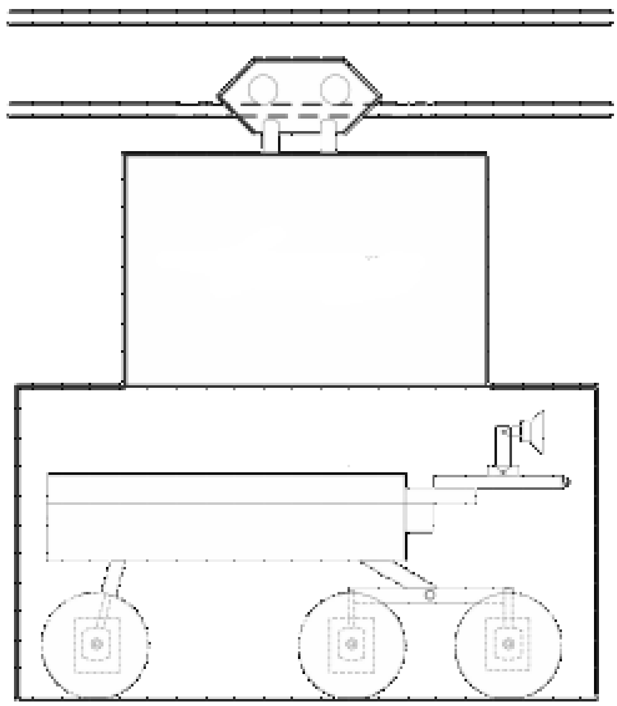

Figure 1: Disasters Information Detection Robot

At present, there is amonorail craneconnected to a working face for coal mining in most underground coal Chemicals in China, so as to transport coal mining machinery, personnel and materials, etc., as shown in Figure 2. Therefore, monorail information detection robots can be used to save resources to the greatest extent. At the same time, the monorailis an energy-saving way, that ensures robots can work for a longer time under the limited energy supply.

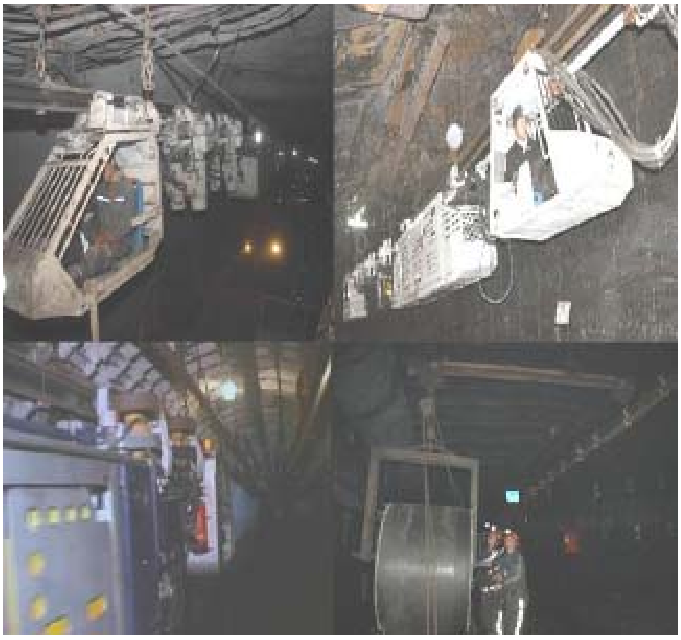

Figure 2: The Tunnel in Coal Chemical

Most of underground coal Chemical disasters occur in or near the working face, including the coal mining face, the tunneling face and so on. Because these places are first-line production areas for coal mining or tunneling, and chamber excavation with a large number of operating engineering equipment, which can easily cause loose collapse accidents of coal seams and rock strata, coal and gas outburst accidents. If the ventilation is not free, gas accumulation and explosion accidents can easily occur. In this paper, a disasters information detection robot is placed in the refuge chamber (as shown in Figure 3). Oncea disaster occurs, the ground staff can remote control the robot to move to the disaster scene quickly from the refuge chamber, along the rail. When the robot reaches the disaster scene or is unable to move on due to the damage of rail, the second-stage robot will be released to detect information, which is transferred to the ground command post by the wireless communication network.

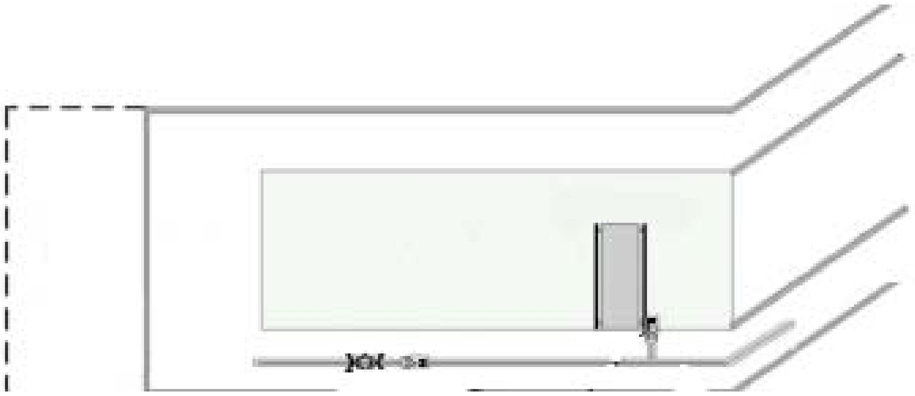

Figure 3: The Tunnel in Coal Chemical

4. Results and Analysis

The computer used in the experiment is Acer laptop (with wireless card) with the IP address of 192.168.1.150, the operating system of Windows 7 and the component of NET Framework 4.0. The network test is conducted at a given point, that is the office where the ground master computer installed, with the SSIDer, a wireless signal scanning tool, to test the network connection. Taking the wireless controller of the robot walking mechanism as an example, the pinging command can be used to test the packet loss rate and average delay of the network. Figure 4 is the network connection test schematic diagram. Table1 shows the underground image information collected by a camera fixed at one location (IP address: 192.168.1.157).

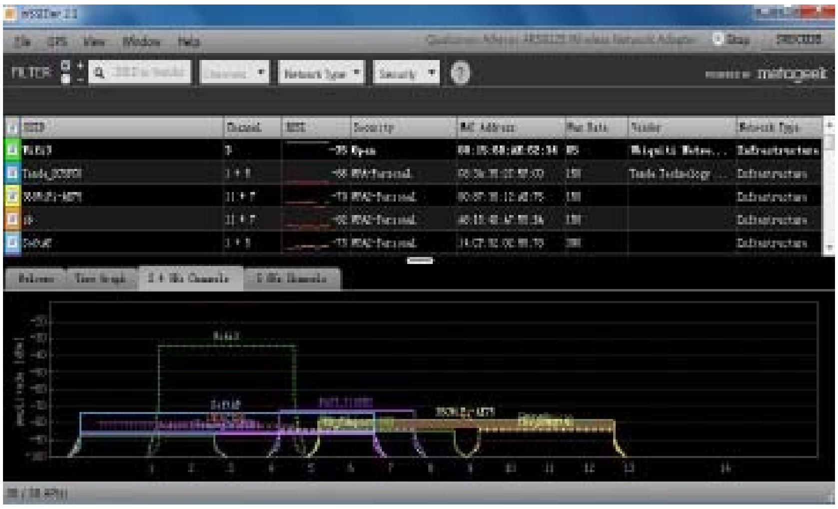

Figure 4: Network Connection Test Schematic Diagram

Table 1: Configuration and Deployment of Laboratory Equipment

Device	Deployment Location	Features
Wireless access point	Middle position of main roadway	Create a wireless LAN
Wireless Controller	Marching along the track	Remote control robot walking
Web video camera	Loaded on the robot	Collecting image information
Wireless bridge	Communication link	Relay， amplify wireless signals

The attachment coefficient of dried cement road surface is 0.8 to 1.0. As shown in Figure 5, the barrier height of ordinary wheeled robot on the cement road is 10 to 12 cm. As the attachment coefficient cannot increase indefinitely, the barrier height will not exceed 16 cm in limiting cases.

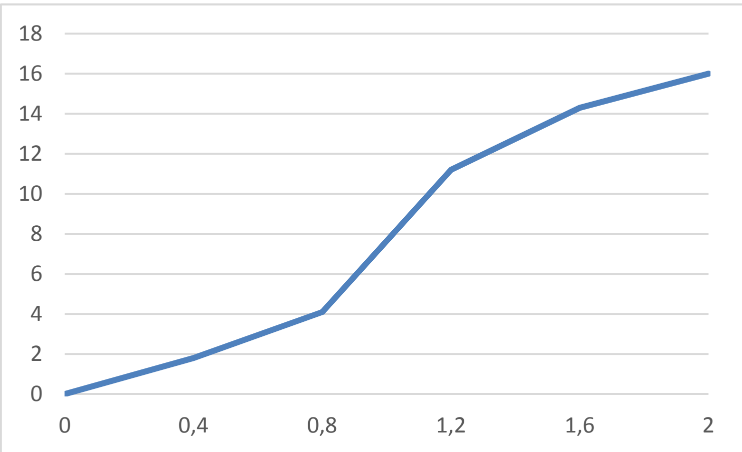

Figure 5: Attachment Coefficient and Barrier Height Change Curve

In order to verify the robots' surmounting barriers ability and the theoretical calculation results, this paper carries out a surmounting vertical barriers ability experiment by the experimental equipment. At first, the vertical barrier height is set to 27 cm. When the robot's swing arms are to over the front end of barrier, front wheels suspend and are away from the barrier surface due to the limitation of backward rotation angle. The gravity center shifts backward, and the robot fails to surmount the barrier. After several tests, when the vertical barrier height is adjusted to 19 cm, the gravity center is perpendicular to the barrier front and the robot successfully surmounts the barrier. That is, the robot reaches its limit in surmounting barriers. Taking the friction coefficient and measurement errors into account, the actual value of 19 cm is basically consistent with the theoretical value of 21.3 cm, verifying the correctness of theoretical calculation. The robot has advantages of fully driven wheeled robot and a strong ability of passive adaptation to terrains due to the design of two-side swing arms. The robot can climb over vertical barriers with a height of 19 cm according to the theoretical calculation and the experiment.

5. Conclusion

After the occurrence of coal Chemical disasters, Chemical disaster information detection robots can enter into the disaster scene immediately to detect the environmental information and transmit it to the ground rescue command post, providing essential information for the post-disaster rescue work and playing an important and practical role. In order to reach the disaster scene smoothly after the occurrence of coal Chemical disasters and transmit the information of disaster scene to the ground quickly and accurately, higher requirements are put forward for the overall system design. The communication system between the coal Chemical disaster scene and ground is designed. The monitoring system of coal Chemical rescue robots designed in this paper is based on WIFI and TCP/IP. A path loss model suitable for special environment of Chemical roadways is obtained by optimizing the RSSI path loss model. The wireless AP nodes layout of Chemical roadways is in accordance with the side model, which provides the basis for the communication system construction of Chemical roadways in the future. The stability conditions and theoretical barrier height of robots are obtained according to the analysis of the static stability and surmounting barriers performance of second-stage information detection robots, which provide theoretical basis for the functional design of robots.

With the continuous development of sensor technology, the research on multi-sensor information fusion has become a focus of researchers. How to more effectively integrate multi-sensor information, as well as how to improve the map construction and path planning of mobile robots need further research in the future work.

Reference

Bandyopadhyay S., Foo D., Tan R., 2017, Pursuing sustainability with process integration and optimization, Process Integration & Optimization for Sustainability, 1(1), 1-2, DOI: 10.1007/s41660-017-0006-1

Bsoul M., 2017, A differential indexing approach for wireless sensor networks, Wireless Personal Communications, 97(4), 1-15, DOI: 10.1007/s11277-017-4628-y

Geng H., Liang Y., Liu Y., 2017, Bias estimation for asynchronous multi-rate multi-sensor fusion with unknown inputs, Information Fusion, 39, DOI: 10.1016/j.inffus.2017.03.002

Li P., 2018, Chemical water problems and solutions in china, Chemical Water and the Environment, 37(2), 217-221, DOI: 10.1007/s10230-018-0543-z

Liu H., Wang C., 2018, An improved genetic algorithm for increasing the addressing accuracy of encoding fiber bragg grating sensor network, Optical Fiber Technology, 40, 28-35, DOI: 10.1016/j.yofte.2017.10.005

Mostafa G., Koroush S., 2016, A new analytical solution for calculation the displacement and shear stress of fully grouted rock bolts and numerical verifications, International Journal of Mining Science & Technology, 26(6), 1073-1079, DOI: 10.1016/j.tust.2017.03.007

Oshiro Y., Ohkohchi N., 2017, Three-dimensional liver surgery simulation: computer-assisted surgical planning with three-dimensional simulation software and three-dimensional printing, Tissue Engineering Part A, 23(11-12), 474, DOI: 10.1089/ten.tea.2016.0528

Pulver A., Medina M., 2017, A review of security and privacy concerns in digital intelligence collection, Intelligence & National Security, 1-16, DOI: 10.1080/02684527.2017.1342929

Wang B., Zhang Y., 2017, Adaptive sliding mode fault-tolerant control for an unmanned aerial vehicle, Unmanned Systems, 5(4), 13, DOI: 10.1142/s2301385017400052