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Jason C. Hung · Jia-Wei Chang · Yan Pei *Editors*

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Editors

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Computer Aided Simulation Experiment of Endogenous Microbial Oil Displacement

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Abstract. Endogenous microbial oil recovery technology has attracted more attention because of its strong adaptability, good compatibility with reservoir and low cost. However, at present, the physical simulation experimental method of microbial oil displacement is quite different from the actual reservoir, and the evaluation method needs to be improved urgently. Therefore, this paper conducted a basic theoretical study on the influencing factors of endogenous microbial model experiment. The computer-aided simulation experiment of endogenous microbial oil displacement is a computer model that simulates the behavior of microorganisms in oil reservoirs. The purpose of this model is to study the effects of different conditions on microorganisms and petroleum hydrocarbons (oil). It can also be used to design remediation strategies for contaminated sites with high microbial activity and low dissolved organic carbon content.

Keywords: Computer-aided · Endogenous microorganisms · Oil displacement simulation

1 Introduction

Microbial oil recovery technology refers to the use of microbial metabolic activities and their metabolites to act on reservoir and reservoir fluids, So as to improve crude oil recovery[". Previous research and field practice have proved that microbial oil recovery technology is a cost-effective method to improve production and recovery. Microbial oil recovery technology has the advantages of low cost, strong adaptability, no damage to the reservoir and no pollution to the environment, and has a wide application prospect. The U.S. Department of energy has listed it as the fourth type of enhanced oil recovery technology after thermal oil recovery, miscible flooding and chemical flooding [1].

Different from chemical flooding, in the process of microbial EOR, microorganisms themselves carry out life activities, and their metabolites can also enhance oil recovery. Although microbial oil recovery technology has a history of decades, it is still difficult to quantitatively describe the detailed mechanism of microbial oil recovery technology due to the complexity of microbial life activities. Therefore, the basic research and evaluation of microbial oil recovery technology mainly rely on physical simulation means, and there

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is still no mature and reliable numerical simulation software of microbial oil recovery [2].

The results of indoor physical simulation evaluation experiment show that both endogenous microbial oil displacement and exogenous microbial oil displacement have significant oil increase effects, and the enhanced oil recovery is between 5% and 15% under the indoor physical model conditions. However, the oil displacement tests carried out in many domestic oilfields show that the effect of microbial oil displacement field test is not significant. Through the analysis and comparison of the physical model of microbial oil displacement and field test literature, it can be seen that there are differences on many issues in the physical simulation of microbial oil displacement. For example, there is a prominent contradiction between the static growth and metabolism simulation of microorganisms in the physical model and the mine construction during the cultivation period, and there is no unified specification for the influencing factors such as core length, anaerobic environment and injection speed, etc. [3].

In conclusion, there are great differences between the physical model experiment of microbial oil displacement and the actual reservoir, and the evaluation method needs to be improved. The above factors should be fully considered, and the research on the physical simulation experiment technology of microbial oil displacement should be strengthened, so that the physical simulation evaluation results can guide the field application more accurately. Compared with the external microbial oil recovery technology, the internal microbial oil recovery technology has the advantages of strong adaptability, good compatibility with the reservoir, low cost and simpler construction [4]. Therefore, the research on the internal microbial oil displacement physical model evaluation technology is more urgent.

2 Related Work

2.1 Research Status of Microbial Oil Recovery Technology

From 1960s to 1990s, microbial oil recovery technology was booming. As the oil crisis in the 1970s hit the world economic development hard, the United States, the former Soviet Union, Canada and other countries have turned to the development of low-cost and high-efficiency oil recovery technology, and carried out a large number of theoretical research and field tests of microbial oil recovery technology. Key technologies such as microbial EOR mechanism, indoor evaluation method, field injection equipment, reservoir screening criteria, and microbial EOR numerical simulation have been comprehensively developed, and microbial huff and puff, wax removal and prevention technologies have been successfully applied in the oilfield. In 1967, hitzman of the United States proposed that because the oil layer is generally in an anaerobic environment, it is necessary to inject oxygen or air for microbial growth and metabolism when strange oxidizing microorganisms are used for oil recovery. In 1963, Kuznetsov et al. Found that some microorganisms released a large amount of methane in some oil and gas reservoirs, and speculated that hydrogen and carbon dioxide produced by bacterial metabolism could act to produce methane [5]. In China, Daqing Oilfield has mainly studied the use of microorganisms to judge the water absorption of oil layers. The results show that taking iron bacteria as indicator bacteria can qualitatively judge whether oil layers absorb water, and has been successfully applied to field tests. In 1966, Xinjiang Oilfield began to carry out research on microbial crude oil dewaxing; In 1986, the research work of microbial heavy oil dewaxing and methanol protein was carried out successively [6].

Since the 1990s, after decades of basic research, microbial single well huff and puff and microbial paraffin removal and control technology have stepped from the basic research stage to the large-scale field application stage. The research focus of this stage has shifted to microbial enhanced water drive technology, and the research content has also shifted from indoor and field qualitative research to numerical simulation quantitative research stage [7]. In the late 1980s and early 1990s, some foreign countries began to study the mathematical model and numerical simulation of microbial oil recovery. Knapp R.A., Zhang X., Islam M.R., Chang M.M. and others have successively put forward the research results of "microbial growth and migration model in porous media reservoir" and "mathematical model of microbial enhanced oil recovery". Sarkar A.K. and others published the research on "simulation of components of microbial enhanced oil recovery" at the international microbial enhanced oil recovery conference in 1994, pointing out that microbial enhanced oil recovery through the production of surfactant is the most potential development direction [8]. After entering the 1990s, China has also accelerated the research pace of microbial oil recovery technology, and introduced a variety of microbial products and microbial enhanced oil recovery technology from micro BAC company, NPC company in the United States and Casco company in Canada. CNPC has carried out field tests of various microbial oil recovery technologies in more than 1000 wells in Jilin, Dagang, Liaohe, Daqing, North China, Xinjiang and other oilfields, with a cumulative increase of more than 80000 tons [9].

2.2 Existing Problems

At present, microbial model and its application research are still in the development stage, and the main factors restricting its development are microbial oil recovery mechanism, the implementation scale of mine projects, the level of model development and the budget of projects. Due to the limitations of the above factors, microbial numerical simulation is far from as perfect as polymer flooding and chemical flooding numerical simulation. At this stage, the problems of microbial EOR numerical simulation are as follows:

(1) Only one microbial component is involved in the mathematical model of microbial oil displacement, that is, the reaction kinetic parameters of all microorganisms in the reservoir are the same, but from the indoor screening and field application of the endogenous microbial oil displacement nutrient system, it can be seen that all mathematical models of microbial oil displacement can not meet the simulation of the oil displacement process. Even if it is anaerobic activation, the kinetic parameters of anaerobic bacteria and methanogens are very different, Microbial components need to be reclassified [10].
(2) There are few studies on the formation process of endogenous microbial field and the adsorption law of microbial oil displacement. Most models only give the initial microbial concentration of suspended phase as a constant, and the initial concentration of adsorbed phase is not considered.

(3) The kinetic model of endogenous microbial reaction is not perfect. There are many studies on microbial growth kinetics, but few on product production kinetics and substrate consumption kinetics. The relationship between product production rate, substrate consumption rate and microbial growth rate is one-sided
(4) The structure design of model data body is quite different from that of commercial software, and has poor compatibility with other numerical simulation and geological modeling software.
(5) The solution of the difference equation involves a variety of solutions, and there is no demonstration of the reliability of the solution.
(6) There is no simulation application of the two-step activation process of endogenous microorganisms, nor a complete set of reaction kinetic parameters of the two-step activation process of endogenous microorganisms.
(7) The principle of microbial EOR mainly refers to the principle of chemical flooding EOR, which does not reflect the difference between endogenous microbial oil displacement process and chemical flooding.

3 Computer Aided Simulation Experiment of Endogenous Microbial Oil Displacement

3.1 Endogenous Microbial Field Model Components

The distribution of microorganisms in the reservoir depends on the structural and attribute characteristics of the reservoir, the degree of water injection development and the physicochemical characteristics of oil, gas and water. Mastering the distribution law of microbial communities in the reservoir is conducive to establishing an accurate endogenous microbial field and improving the accuracy of numerical simulation of endogenous microbial oil displacement. Generally, according to the characteristics of microbial nutrient consumption, metabolic pathway and oxygen demand in the reservoir, the endogenous microorganisms in the reservoir are classified as follows:

① Hob: Taking monsters as the only carbon source, the metabolic process is an aerobic process. The burning oxidizing bacteria are the main flora activated by endogenous microorganisms, and their activation systems are mainly phosphate and ammonium salts.
② Saprophytic bacteria (TGB): saprophytic bacteria are aerobic bacteria. Its growth and reproduction must be completed in an aerobic environment. It can use all kinds of sugary substances, decompose sugars, metabolize carbon dioxide, and change pH value.
③ Nitrate reducing bacteria (NRb): these bacteria can reduce nitrate to nitrite in anaerobic or low dissolved oxygen environment, and finally produce ammonia, nitrogen or coz. In addition, nitrate reducing bacteria can make better use of nutrients than sulfate reducing bacteria. Therefore, sulfate reducing bacteria can be inhibited.
④ Sulfate reducing bacteria (SRB): under anaerobic conditions, the bacteria can reduce the sulfate radical existing in formation water and injection water to produce reduced sulfur. Sulfur will combine with hydrogen to form HS, which will corrode various pipelines. It is generally considered as a harmful bacterium.

3.2 Mathematical Model of Endogenous Microbial Oil Recovery

Combined with Zhang Xu model, the mathematical model is cited. The model divides the microorganisms in each phase into three different components:

(1) Microbial flora with oxygen as the final electron acceptor (microorganism 1): including strange oxidizing bacteria and saprophytic bacteria;
(2) Flora that does not rely on oxygen for growth and reproduction (microorganism 2): fermentation bacteria;
(3) The main metabolite is methane, and the microbiological reaction rate parameters are significantly different from the first two components (microorganism 3): methanogens.

Considering the convection dispersion, adsorption desorption and precipitation of nutrients, microorganisms and their metabolites, combined with microbial reaction kinetics, the control equation of the biological field model:

$$\|e_{k+1}(t)\|_{\lambda} = \|C(t)\|\|\Delta x_{k+1}(t)\|_{\lambda} \tag{1}$$

To truly reflect the actual production situation, the indoor oil displacement experiment needs to adopt the "completely proportional" model, but due to the complexity of reservoir seepage and development process, it is impossible to simulate and reproduce these processes completely and truly. Therefore, it is necessary to deduce the similarity criteria of physical simulation according to the mathematical model to restrict the parameters in the development process, so that various factors affecting the physical model experiment can be agreed. The similarity principle requires that the similarity criteria between the physical model and the prototype must be completely equal, which can be satisfied for a simple physical system. However, for complex systems, it is difficult to meet all the similarity criteria. Sometimes, there are contradictions between the similarity criteria. Therefore, it is necessary to determine which similarity criteria are primary and which are secondary, which can be moderately relaxed. Due to the complexity of oilfield production and reservoir, it is impossible to design a simulation experiment with all the derived similarity criteria in proportion. Therefore, it is necessary to analyze and study the specific problems of the reservoir and select the similarity criteria that can be realized in the simulation and play a leading role in the recovery, that is, sensitivity analysis. Generally, there are analysis methods of numerical experiments and approximate modeling methods, as shown in Fig. 1.

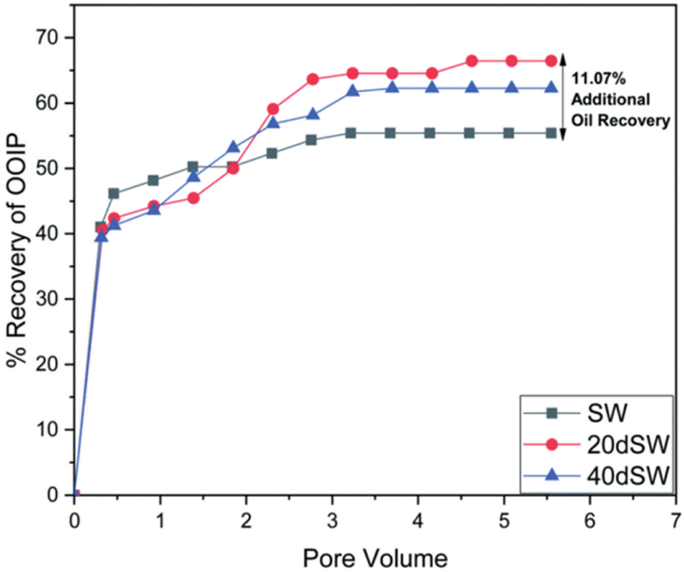

Fig. 1. Comparison of analytical methods of mathematical models of endogenous microbial oil recovery

4 Conclusion

Under the condition of medium and high permeability endogenous microbial oil displacement, whether gas injection or no gas injection, the EOR of quartz sand material is significantly higher than that of channel sand material, and the core materials with different wettability have a certain impact on EOR, among which the EOR of strong hydrophilic core is the largest, followed by neutral wetted core, and the EOR of weak hydrophilic core is the smallest. Finally, it is considered that the recovery rate range of water drive in channel sand cemented core with weak lipophilicity is closer to the actual reservoir, which can more truly simulate the pore structure of the reservoir and reflect the reservoir situation.

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Construction and Application of Intelligent Sensing Ability in Infrastructure Construction Site Based on Fish Swarm Algorithm

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Abstract. Intelligent sensing capability is the key technology of building intelligent infrastructure. It can be used in many fields, such as smart cities, smart buildings and smart agriculture. Intelligent sensing capability is an artificial intelligence (AI) technology that can sense the real-time environment. It is widely used in safety, environmental protection, medical and other fields. This paper will use the fish swarm algorithm to detect the fish swarm on the construction site based on the intelligent sensing ability. The application of fish swarm algorithm in intelligent sensing capability is to detect the construction site based on the information received from different sensors. The main objective of the project is to improve and enhance the performance of intelligent perception through the use of artificial intelligence technology. It will be used to detect and track any type of motion on the construction site, which will help reduce human errors and improve efficiency.

Keywords: Fish swarm algorithm · Infrastructure site · Perception

1 Introduction

As we all know, the new infrastructure includes information infrastructure, integration infrastructure and innovation infrastructure. It is an infrastructure system that provides services such as digital transformation, intelligent upgrading and integration innovation. However, in the face of such a huge system, many regions do not know where to start when developing new infrastructure.

In this regard, The "intelligent agent" released by Huawei on full connection 2020 puts forward a new idea, and all industries use "intelligent agent "To practice the new infrastructure as an entry point can further accelerate the implementation of the new infrastructure [1]. It is understood that the intelligent agent includes four layers of intelligent interaction, intelligent connection, intelligent hub and intelligent application. Based on the cloud and AI as the core, it will build an open intelligent system with three-dimensional perception, global coordination, accurate judgment and continuous

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evolution, which can bring the whole scene intelligent experience for urban governance, enterprise production and resident life.

It can be seen that the emergence of intelligent agents, integrating various information technologies, can promote the construction and coordination of new infrastructure information infrastructure and reduce the difficulty of information infrastructure construction; From the perspective of application, as the technical reference framework for intelligent upgrading, the agent provides strong support for the construction of integration infrastructure and innovation infrastructure.

If the agent is Huawei's practice of new infrastructure, it is the reference framework for realizing the upgrading of government enterprise intelligence; The urban agent is a city level integrated intelligent collaborative system built by the collaborative innovation of multiple technologies such as connection, cloud [2], Al, computing and urban application, which can make the city feel, think, evolve and have temperature. In comparison, the "urban brain" often referred to in the industry in the past is based on the Internet, mainly focusing on the analysis and processing of urban data to realize the centralized management and monitoring of the city; while the "urban agent" is an integrated intelligent system, just like the "five senses", "hands and feet", "nerves", "trunk" and "brain" of the human body, so that the city can fully and real-time perceive the people, things, space and processes in the city, Through real-time data, we can timely find urban problems, study and judge the situation, prevent risks, and conduct real-time interaction [3]. Based on this, the research of this paper is the construction and application of intelligent sensing ability based on fish swarm algorithm.

2 Related Work

2.1 Fish Swarm Algorithm

The artificial fish swarm algorithm is that in a water area, fish can often find places with more nutrients by themselves or following other fish. Therefore, the place with the largest number of fish is generally the place with the most nutrients in the water area [4]. According to this feature, the artificial fish swarm algorithm simulates the foraging, clustering and tail chasing behavior of the fish swarm by constructing artificial fish to achieve optimization. Figure 1 below shows the iterative behavior flow of fish swarm algorithm.

Iterative behavior flow of fish swarm algorithm.

Artificial fish have the following typical behaviors:

(1) Foraging behavior: generally, fish swim freely in the water at random. When they find food, they will swim quickly in the direction of gradually increasing food.
(2) Swarm behavior: in order to ensure their own survival and avoid hazards, fish will naturally swarm in groups. There are three rules for Fish Swarm: separation rules: try to avoid overcrowding with neighboring partners; Alignment rules: try to be consistent with the average direction of neighboring partners; Cohesion rule: try to move towards the center of the neighboring partner [5].
(3) Tail chasing behavior: when one or several fish in a shoal find food, their neighboring partners will follow them to the food point quickly.

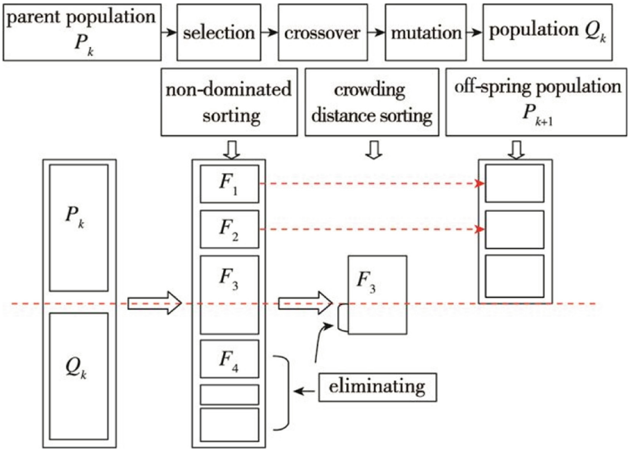

Fig. 1. Iterative behavior flow of fish swarm algorithm

(4) Random behavior: individual fish usually swim randomly in the water, in order to find food points or companions in a wider range.

$$O_{v,j} = h\left(\sum_{i=1}^{f_{k-1}} \sum_{u \in N[v]} w_{i,j,u,v} x_{u,i}\right), (j = 1, \ldots, f_k) \tag{1}$$

$$\max \sum_{I} \left[U^I(X^I) - C^I(X^I)\right] \tag{2}$$

Steps of implementing artificial fish swarm algorithm:

(1) Initialization settings, including population size n, initial position of each artificial fish, visual field of artificial fish, step size, crowding factor 5, and number of repetitions trynumber;
(2) Calculate the fitness value of each individual in the initial fish school, and give the best artificial fish state and its value to the bulletin board;
(3) Evaluate each individual and select the behaviors to be performed, including foraging pray, swarm, tail chasing follow and evaluation behavior Bulletin; (4) Implement the behavior of artificial fish, update themselves, and generate new fish schools;
(4) All individuals were evaluated. If an individual is superior to the bulletin board, the bulletin board is updated to that individual;
(5) When the optimal solution on the bulletin board reaches the satisfactory error range or reaches the upper limit of the number of iterations, the algorithm ends, otherwise, go to step 3.

2.2 Intelligent Sensing Hibernate Technology

Hibernate is a lightweight persistence layer solution. It is an open source ORM framework, i.e. object relational mapping framework 9 ‘. Hibernate encapsulates JDBC in a lightweight manner, and packages the relational database into an object-oriented model, so that developers can operate the relational database in an object-oriented manner, and only need to write simple HQL (hibernate query language) statements, thus greatly reducing the development time of manually writing SQL statements and processing JDBC. Hibernate advocates low intrusion design and fully adopts POJO programming.

There are many persistence layer solutions based on ORM framework, and Hibernate can stand out because hibernate has the following advantages compared with other ORM frameworks [6].

(1) Hibernate is completely free and open source.
(2) Hibernate is a lightweight framework that is non intrusive and avoids complex problems as much as possible.
(3) Active developers can have stable development.
(4) High scalability and open API. When the function is insufficient, it can be coded and expanded by itself.

Hibernate has five core interfaces: configuration, sessionfactory. Session, transaction and query. Hibernate accesses persistent objects and manages database transactions through these interfaces. The architecture of Hibernate is shown in Fig. 2.

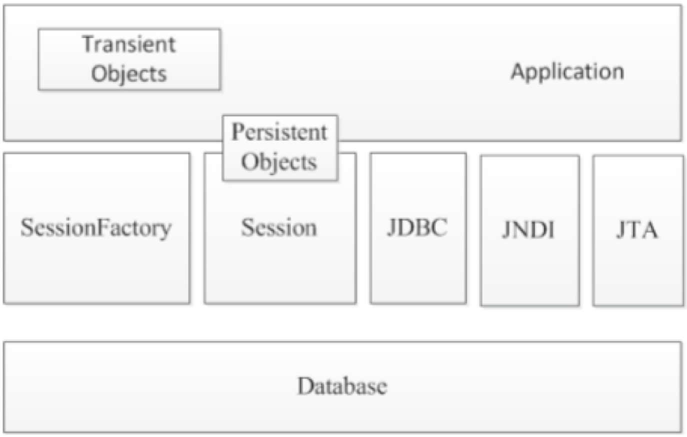

Fig. 2. Hibernate architecture

3 Construction and Application of Intelligent Perception Ability on Infrastructure Construction Site Based on Fish Swarm Algorithm

The construction site management function manages the construction projects undertaken by enterprises. A construction site is an engineering construction project. The commencement of a project needs to be added to the system and the relevant information of the construction site project can be configured. Then, the relevant information of the construction site can be modified and the completed construction site project can be deleted from the system. The module also needs to set up site personnel and internal law enforcement personnel at each construction site. In addition, when displaying the site list, you can display the completed site and uncompleted site as required.

The main function of the equipment management module is to manage the intelligent induction equipment installed on the construction site. One induction equipment is equipped with noise and dust sensors [7]. The functions of the device management module include:

(1) When new equipment is installed on the monitoring site, it is necessary to manually edit the basic information of the equipment: Province, city, district / county, construction site, installation location, detailed address and intelligent equipment coordinates (longitude, latitude and altitude).
(2) Manually enter the SIM card number of the device communication module, and the SIM card number uniquely identifies a device.
(3) Configure the p address and port number of the intelligent site monitoring system server in the area where the equipment belongs.
(4) Configure the equipment maintenance information, including the time of the last battery change, the time of cleaning the sensor, and the time when the equipment should be maintained next time.
(5) Inquire the induction equipment according to the district and county of the construction site or the name of the construction site.
(6) Configure the working parameters of the sensing device, including alarm interval and sleep time.
(7) Get the real-time status of the device.
(8) Enable and disable devices.
(9) Stop the equipment alarm function.

The data statistics module is required to define the data transmission mode between the server and the sensing device, collect the noise and dust data transmitted by the sensor, and filter and store the data [8]. The statistical data information can be displayed on the web page in the form of charts according to the district / county, construction site, specific intelligent sensing equipment, data type (noise or dust) and start and end time, so that relevant personnel can view the emission of noise and dust during construction.

4 System Design

The project construction enterprise will install a series of induction equipment at the project construction site, and then set up the site monitoring system, i.e. the data management server. The data exchange between the equipment and the server can be conducted in two ways. One is to send the configuration and response protocol and the sensor to the server through the GRPS wireless network using the TCP protocol. Second, the server sends the configuration command to the sensor device through the SMS cat. When using this method, it is unidirectional, and the sensor device does not need to send a response to the server. The server stores, statistics and analyzes the data sent by the sensor device. The user can easily view the real-time data information through the PC browser or the mobile phone mobile device installed with the intelligent site monitoring system application.

The project data, enterprise data and enterprise related personnel data of the system are based on the Enterprise GIS integrated business system, which is responsible for pushing the data of the project, enterprise and enterprise related personnel to the noise and dust monitoring system database [9]. The system can start working after obtaining these data. When a new intelligent sensing device is installed in a construction site project, the system will input the basic information of the device, such as installation location, SIM card number, etc., and store it in the database. Then, the system sends configuration information (server p address and port number) to the newly installed device, and configures the working frequency of the device (here, the working frequency refers to how often the intelligent sensing device performs data sampling) and the sampling frequency (the number of sampling times for each operation). Then the sensing device can start to work, collect data every once in a while and send the data to the server. After receiving the data, the server analyzes the data and stores the correct data into the database. According to the user's operation, the system makes statistical analysis on the data of a certain construction site in a specific time, and draws a chart on the front page for the user to view the real-time emission of noise and dust of the construction site project [10]. If the data transmitted by a construction site project exceeds the alarm threshold value of the construction site for several consecutive times, the system sends an alarm message to the on duty management personnel of the construction site through the SMS cat, and the management personnel can take relevant measures to deal with it, so as to ensure a good construction environment. If several alarm messages are sent to the site management personnel, and the noise or dust data still exceeds the standard, the alarm information will be sent to the law enforcement department for filing.

5 Conclusion

The construction of intelligent sensing capability on the infrastructure construction site based on fish swarm algorithm, the overall framework of the system, the main business process, and the database. Next, according to the overall design, each functional module is refined, and a good interactive communication interface is designed between each module, which greatly simplifies the system development complexity and development efficiency. During the development process, the strategy of "developing while testing" is implemented, which not only ensures the stability of the system, but also reduces the difficulty of positioning problems and the complexity of error accumulation in later testing. Finally, in the centralized test stage of the system, the function and performance of the system are comprehensively tested to ensure that the system has high performance while achieving the expected functional objectives.

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