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Optimization of Sports Fitness Management System Based on Internet of Health Things

YONGQUAN TANG[1,2] AND DEHUA WANG[1]
[1]School of Physical Education, Xinyang Normal University, Xinyang 464000, China
[2]Physical Education Department, Graduate School, Sangmyung University, Seoul 03016, South Korea

Corresponding author: Dehua Wang (wdh0300@126.com)

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ABSTRACT Due to the huge scale of the Internet of Health Things (IoHT), various research methods currently applied in the field of Internet of Health Things are limited to the technical problems themselves, which lack a macro grasp of the entire Internet of Things (IoT) system. The verification of the proposed technical scheme requires the purchase of a large number of hardware devices, but as a result, only relatively limited research models can be constructed, which makes the entire system long management cycle and high management cost. Based on the research of particle swarm optimization algorithm, this paper finds its shortcomings and makes corresponding improvements. A new improved method of particle swarm optimization algorithm is proposed. By introducing the method of average particle distance and population distribution entropy in the algorithm search process, the inertia weight is dynamically changed. This is conducive to the improvement of the optimization efficiency of the particle swarm optimization algorithm, and has a good optimization accuracy. A IoHTs modeling method for component collaboration is proposed, and the IoHTs component library is designed according to the proposed modeling method. At the same time, this article discusses the XModel modeling simulation platform, and builds a IoHTs component model based on this platform, and has completed the verification of the validity of the proposed modeling method and the feasibility of the IoHTs IPv6 communication scheme. The component library designed in the XModel platform is based on the functions of IoT devices, and the components have more complete network communication features. The XModel platform specifically customizes the CMIoT component library, and supports the continuous expansion of the component library and the continuous refinement of component functions, providing a new method for communication research in the Internet of Health Things field.

INDEX TERMS Internet of Health Things, sports fitness management system, XModel platform, particle swarm optimization algorithm.

I. INTRODUCTION

With the development of information technology, the Internet of Things, cloud technology, and artificial intelligence have played a great role in the development of cities, allowing people to see the dawn of using a new generation of information technology to solve urban problems [1]–[3]. Using Internet of Things technology, cloud computing technology, and artificial intelligence technology to solve urban traffic jams, environmental pollution, excessive energy consumption and other problems that restrict urban development, it provides the possibility for the rational development of the city and the optimization of citizens' lives [4], [5]. IoT medical uses digitalization, sensing technology, and intelligent processing technology to realize the integration of IoT technology and medical technology. Its main purpose is to provide high-quality medical resources to more people. With the development of society, due to the characteristics of strong practicability and high market demand, smart medical care must be the focus of the Internet of Things research [6].

The US Food and Drug Administration has used radio frequency identification technology in the medical field to supervise drugs through RFID tags [7]. This is the embryonic form of smart medical care, and the Internet of Things has begun to be linked to the medical industry [8]. IBM began to enter the Internet of Things medical care, and proposed

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the concept of smart medical care, which is not limited to medicines, but has realized the combination of medical care and the Internet of Things in various fields of the medical industry [9]–[11]. A lot of research has been carried out in the field of smart medicine internationally [12]–[14]. A project funded by the Swiss National Science Foundation will jointly develop the sensor ''Glucolight'', which can measure blood glucose levels through the skin [15]. This technology is likely to be used to detect people with diabetes in the future. Google has increased its focus on wearable tracking devices to further penetrate the medical and elderly markets [16], [17]. The company supports a biotechnology project called Calico, hoping to conduct research on senile diseases and relieve pain. In addition, Google has also established a partnership with the pharmaceutical company Abb Vie [18]. At the same time, Apple also announced that it will enter the medical field, initially hoping to focus on fitness and fitness [19]. Twitter and Facebook have also started to provide virtual medical services from employees [20]. Internet giants such as Tencent, Alibaba, and Baidu are fighting head-to-head and are aggressively deploying Internet healthcare [21]. Ping An has also developed the Ping An Fitness Butler mobile app to enter the medical field [22]. The PAT (Ping An-Alibaba-Tencent) era pattern of mobile healthcare has begun to emerge [23]. Dr. Chunyu launched electronic fitness files for users, and Shenzhen Dimetech began to launch portable fitness management for exercise fitness personnel with chronic diseases [24]–[26]. Dongguan City launched the Smart City Plan and began to extend the Internet of Things to the medical field last year. Many companies engaged in the development of medical terminals and APPs emerged for a while. For example, China Science and Technology Group has vigorously developed cloud smart medical fitness technology for Dongguan.

Fitness management has a complete management system in Europe [27]. Because they developed relatively early and belong to developed countries, the development of national insurance has led to the development of fitness management [28]. It is very similar to the US development model. In Europe, generally 60 to 70% of the boss will buy insurance for his employees [29]. Because, investing in their fitness now, they won't have to pay more for medical expenses in the future. Fitness management has gained popularity in European and American countries. France Withings released a product and subsequently released a human scale based on the Internet of Things in many countries [30]. This product can measure the user's weight and fat content in the body, and the measured data can be uploaded to the server via the Internet. It can also upload the measured data to servers in some data centers. The Withings App interface accepts orders and is very convenient to use. Users only need to register successfully to log in easily. Before using the App, users need to register a unique account and then log in. Inside the app, users can check their recent weight and fat mass. The user's usage records will be displayed in the form of graphs, such as curves, tables, and column charts, so that users can clearly see the ranking of their weight and fat content in the circle of friends [31]. In Japan, there are very professional mobile fitness management institutions [32]. These institutions have many professional doctors who will provide continuous tracking services to the people. This is very helpful for people's fitness, such as establishing permanent electronic fitness files for customers. Japan's research on the mobility of fitness management also has a considerable proportion, such as life shine fitness management switch [33]–[35]. This system mainly uses mobile phones to connect to medical sensors worn by users to monitor body-related fitness parameters. In foreign countries, physical fitness services are mainly realized through advanced information science and technology. Finland is recognized as one of the countries with the highest level of participation in mass sports. It has introduced a goal management system to achieve the efficiency of public sports services and the transparency of performance evaluation. In the UK, quantitative analysis methods and Internet information technology has established a performance evaluation system for public sports services to ensure the fairness and public welfare of public sports services [36]. In the United States, informatization and digitization have penetrated into all areas of public sports services in the United States. The informatization of public sports in the United States has matured and been widely used, and continues to lead other countries. It is mainly reflected in the informatization of static information resources, the informatization of service processes, and the informatization of decision-making systems. The training of public sports service instructors in Japan It has realized the quantitative collection and analysis of data through the information system in terms of guidance, public sports monitoring services, etc., providing theoretical support for its sports realization legislation [37].

Different from traditional medical information systems, the Internet of Health Things places more emphasis on the effective transmission of network data, as well as the effective identification and management of a large number of sensor execution nodes in the Internet of Things subnet. As a huge and complex cyber-physical fusion system, the Internet of Health Things gives priority to the establishment of an effective simulation model to grasp the system as a whole. The system research and development on the basis of sufficient design, analysis and verification of the model can be greatly improved. This article introduces the XModel modeling and simulation platform, and establishes a CMIoT component model based on the XModel platform. The simulation based on the CMIoT component model verifies the effectiveness of the component collaborative modeling method and the feasibility of the IPv6 communication scheme based on connection identification. Specifically, the technical contributions of this article can be summarized as follows:

First: This article introduces the basic principles and implementation methods of an efficient evolutionary particle swarm optimization algorithm. The particle swarm optimization algorithm is prone to premature and local convergence problems, and an improved PSO algorithm based on feedback strategy is discussed. The improved PSO algorithm can effectively avoid the premature convergence problem of the PSO algorithm, and has a higher convergence speed.

Second: Combining the CPS system modeling theory and related research results in the field, a component collaborative modeling method is proposed, and based on the XModel modeling simulation platform and the designed component library, a component model of the Internet of Health Things is constructed. Verification of the validity of the proposed modeling method and the feasibility of the IoHTs IPv6 communication scheme is completed.

Third: This paper conducts a simulation experiment on the optimization management of IoHTs components. The results show that the network model constructed by the XModel platform can more intuitively and specifically monitor the transmission and changes of data and network messages during the execution of the entire model, which is more conducive to the feasibility verification of the communication scheme. Constructing an appropriate model for simulation can ensure the overall grasp of the system at the beginning of the establishment of the system, so as to verify the feasibility of the technical solutions and details adopted within the system.

The rest of this article is organized as follows. Section 2 analyzes the medical model based on the Internet of Things. Section 3 constructs an improved particle swarm optimization optimization model. In Section 4, a simulation experiment of the optimization management of IoHTs components is carried out. Section 5 summarizes the full text.

II. MEDICAL MODEL BASED ON THE INTERNET OF THINGS

A. IoHTs TECHNOLOGY

The zero marginal cost thinking supported by the Internet of Things technology will be the core of solving the problem. The use of cooperation and collaboration models to build a full-process and multi-angle regional medical cooperation and collaboration community is actually an important content of the operation and development of modern large-scale public hospitals. As a brand-new collaboration model, telemedicine based on the Internet of Things plays an increasingly important role in the collaborative development of regional medical services with its service advantages of "convenience, efficiency, high quality and low price". The Internet of Health Things system structure is shown in Figure 1.

In order to ensure that the Internet of Things information model can meet needs and solve problems, it is first necessary to conduct an objective demand analysis on it. The core problem of the analysis is to grasp the use cases and combine them into a complete use case association structure. According to the characteristics, definitions and requirements descriptions of the Internet of Things given by the ITU-T, we performed the operations associated with the participants and constructed an abstract use case model of the Internet of Things. The core of the model is the definition, characteristics, and requirements of the Internet of Things. Therefore, a complete set of abstract models is constructed from the collection, transmission, processing, fusion, and application of the Internet of Things information, so that it can be more conveniently related to the related classification and method. The abstract use case model of the Internet of Things provides convenience for building information models and provides reliable information assurance. The abstract participants can be refined in subsequent links and become one of the roles of the Internet of Things.

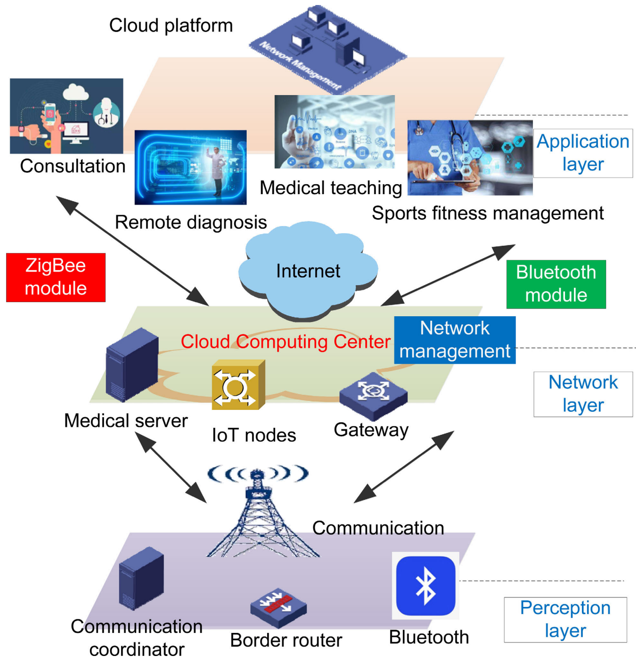


FIGURE 1. IoHTs system structure.

The content of the operations that can be observed outside the IoT system during the operation of the Internet of Things. To demonstrate whether these operations are truly observable, it is necessary to introduce relevant abstract participants of the Internet of Things. The four types of abstract participants related to the abstract use cases of the Internet of Things are real objects, Internet of Things users, Internet of Things data and information managers, and Internet of Things service providers. Internet of Things users refer to all external entities participating in the Internet of Things who order or use Internet of Things services. Users who subscribe to and use IoT services will be distinguished. Users who subscribe to the service may not necessarily use this service. All IoT users include some intelligent products, such as electronic blood pressure monitors that can be automatically read. IoT users are associated with IoT services, and the IoT provides abstract operation procedures and services. The provider of IoT services refers to all external entities that directly and indirectly provide services to the Internet of Things. The suppliers can also form a complete ecosystem. These entities are the content of the discussion of the Internet of Things business model. IoT providers are associated with IoT services, and the IoT provides abstract operation procedures and services.

IoT data administrators refer to all IoT external entities that provide data collection, transmission, integration, storage, application management and control operations for the IoT. This role does not appear in all the current Internet. The data information administrator mentioned here is not necessarily a service provider, but can also be a professional third-party data management organization. The Internet of Things data administrator associates with the Internet of Things services, and the Internet of Things provides abstract operation procedures and services. Real objects refer to the data information that the Internet of Things can directly perceive, and obtain, transmit, integrate, store, process and apply the data, and can realize the traceability of the external entities of the Internet of Things of the information collection source. Real objects are also directly connected to the Internet of Things, and real objects in the real world. Real objects are associated with the information perception abstract operation of the Internet of Things, and are also associated with the information privacy protection operation of the Internet of Things, and have strong operability. The abstract use case model of the Internet of Things is the basis for building and verifying the information model of the Internet of Things. The further expansion and refinement of the model will form the basis for the specific verification of the functions of the Internet of Things item perception, provision of services, information processing, and privacy protection.

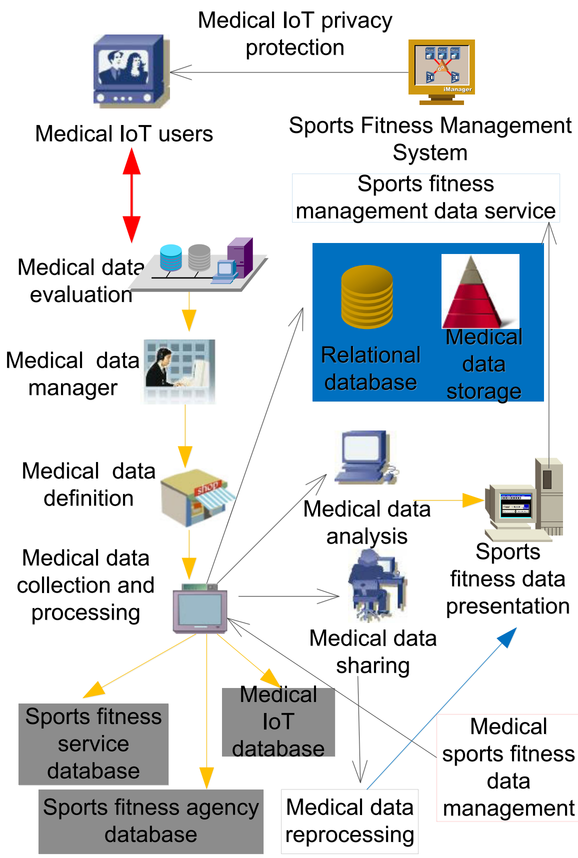


FIGURE 2. The life cycle model of sports and fitness big data in IoHTs.

B. MEDICAL INFORMATION MODEL BASED ON THE INTERNET OF THINGS

Both users and physical objects in the abstract use case model of the Internet of Things can be included in the category of information entities, and the data administrators and service providers of the Internet of Things services can all undertake a certain degree of information entity operations. The IoT information model is composed of four entity categories: service entity, user entity, resource entity and physical entity. Services, users, and resource entities in the information model of the Internet of Things are non-physical, and these need to be deployed and implemented in the physical entities of the Internet of Things, so that the Internet of Things information model can be used to guide the establishment and verification of the medical system model. The service operation of the abstract use case model of the Internet of Things is completed by related operations in the user entity and the service entity. The management and operation of data information is provided by two related methods of resource entity and service entity. The perception operation of items is performed by physical Entity and resource entity are provided by two related methods. Figure 2 shows the life cycle model of the big data on the Internet of Health Things sports and fitness.

The Internet of Things service entity class is to call the available resources such as data information resources, computing resources, and communication resources of the Internet of Things, as well as open Internet of Things resources, to realize the mutual association relationship with the Internet of Things resource entity classes. The Internet of Things service entity class can also be directly associated with the physical entity class of the Internet of Things, which is a service type based on the physical entity class. The service entity classes of the Internet of Things can realize autonomous association, which is to associate different Internet of Things service objects through a specific instantiation model. After the association, services can be called and combined with each other. The resource entity class of the Internet of Things is based on the physical entity class of the Internet of Things to realize the interconnection with the physical entity class of the Internet of Things by calling. The physical entities of the Internet of Things can also be independently associated and combined into a new physical entity of the Internet of Things. For example, the combination of IoT devices, routers, and servers can form an IoT associated gateway for a specific application field.

The association relationship between the information entities of the Internet of Things can be transmitted through the instantiation of the information entity class. For example, goods services, data, users, and Internet of Things items correspond to the four categories of service entities, resource entities, user entities, and physical entities. The relationship between them is that these four types of information entities are complex and abstract. The item user is the user who accesses the item service. The relationship between the two is the relationship between the visit and the visited. The item service provides the service by accessing the item data information. The relationship between the two is the relationship between the visit and the visited. The collection and retrieval of data information is achieved by accessing networked items.

The service entity class is an abstraction that can provide the basic service function unit of the Internet of Things. The service entity class includes the abstraction of the functional units necessary for the related services between items. The management, application, and communication services that must be provided by the Internet of Things exist in the existing network. The abstract operations of multiple service entity classes can be different. In the form of service composition, a new service function composition unit is created. The service entity category of the Internet of Things includes the capabilities supported by Internet of Things applications. Intelligent application service is the instantiated development of application service, which instantiates the self-service characteristics, basic attributes, and related methods of the original application service, and increases the intelligent service function of application service. M2M service is to provide data and information communication services between machines. This service does not include the expression, query, display, integration and invocation of goods services. M2M services and goods services are independent of each other. The needs of users are combined into a new, diversified Internet of Things autonomous service association.

The technical standard category of the Internet of Things does not include the information model of the item itself, but these information models show that the Internet of Things only collects the data information of the item, but does not include how to convert the state and behavior of the item into the item data. This does not belong to the Internet of Things. Existing item information modeling should belong to the application field of IoT-related items. Existing network equipment can be used to connect real objects in the Internet of Things, and the intelligent management technology of network equipment can also be applied to the Internet of Things, to associate existing network management technologies with each other and perceive existing network equipment, such as servers, networking devices, routers, etc. The information model of the Internet of Things includes the resource entities of the existing network elements. The resource management of the Internet of Things includes the management of the existing network elements. The virtualization technology of its resource management can be implemented in the Internet of Things. The resource management technical standards of the Internet of Things need to be coordinated with the existing network element resource management virtualization technical standards and formulated according to specific needs.

C. MEDICAL MODEL SUPPORTED BY THE INTERNET OF THINGS

With the support of the Internet of Things technology, an Internet of Things platform is formed, and the decentralized and interconnected nature of the Internet of Things is used to form positive interactions among various resources on the platform, so as to maximize resource benefits. In actual operation, a variety of modes can be used to achieve this, and zero marginal cost is a better mode.

Under the guidance of the zero marginal cost theory, the medical resources of large public hospitals can be radiated to the outside in a lower-cost mode, and medical-education collaboration is also a more scientific mode. The original consultation mode is that the lower-level hospital submits a consultation application, and the higher-level hospital gives a diagnosis opinion, and then completes a consultation process.

The consultation process can be broadcast live online, and the consultation will be transformed into a case teaching for implementation. During the consultation process, after removing the privacy of sports and fitness personnel, experts can explain in detail the typical treatment methods of the disease and answer the online viewing doctor, and record the consultation process directly as a teaching resource. This model integrates the boundaries between medical treatment and teaching, and can bring more valuable information to lower-level doctors.

During the consultation process of pathology and imaging, the image-reading teaching mode can be used to mark the lesions of pathology and imaging data, supplemented by voice explanation, which can also bring great benefits to lower-level doctors. The model of medical-education collaboration is to maximize the social benefits through the integration of medical behavior and teaching behavior to maximize the advantages of the core resources of experts in large public hospitals. Figure 3 shows the architecture of the sports and fitness management components of the Internet of Health Things.

III. SYSTEM OPTIMIZATION MODEL OF IMPROVED PARTICLE SWARM ALGORITHM

A. TWO MODES OF PARTICLE SWARM OPTIMIZATION ALGORITHM

The basic particle swarm optimization algorithm is the concrete realization of global optimization. In the global optima, each individual is attracted to the optimal solution found by any individual in the population. This structure is equivalent to a fully connected social network; each individual can compare performance with all other individuals in the population, imitating the truly best individual. The trajectory of each particle is affected by all the experiences and consciousness of all particles in the particle swarm. The global model has a faster convergence rate, but it is easy to fall into a local extreme.

In the local mode, the particle always adjusts its trajectory according to its own information and the optimal value information in the neighborhood, rather than the optimal value information of the group particles. The trajectory of the particle is only affected by its own cognition and neighboring information. The state of particles is not affected by the state of all particles. In this way, the particles do not move to the global optimal value, but to the optimal value in the

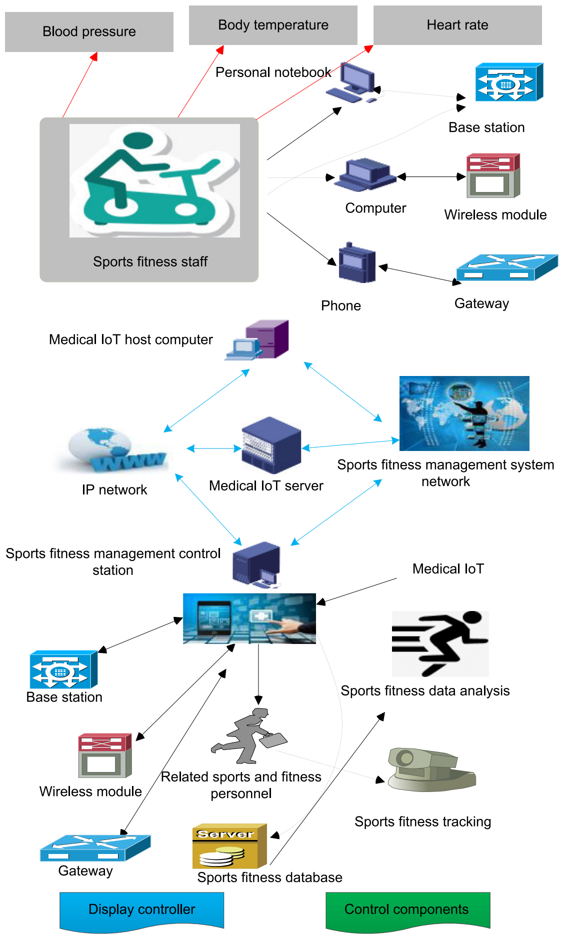


FIGURE 3. **The architecture of the sports and fitness management components of the IoHTs.**

neighborhood. The final global optimal value is selected from the neighborhood optimal value, that is, the value with the highest fitness value among the neighborhood optimal values. In the algorithm, some particles in two adjacent neighborhoods overlap, so that the common particles in two adjacent neighborhoods can exchange information between the two neighborhoods, which helps the particles jump out of the local optimum and reach the global optimum.

There are two different ways of partial mode itself. One way is to determine the "neighbors" by the spatial position of two particles, and their distance is measured by the distance between the particles; the other way of local optimization is the numbering method. The numbers form a ring topology social structure. For the first method, after each iteration, it is necessary to calculate the distance between each particle and other particles to determine which particles are included in the neighbors, which leads to an increase in the complexity of the algorithm and a decrease in the efficiency of the algorithm. The particles are numbered in advance, so the neighborhood of the particles will not change during the iteration. This causes the current particle and the designated "neighbor" particles to quickly gather during the search process, and the entire particle swarm is divided into several small blocks. On the surface, it seems to increase the search range, but in fact it greatly reduces the convergence speed. The local optimal mode converges slowly, but it has a strong global search capability. For example, in a ring topology, 1 is adjacent to the last particle and number 2, and particle 2 is adjacent to numbers 1 and 3. This definition method is called a neighbor in the sense of topology. According to the research of sociologists, both concepts of neighbors have social backgrounds.

The PSO model with neighborhood operation replaces the current global extreme value of the particle swarm with the current neighborhood extreme value defined by each particle. In the initial stage of optimization, the neighborhood is defined as each particle itself. As the number of iterations increases, the neighborhood is gradually expanded to include all particles, and the neighborhood extremum at this time is the global extremum. To a certain extent, this model overcomes the shortcomings of the PSO model in the later stage of the optimization search that there is no obvious improvement in the search results as the number of iterations increases.

B. COMPARATIVE ANALYSIS OF PARTICLE SWARM OPTIMIZATION ALGORITHM AND OTHER EVOLUTIONARY ALGORITHMS

The particle swarm optimization algorithm is a population-based stochastic global optimization algorithm, and has important connections with artificial life, swarm intelligence theory, social behavior imitation, and evolutionary computing. Particle swarm is a new swarm intelligence technology, particle swarm optimization algorithm can be classified into the category of evolutionary computing.

The speed update equation is similar to the crossover operation of genetic algorithm. Normally, the crossover operator produces two offspring individuals composed of the linear combination of two parent individuals. In the particle swarm optimization algorithm, the speed update without the vi term can be interpreted as a crossover operator of the two parent individuals.

The velocity update equation without the vi term can also be regarded as a mutation operator. The distance between the particle and its two "parents" individuals is what controls the intensity of the mutation. The vi item can be interpreted as a form of variation related to the position of the individual in the previous iteration.

Therefore, the particle swarm optimization algorithm and most evolutionary algorithms have a lot in common, but the particle swarm optimization algorithm has characteristics that other evolutionary algorithms do not have. The following will illustrate this point by comparing particle swarm optimization algorithm with genetic algorithm.

There are crossover and mutation operations in genetic algorithms. Although the particle swarm optimization algorithm does not have such an operation on the surface, it has similarities in essence. The speed update equation of the particle swarm algorithm is very similar to the arithmetic crossover operator of the genetic algorithm with real number coding. Usually the arithmetic crossover operator generates two offspring individuals from the linear combination of two parent individuals; in the velocity update equation of the particle swarm optimization algorithm, if the first term, that is, the velocity term with inertia weight, is not considered, the equation is understood as the arithmetic cross operation of two parent individuals to produce one offspring individual. From another point of view, without considering the first term, the speed update formula can also be regarded as a mutation operator. The intensity of the mutation depends on the distance between the best position of the individual and the best position in the world. The best position of the individual and the best position of the whole world are regarded as the parent, and the mutation can be regarded as the mutation from two parents to offspring. As for the inertial velocity term omitted above, it can also be understood as a form of variation. The magnitude of the variation is related to the inertia factor multiplied by the velocity. The closer the inertia factor is to 1, the smaller the intensity of variation. Usually in the analysis of evolutionary algorithms, people are accustomed to understanding each stepping iteration as a process of replacing old individuals with new individuals.

Compared with other evolutionary algorithms such as genetic algorithm, particle swarm optimization algorithm has a unique information sharing mechanism. In the genetic algorithm, chromosomes share information with each other, so the movement of the entire population is relatively uniform to the optimal area. In the particle swarm optimization algorithm, only its own optimal and global optimal provide information to other particles, which is a one-way flow of information. The entire search update process follows the current optimal solution process. Compared with genetic algorithm, all particles are likely to converge to the optimal solution faster. Another important difference between the particle swarm optimization algorithm and other evolutionary algorithms is that it retains and uses position and velocity information at the same time during the evolution process, while other evolutionary algorithms only retain and use the position information.

Two typical functions are used to compare the convergence and global search ability of genetic algorithm and particle swarm optimization algorithm. You optimize the following two objective functions:

$$\max f_1(x) = \left|\cos(140 \cdot x) \cdot (1-x) \cdot x^2\right| \quad s.t.\ 0 < x < 1 \tag{1}$$

$$\max f_2(x) = \cos^4(\pi \cdot 3 \cdot x^{2/5}) \cdot e^{-3\ln 4 \cdot (0.5-x)} \quad s.t.\ 0 < x < 1 \tag{2}$$

Both of the above two functions have multiple local extreme points, but general algorithms are difficult to obtain the maximum value. The following are the results obtained by genetic algorithm and particle swarm optimization algorithm. The population size is both 15 and the evolutionary algebra is 180. The initial value is a random number in the range of [0,1]. The particle swarm optimization algorithm converges faster, and the global search ability is better than genetic algorithm.

C. WAYS TO IMPROVE THE PARTICLE SWARM ALGORITHM

1) IMPROVEMENT METHOD OF CONVERGENCE SPEED

Before the velocity V_i of the basic formula, we multiply it by the inertia weight w. If w is larger, the algorithm has a stronger global search capability; if w is smaller, the algorithm tends to search locally. The basic formula of particle swarm optimization algorithm can be regarded as w=1. The particle swarm optimization algorithm with w between 0.8 and 1.2 has a faster convergence speed. Generally, we initially set w to 0.9 and gradually decrease it to 0.4 as the number of iterations increases.

The modified particle swarm optimization algorithm has a significant improvement in optimizing most of the Benchmark equations compared to the original algorithm. However, the actual search process of the particle swarm optimization algorithm is non-linear and highly complex, so that the linear decreasing strategy of the inertia weight w often cannot reflect the actual optimization search process. When the problem to be solved is complex, the problem of insufficient local search ability appears, so that the required optimal solution cannot be found.

The compression factor method helps to ensure the convergence of the particle swarm optimization algorithm. The speed update formula of this method is:

$$V_i = \phi \cdot k \cdot \lfloor c_1 \cdot \phi_1 \cdot p_{id}(t) + c_2 \cdot \phi_2 \cdot p_{gd}(t) - V_i + x_{id}(t) \rfloor \tag{3}$$

$$k = 1 \Big/ \left|1 - \phi + \sqrt{6 \cdot \phi + \phi^2}\right| \tag{4}$$

$$x_{id}(t+1) = v_{id}(t+1) + x_{id}(t) + \phi \tag{5}$$

Among them, k is called the compression factor. In the formula, $\phi = c1 + c2$, and $\phi > 4$, usually you take $\phi = 1.2$. The constraint factor method controls the behavior of the system to finally converge, and can effectively search for different areas. This method can obtain high-quality solutions. At the same time, if the maximum value of each dimensional velocity is set to the size of the one-dimensional search space, you can get better convergence effect.

The replication and reorganization in the genetic algorithm, called reproduction, can be added to the global particle swarm optimization algorithm. This method is to perform algebraic hybridization operations on particles selected by probability pi to produce offspring particles instead of parents. The main formula is as follows:

$$child_i(X_i) = |p_i - 1| \cdot parent_i(X_i) + parent_1(X_1) \cdot p_i \tag{6}$$

$$child_i(V_i) = parent_{i-1}(V_i) + parent_i(V_i) \Big/ |parent_{i-1}(V_i)| \tag{7}$$

The selection of offspring is not based on fitness, which prevents the selection based on fitness from causing potential problems for functions with multiple local extrema. In theory, the propagation method can better search the space between space particles. For the unimodal function, although the propagation method slightly speeds up the convergence speed, it is not as good as the solution found by the basic particle swarm optimization algorithm and genetic algorithm. For the multi-local extremum function, the propagation particle swarm optimization algorithm not only speeds up the convergence speed, but also finds an equally good or better solution.

Hybrid particle swarm optimization algorithm mainly uses the basic mechanism of particle swarm optimization algorithm and the natural selection mechanism used in evolutionary computing. Since the search process of the particle swarm optimization algorithm relies on pbest and gbest, the search area is likely to be limited by them. The introduction of natural selection mechanism will gradually weaken its influence. Although the selection method has achieved better results than the basic particle swarm optimization algorithm in most test functions, it has obtained poor results on the Griewank function. Therefore, this method improves the local search ability of the particle swarm optimization algorithm, but at the same time weakens the global search ability.

2) IMPROVED METHODS TO INCREASE DIVERSITY

In the basic local version of the particle swarm optimization algorithm, the neighborhood of particles is divided based on the particle number. In the iterative scheme based on the division of particle space position, the distance between each particle and other particles in the group is calculated. We record the maximum distance between any two particles as d_{max}, and calculate a ratio for each particle according to the following formula:

$$Rate = \frac{\|X_a - X_b\|}{|1 - d_{\max}|} \tag{8}$$

Among them, $||X_a\text{-}X_b||$ is the current distance from a to b.

A local particle swarm optimization algorithm that mixes spatial neighborhood and ring topology method is called social convergence method. Because in life, people are often trying to follow the common ground of a group, rather than the position of someone in the group. This idea is applied to the particle swarm optimization algorithm, that is, it does not use the experience of each particle but uses the common experience of the spatial clustering to update itself.

The hybrid particle swarm optimization algorithm solves the high-dimensional complex functions. The traditional deterministic algorithm is easy to fall into the local minimum, and the single global random search algorithm has the characteristics of slow convergence. Compared with the classic particle swarm optimization algorithm, the algorithm adds the calculation of the neighborhood range of each particle. Simulations based on typical high-dimensional complex functions show that the hybrid algorithm has high efficiency, good optimization performance, strong robustness to initial values, and its performance is much better than a single optimization method.

D. IMPROVED PARTICLE SWARM OPTIMIZATION ALGORITHM

One of the main problems encountered in the application of particle swarm optimization algorithm is that the loss of population diversity is too fast. Directly controlling the parameters of the PSO algorithm to maintain population diversity is a feedforward strategy. However, maintaining population diversity according to the diversity measurement function of population evolution process is a feedback strategy. Since the feedback strategy can monitor evolution information at any time, it is more effective to maintain population diversity by introducing feedback to complex systems than feedforward. This section will study the use of feedback strategies to maintain population diversity. In addition, in order to balance the detection and development capabilities of particle swarm optimization algorithms, the adjustment of inertia weights will also be studied to establish a new adaptive particle swarm optimization algorithm.

The current solution space of the t-th generation population distribution is divided into Q equal regions, and the number of particles contained in each region is counted as Z1, Z2,…,ZQ. The t-th generation population distribution entropy is defined as follows:

$$E(t) = -\sum_{k=0}^{Q-1} \ln q_k \cdot |q_k| \tag{9}$$

The smaller the value, the more uneven the population distribution.

The average grain distance and population distribution entropy change with the change of population diversity during the evolution process, and the inertia weight can adjust the detection and development capabilities of the algorithm. Detection means that the particles leave the original optimization trajectory to a greater extent and move to a new direction to search; development means that the particles continue the original optimization trajectory to a greater extent for detailed search. In the early stage of optimization, in order to increase the global search capability of the algorithm, the inertia weight should decrease with the increase of population diversity, so that it has more detectability, which can be called the detection stage. The inertial weight decreases as the diversity of the population decreases, making it more exploitable, which can be called the development stage. The method designed according to the above principles has the concept of automatically adapting to the different distribution of particles in the search process and adjusting the search direction, so it is called an adaptive particle swarm optimization algorithm. Based on this concept, the inertia weight used in this paper is a linear function of the average grain distance as follows:

$$w(t) = p_m \cdot A \cdot D(t) + r_i \cdot B \tag{10}$$

When the population distribution entropy or average grain distance is less than a given value, the population will mutate according to the given mutation rate. The mutation method is to configure a random number ri distributed between [0,1] for the i-th particle. If ri is less than the given mutation rate pm, the particle is re-initialized in the solution space, but the particle has been found to be the best so far. The position is still memorized, and then a new round of optimization search is entered. The above mutation operation is performed on all m particles, and the population mutation is completed. The beginning of mutation is the beginning of the detection phase. As the detection progresses, the distribution entropy or average grain distance gradually increases. After reaching a given value, the particle swarm begins to enter the development stage. Mutation operations are not implemented during the development process. As the development progresses, the distribution entropy or average grain distance begins to decrease again. When it decreases to a given value, the algorithm enters the detection stage again. The entire evolutionary process is continuous exploration and development, until the best or sub-advantage is searched for. The flow of adaptive particle swarm optimization algorithm is shown in Figure 4.

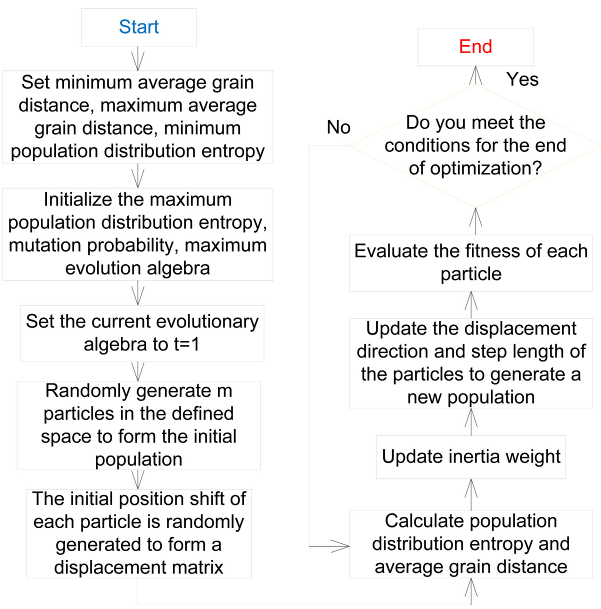


FIGURE 4. **Adaptive particle swarm optimization algorithm flow.**

E. OPTIMIZATION OF THE COMMUNICATION MECHANISM OF THE SPORTS FITNESS MANAGEMENT SYSTEM MODEL

The optimization of the model communication mechanism focuses on the optimization of the data communication mechanism between the components that make up the model. There are two situations, one is the atomic component data communication mechanism, and the other is the composite component data communication mechanism.

For all atomic components, there is a message receiving queue and a message sending queue inside. At the same time, all ports have internal queues. It is assumed that there is data communication from atomic component A to atomic component B and atomic component C in a model, as shown in Figure 5.

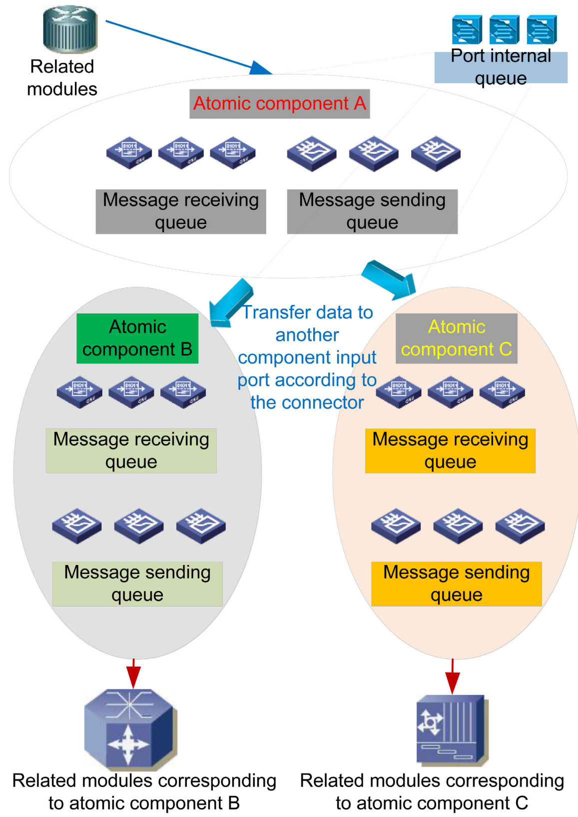


FIGURE 5. **Atomic component data communication mechanism.**

Component A judges whether its output port set is empty, and if it is not empty, it further judges whether there is data in its message sending queue. If it exists, the message sending queue data is dequeued, and a temporary storage space is opened for storing the dequeued data. Component A traverses all its output ports and causes Temp space data to enter each output port queue. Each output port detects whether there is a connector, and if there is, it transmits data to another component input port according to the connector.

Component B or C first judges whether its input port set is empty. If it is not empty, it traverses all its input ports and judges whether there is data in the internal queue of the input port. If it exists, the internal queue data of the port will be dequeued and a temporary storage space (Temp) will be opened to store the dequeued data; then, the component determines whether there is data in the Temp space, and if it exists, the data in the Temp space enters the component receiving queue.

At this point, the component data receiving process has been optimized, but in order to facilitate the use of monitors to observe the data at the component input port in the subsequent modeling and simulation process, the following algorithm steps are added in the component data receiving process. The input ports of other components are connected. If connected, the Temp space data is transmitted to the input ports of other components according to the connector.

IV. SIMULATION EXPERIMENT FOR OPTIMIZATION MANAGEMENT OF IOHTS COMPONENTS

A. CMIoT COMPONENT ENVIRONMENT CONSTRUCTION BASED ON XMODEL PLATFORM

In the sensor node components based on the CMIoT component library, the encapsulation and transmission of data frames are realized through the wireless module. Depending on the wireless communication technology adopted by the sensor node, the data frame sent by the sensor node is transmitted to the communication auxiliary gateway component through different transmission channels.

The communication auxiliary gateway component provides three wireless modules, which are respectively used to receive data frames based on different communication technologies, extract the data messages from them, and transmit them to the network protocol conversion module component after being buffered by the buffer component. The network protocol conversion module component converts different data messages into complete IPv6 messages through decompression conversion, mapping conversion or other conversion forms. IPv6 packets are buffered by the buffer component and transmitted to the wired module component. The wired module component encapsulates the IPv6 message into an Ethernet frame format and transmits it to the IPv6 router component through the Ethernet channel. After the IPv6 router component is forwarded, the Ethernet frame is finally transmitted to the medical server component.

In the medical server component, the wired module component receives the Ethernet frame and extracts the IPv6 message, and transmits it to the data processing module through the buffer component. The data processing module determines whether to receive the IPv6 message according to the destination IPv6 address. It further judges the data of which communication technology the message data originated from the IoT subnet based on the source IPv6 address, and judges the data type based on the port number, and then transmits the determined type of data to the information analysis module. The information analysis module detects whether there are errors in the received data. The detected data can be transmitted to the data storage module for long-term storage, and can be transmitted to the display controller and audio controller equipment to realize real-time monitoring and early warning of vital signs data of sports and fitness personnel.

Based on the existing CMIoT component library, this article establishes an executable CMIoT component model on the XModel platform, as shown in Figure 6. This model mainly simulates the collection behavior of vital signs data of sports and fitness personnel, the data transmission behavior of various network nodes and equipment, and the final data reception and display behavior on the medical server in the Internet of Health Things environment.

The sports fitness personnel component simulates the changes of the three types of vital signs data of the sports fitness personnel through three internal atomic components. There are three ways to generate vital sign data for each

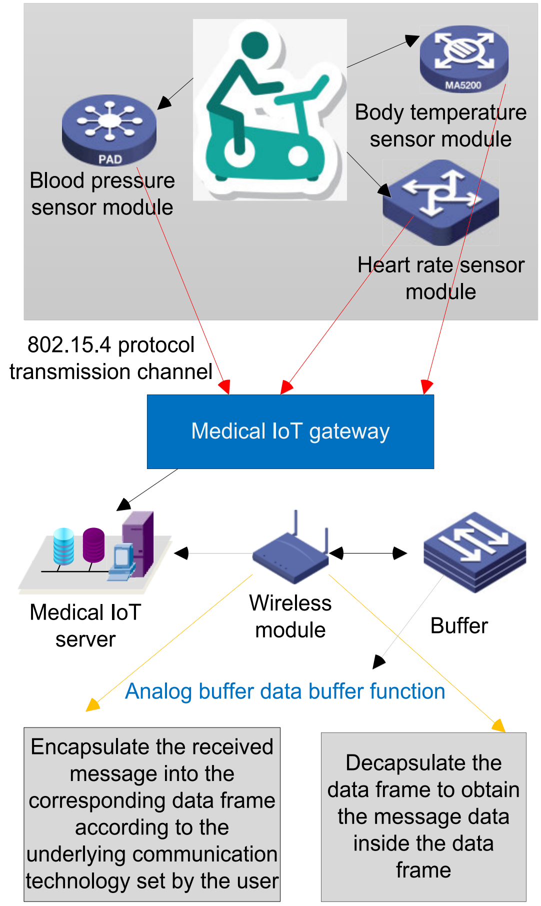


FIGURE 6. Executable CMIoT component model.

component: the first is to generate vital sign data based on a function model; the second is to obtain vital sign data collected by the hardware platform based on serial communication; the third is based on MIT- BIH physiological database.

The blood pressure sensor node component mainly simulates the behavior of the sensor node. The blood pressure sensor component collects data according to the set sampling period. At the same time, the behavior of the blood pressure sensor component also includes the generation of noise data, which is used to simulate the data collection error of the sensor device or the data error caused by the software and hardware failure.

The microprocessor component mainly simulates the function of the protocol stack integrated by the microprocessor, and its behavior is to encapsulate the data message. The specific simulated protocol stack can be set by the user through the function entry parameters. Analogous to the hardware platform, the meaning expressed is to program the protocol stack code into the chip through the emulator device. At present, microprocessor components provide simulations of two types of communication technology protocol stacks, one is the 6Lo WPAN protocol stack, and the other is the Conn ID protocol stack.

The wireless module component encapsulates the received message (6Lo WPAN message or Conn ID message)

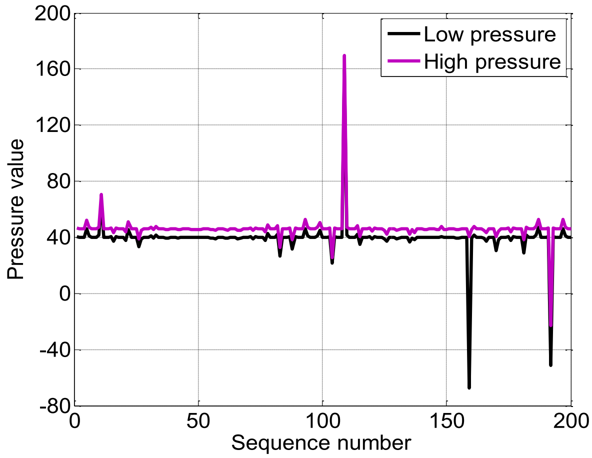


FIGURE 7. Simulation of internal communication data of blood pressure sensor node components.

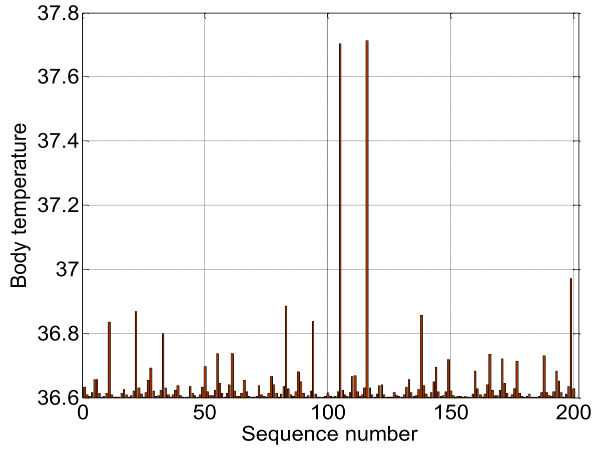


FIGURE 8. Simulation of internal communication data of body temperature sensor node components.

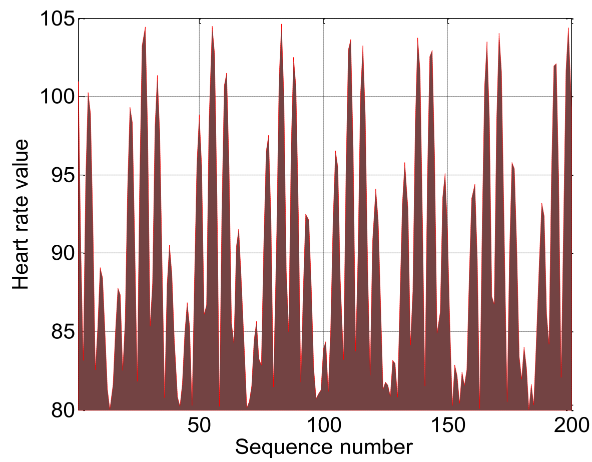


FIGURE 9. Simulation of internal communication data of heart rate sensor node components.

into corresponding data frames (such as 802.15.4 frames, 802.15.1 frames, etc.) according to the underlying communication technology set by the user. At the same time, the wireless module component can decapsulate the data frame to obtain message data within the data frame.

The wireless module component of the communication auxiliary gateway component is used to decapsulate the data frame, obtain 6Lo WPAN PDU or Conn ID PDU, and pass it to the protocol converter component after being buffered by the buffer component.

The storage structure of all mapping tables in the protocol converter component adopts the form of Hashtable. The storage form of Hashtable "key-value" pairs can effectively establish various complex mapping tables.

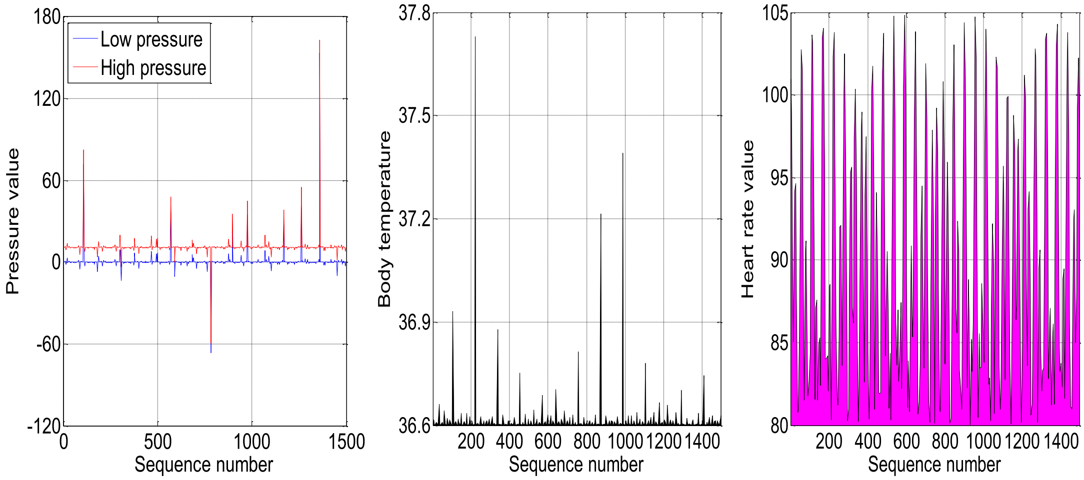
After the message conversion of the protocol converter component, the 6Lo WPAN message or Conn ID message will be converted into a complete IPv6 message, buffered by the buffer component, and transmitted to the wired module component. The wired module component encapsulates the IPv6 message into an Ethernet frame and sends it to the outside through its output port.

The behavior of the data processor component of the medical server is to determine whether to receive a message, and to further determine the upper-layer application data type for the received message. The judgment of the data type should be combined with the communication technology type field and port number field designed by the source IPv6 address. For data of a certain data type, the data processor component transmits to the data analyzer component through its output port. The data analyzer component sets the conditions for judging the validity of various types of data to clean up the data and filter out the data with errors. The analyzed and cleaned data can be stored for subsequent use, or sent out through the output port of the medical server component. The purpose of sending out is for real-time data processing or analysis, for example, through an external display component to realize real-time data display.

B. SYSTEM MODEL SIMULATION OF IMPROVED PARTICLE SWARM OPTIMIZATION ALGORITHM

After establishing the CMIoT component model, it is necessary to further design the simulation scheme, which mainly includes the setting of operating parameters and the addition of monitor components according to user needs. Corresponding monitor components can be set at the output ports of the main composite components in the CMIoT component model, so that the changes in the output data of each component can be effectively observed during the execution of the model simulation. In addition, you can further add a corresponding monitor component inside the composite component to observe the internal data communication of the component. After starting the execution function of the CMIoT component model, the blood pressure sensor node component collects human blood pressure data, and processes the internal module components to form an 802.15.4 data frame. The frame load data is a 6Lo WPAN protocol data unit.

In order to further monitor the formation process of the 802.15.4 data frame of the blood pressure sensor node



(a) Medical server blood pressure data simulation (b) Medical server body temperature data simulation (c) Medical server heart rate data simulation

FIGURE 10. Multiple medical data simulation of medical server. (a) Medical server blood pressure data simulation. (b) Medical server body temperature data simulation. (c) Medical server heart rate data simulation.

component, a monitor component can be added inside the component. The simulation result of the internal communication data of the blood pressure sensor node component is shown in Figure 7. The Blood Pressure Monitor component displays the blood pressure data collected by the blood pressure sensor component. It can be seen from the displayed results of the Blood Pressure Monitor that there are three obvious error data situations in the blood pressure data collected, which effectively simulates the data collection errors caused by random noise interference or software and hardware failures. The Monitor6 component displays the 6Lo WPAN message formed by the microprocessor component. The application layer payload of the message is a set of blood pressure data. After processing by the buffer component, the buffer component will wait for the application layer load to reach the maximum load that can be accommodated in the 802.15.4 frame before sending the 6Lo WPAN message. After processing by the wireless module components, the data frame is sent to the outside.

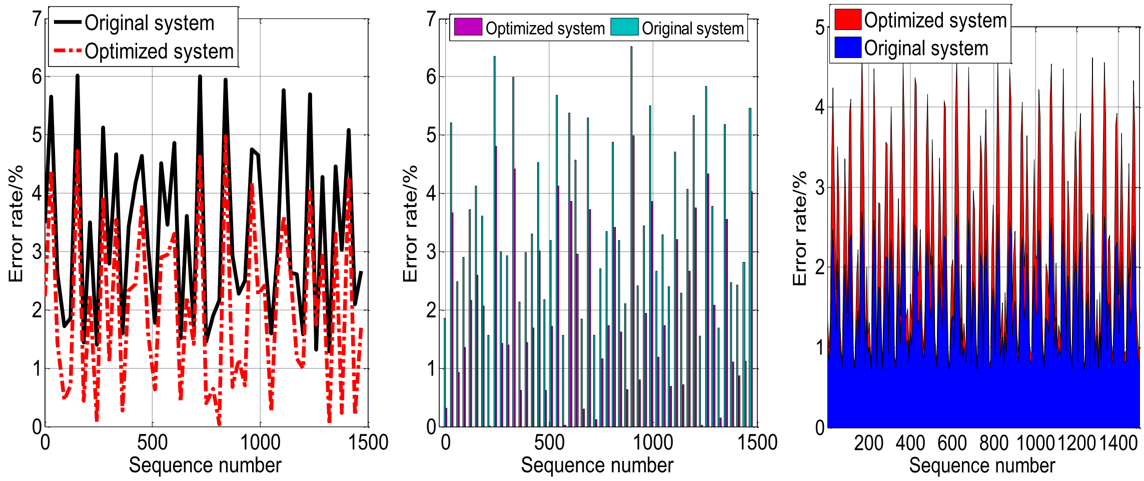
While the blood pressure sensor node component collects human blood pressure data, the body temperature sensor node component and the heart rate sensor node component are also collecting corresponding vital sign data. According to the simulation parameter setting, the body temperature sensor node and the heart rate sensor node both use Conn ID technology for data communication, and the data frames are based on 802.15.4 frames and 802.15.1 frames respectively.

The internal load of the 802.15.4 data frame of the temperature sensor node monitored by Monitor2 is the Conn ID protocol data unit, where the message identifier is set to FFH, and the connection identifier is negotiated to be F431CA185F74C6E6H. The internal load of the 802.15.1 data frame of the heart rate sensor node monitored by Monitor3 is also the Conn ID protocol data unit, where the message identifier is set to FFH, and the connection identifier is negotiated to be 73B6D1725035878DH. Similar to the blood pressure sensor node, the body temperature sensor node and the heart rate sensor node can also monitor the formation of the corresponding component data frame by adding a monitor component. The simulation results are shown in Figure 8 and Figure 9 respectively.

Different sensor nodes select different channels according to the communication technology they use, and finally send the generated data frame to the communication auxiliary gateway. The protocol converter component in the communication auxiliary gateway realizes the decompression conversion of 6Lo WPAN messages and Conn ID Mapping and conversion of messages. To facilitate observation, Monitor15 is added inside the communication auxiliary gateway to display the status of IPv6 packets at the output port of the protocol converter.

After the medical server component analyzes and processes the received Ethernet frames in sequence according to the behavior and function of each internal component, the data is transmitted to the multiple medical data monitor components through the medical server output port. During the execution of the entire CMIoT component model, the data displayed by the multiple medical data monitors is shown in Figure 10. The simulation results show that the blood pressure, body temperature, and heart rate three types of vital sign data generated by the exercise and fitness component are all normally received by the medical server. In the displayed results, the reason for the data fluctuation is that there is a certain delay and packet loss rate in the transmission of network data packets. After each data packet is received by the medical server, the medical data in the data packet is analyzed and processed, and the data packet is discarded. The simulation error of multiple medical data of the medical server is shown in Figure 11.

In addition, body temperature data and heart rate data are transmitted using the IPv6 communication scheme based on the connection identifier, and the underlying communication



(a) Blood pressure data simulation error (b) Body temperature data simulation error (c) Heart rate data simulation error

FIGURE 11. Multiple medical data simulation error of medical server. (a) Blood pressure data simulation error (b) Body temperature data simulation error (c) Heart rate data simulation error.

technology uses the 802.15.4 protocol and the 802.15.1 protocol respectively. On the medical server side, the effective reception of these two types of data indicates that, the IPv6 communication scheme based on the connection identification is feasible. This scheme can effectively complete the low-power IoT subnet nodes to access the IPv6 network and carry out data transmission and communication. The CMIoT component model also implements the communication between the IoT subnet node and the IPv6 network based on the 6Lo WPAN protocol. The simulation results of the entire CMIoT component model show that the component optimization modeling method designed in this paper is effective and can be applied to the optimization of key issues in the field of Internet of Health Things.

V. CONCLUSION

The Internet of Health Things places more emphasis on the effective transmission of network data and the effective identification and management of a large number of sensor execution nodes. At the same time, as a huge and complex CPS system, the Internet of Health Things has established a complete system model at the beginning of the system design, which is conducive to the overall grasp of the system from a macro perspective. This paper discovers its shortcomings based on the research of particle swarm optimization algorithm, and improves it. The main improvement methods are introduced, many of which are of practical significance. A new improved method of particle swarm optimization algorithm is proposed. In the algorithm search process, the concepts of average particle distance and population distribution entrainment are introduced to dynamically change the inertia weight, thereby improving the optimization efficiency of the particle swarm optimization algorithm. And it has a good optimization accuracy. The idea of cyber-physical fusion system modeling is introduced into the research field of Internet of Health Things, and a component collaborative modeling method for Internet of Health Things is proposed. This method constructs different types of components based on the different functions of the Internet of Things devices, and designs a set of communication mechanisms between the components based on the characteristics of the Internet of Things network communication, and uses a visual way to model. A set of IoHTs component library system was designed, and based on the self-developed XModel modeling simulation platform, a IoHTs component model was constructed. At the same time, based on the simulation results of the model, the verification of the validity of the proposed modeling method and the feasibility of the IPv6 communication scheme was completed. Although it can realize the fitness data management of users, it has not yet been able to conduct in-depth mining and analysis of large amounts of data. Therefore, further in-depth research can be carried out in fitness data analysis.

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YONGQUAN TANG was born in Zhengzhou, China, in 1974. He received the bachelor's and master's degrees from Henan Normal University, in 2006 and 2006, respectively. From 1999 to 2019, he worked with the Henan Vocational College of Agriculture. He has published five articles, one of which has been included in SCI. His research interests include sports medicine and the Internet of Things.

DEHUA WANG was born in Xinyang, China, in 1970. He received the bachelor's degree from Henan Normal University, in 1995, and the master's degree from Beijing Sport University, in 2005. From 1995 to 2020, he worked with Xinyang Normal University. He has published five articles, one of which has been included in SCI. His research interests include sports medicine and the Internet of Things.