Design of Sports Health Monitoring System based on Computer-Aided Virtual Reality Technology

Xiangwen Zhao

Department of Command and Tactics, Henan Police College, Zhengzhou 450046, China, zxw@hnp.edu.cn

Corresponding author: Xiangwen Zhao, zxw@hnp.edu.cn

Abstract. Aiming at a series of problems existing in the existing sports health monitoring system, the optimized virtual reality algorithm is adopted to monitor and analyze sports health based on computer-aided theories. By optimizing the original model, the optimization model that can better reflect the design of sports health monitoring system is obtained, and the accuracy of the optimization model is verified by carrying out relevant experiments. The research shows that: with the increase of time, the development of virtual reality technology shows a fluctuating trend, which can be divided into five stages: birth period, peak period, trough period, climbing period and corresponding production period. According to the graph of the influence of computer-aided virtual reality technology on sports, more than 60% of people show strong interest in the sports monitoring system, indicating that most people show strong interest in the computer-aided sports health monitoring system. There were significant differences in the daily walking activity of different subjects: the daily walking amount of experimenter 1 and 2 changed little, indicating that the subjects' activity had a good regularity. The subjects' daily walking amount fluctuated greatly from 3 to 6, indicating that the subjects' daily activity pattern was poor. Finally, the optimization model is verified and analyzed by using the method of relevant experiments, which shows that the optimization model can provide basis and theoretical support for the design and application of sports health monitoring system.

Keywords: Computer Aided; Virtual Reality Technology; Sports Health Monitoring; System Design; Optimization Model
DOI: https://doi.org/10.14733/cadaps.2023.S1.97-107

1 INTRODUCTION

Computer-aided virtual reality technology has a wide range of applications in various aspects: a series of problems exist in the real-time rendering and visualization requirements of virtual reality system. Yoon et al. [1] proposed a CAD model simplification and transformation method and applied it to virtual system. By adopting a new adaptive simplification method based on classification, multi-resolution mesh simplification can be realized and applied to materials field. Through the comprehensive analysis of materials, the internal law of materials is explored from various angles, thus providing theoretical basis for the promotion of materials. Junior et al. [2] proposed an optimized model for designing virtual reality based on computer-aided design (CAD) to address the problems in prototyping and process modification. At the same time, this model adopts centralized software architecture, which consists of CAD editor, input manager and VRS, and applies it to related fields such as substation, and then verifies the accuracy of the model by experiments. Rasheed et al. [3] proposed a new type of virtual reality technology that provides a unique way to enhance the use of complex 3D graphics and visualization environments. By integrating virtual reality technology into computer-aided design networks to facilitate student learning and practice. Ye and Li [4] proposed a new computer aided virtual reality technology, which mainly involves from the field of industrial design and digital media art. The model is optimized and verified by experiments. The aim of the model is to predict the maturity and widespread adoption of the technology. Yu and Han [5] proposed a design method combining layout optimization, discrete event simulation and virtual reality platform to solve the problems existing in the process of nuclear operation. The method verifies the practicality of process equipment layout and floor plan by using an integrated computer-aided platform and related data, thus providing a detailed VR environment for process model testing. In view of the relevant problems existing in the urban living environment, a computer-aided correlation model is proposed [6]. This model is built on the basis of adjusting the perception of people with different living environments to the city. The model studies relevant urban indicators through the combination of virtual reality technology, and finds out the optimal scheme through the analysis of indicators. Finally, relevant experiments are carried out to further verify the accuracy of the model. Relevant research indicates that more attention should be paid to virtual reality technology related to people's living environment in urban design practice. This study further proves that the combination of computer-aided virtual reality technology and joint analysis can be used as urban design research. In view of the problems existing in the automatic driving scene, a new interaction mode based on computer aided technology is established [7]. By introducing two layered human-computer interaction information systems under the effect of virtual reality technology, it is used to build new optimization system and design. Based on the automatic driving application scenario, the corresponding computer-aided virtual reality scenario is developed. To verify the accuracy of the optimization model, the test data were imported into the computer-aided system. The superiority and accuracy of the model are illustrated by calculation. The research can provide a theoretical basis for the design and development of human-computer interaction system in the field of autonomous vehicles with computer-aided virtual reality technology. To improve the ability of experts, researchers and scholars to understand and develop human-computer interaction in computer-aided design. Aiming at a series of complex problems existing in the input technology and interaction technology of cad applications, a new computer-aided technology and virtual reality system is constructed [8]. The model firstly introduces the role of virtual reality technology in cad applications and develops corresponding input technology and interaction technology based on the relevant characteristics of CAD. These optimization features are introduced into the conventional model to obtain a computer-aided optimization system, which is based on virtual reality technology to carry out relevant tests. The accuracy of computer-aided design and virtual reality theory is verified by experiments, and an alternative method is discussed based on the optimization model, so as to integrate the material culture level of computer-aided design into the input technology and interaction technology of computer-aided design.

Through the above research, we can see that computer-aided virtual reality technology has a wide application prospect in industry and other fields, but virtual reality technology has not been used in the design of sports health monitoring system. Therefore, in order to realize the application of virtual reality technology in the field of sports, in this paper, the related theory, based on computer aided by adopting optimized correlation algorithm of virtual reality technology, and the corresponding optimization model, the model is verified by relevant test has a good application in the field of fitness, the study for further popularization and application of virtual reality technology provides a theoretical basis.

2 PRINCIPLES AND TECHNOLOGY OF COMPUTER AIDED DESIGN

2.1 Principles of Computer-Aided Design

The research and application of computer-aided virtual reality technology is far behind the corresponding monitoring system because of the complexity of its domain problems and the disunity and ambiguity in concept, research content and technical system. Aiming at the design of sports health monitoring system, this paper studies and discusses the concept, basic characteristics, research objectives, technical route, technical system, research difficulties and emphases, key technologies and technical risks of computer aided design.

(1) Computer aided design principle

Computer-aided virtual reality technology is based on scientifically collected sample data, based on the relevant characteristics of the sample, combined with the standardized data and empirical knowledge of health sports experts, supported by intelligent technology, statistical analysis technology and information technology, automatic learning and mining the rules contained in the data from the knowledge samples. By establishing various intelligent models to simulate the standardized features given by experts, the computer aided quality evaluation and optimal design of sports health monitoring system can be realized.

DBN (Deep Belief Network) model is a very typical model of deep neural network, which can fully reflect the relevant theory of computer-aided design. It is widely used in feature generation and data classification. The corresponding RBM (Restricted Boltzmann Machines) model is a fully connected structure between layers, usually consisting of visible layer and hidden layer, as shown in Figure 1.

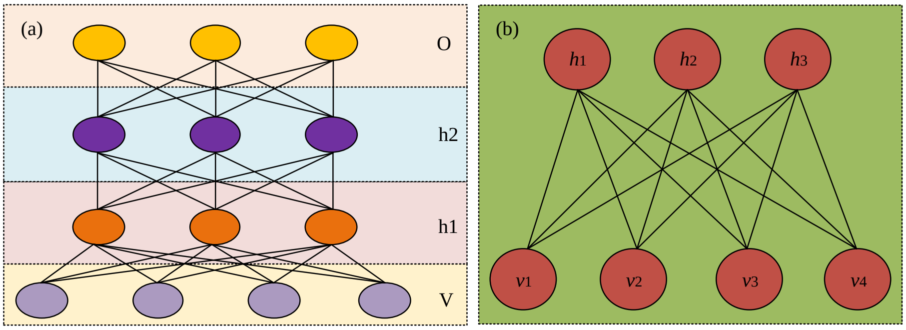

Figure 1: Classification model (a) RBM model (b) DBN model.

(2) Basic features

The basic characteristics of computer-aided design principle mainly include [9]: (1) computer-aided virtual reality technology is supported by information technology, covering the new design patterns and methods of digital technology, internal law mining, modeling, optimization design and other technical fields. (2) The design of intelligent sports health monitoring system is its core supporting technology and main feature. (3) Pay attention to the in-depth analysis and utilization of data and the mining of internal rules, and express, store and apply them in the way of digitalization or model. (4) To complete the development of a sports health monitoring system using a combination of computer-aided and expert-designed models.

2.2 The Connotation of Computer-Aided Design

The design of computer-aided virtual reality technology is a more scientific and rational sports design mode that combines sports and information technology. It is also a comprehensive and marginal subject involving many fields, including mechanical engineering, computer, intelligent information processing, simulation biology, statistics and so on. The connotation of computer-aided data is as follows [10]:

(1) Optimization design: The optimization design of computer-aided design technology is mainly reflected in the research idea of "digitalization, standardization and intelligence". The technical characteristics of "digitalization" are embodied in the digitalization of data monitoring, product and design. The technical characteristics of "standardization" are embodied in the standardization and unity of data detection and sports expert evaluation. "Intelligence" is embodied in the use of intelligent technology to realize the mining of internal laws, simulation of expert behavior activities.

(2) Agility and complexity: With the help of computer system, technicians can realize the virtual design and system simulation of sports health, thus reducing the number of experiments, fully embodies the agility of sports health monitoring system research and development.

(3) Collaborative research and development: The integration of computer-aided design and information technology can effectively associate and organically integrate multiple technical links such as production, reflecting the collaborative design of multiple business links. At the same time, it can effectively integrate technical research, research and development management and production control, reflecting the synergy between multiple levels.

By analyzing the relevant connotation of computer-aided design, the above DBN model is optimized and the corresponding optimization model is obtained. The optimization model of DBN contains two hidden layers, and each hidden layer has 100 nodes. The model structure is shown in Figure 2.

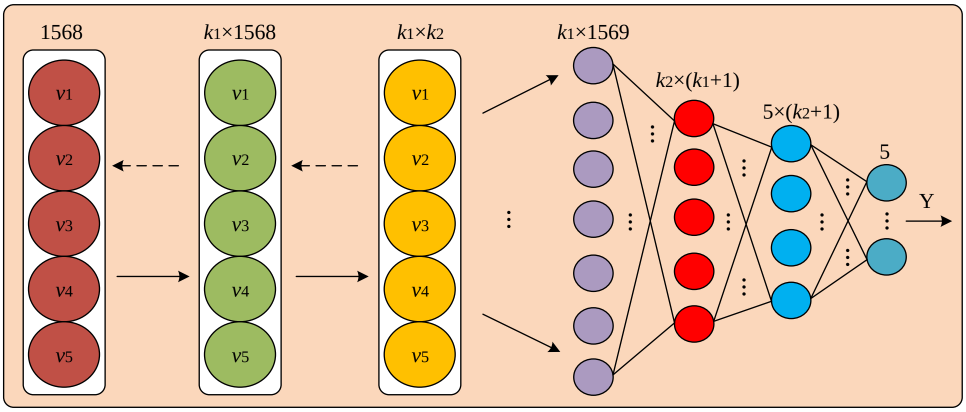

Figure 2: Optimized DBN model.

It can be seen from Figure 2 that the optimized DBN model mainly conducts unitary processing of data and accurate positioning of data in the form of cell grid division. Then the corresponding data is imported into the optimization model, and different data element nodes are analyzed according to different matrices, and corresponding values are finally derived.

2.3 Computer-Aided Design Technology System

The technical system of computer aided virtual reality technology design mainly includes: (1) computer aided related technology, (2) virtual reality technology. It is worth noting that the two are interrelated and mutually supportive. Figure 3 shows some related technical content and structural system of computer aided sports health monitoring system. It can be seen from Figure 3 that the computer-aided sports health monitoring system first needs to carry out the computer-specific auxiliary design. By improving the combined efficiency of multiple objectives and multiple constraints, the purpose of optimal design has been achieved. On the basis of the optimization model, the structural characteristics and capacity design are analyzed, so as to conduct systematic research on the material properties and simulation biology, and finally through the processing industry and deepening industrial structure and other methods to excavate the relevant laws of sports health.

The integrated technology of computer-aided design is based on the key technology and health movement monitoring, combined with the design idea, management idea and characteristics of monitoring system research and development to complete the specific design research and development, embodies the idea of knowledge engineering and technology integration application. Although basic technology and supporting technology do not directly solve specific business problems, but as the foundation of solving specific problems of industry technology and key technology, the development of its new theories and new methods will have a fundamental role in promoting cad. From the analysis and understanding of the technical system, we can know more clearly that the research and construction of computer-aided virtual reality design technology is not a few single points of research content. It requires the support of a whole set of theories, technologies and domain knowledge, as well as integration and integration with R&D management and basic data.

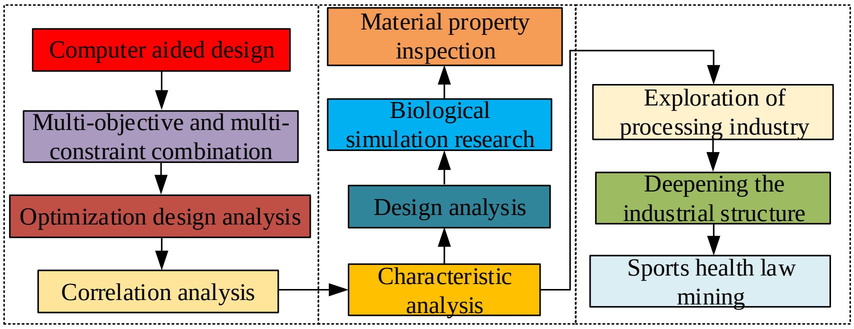

Figure 3: Technical content of computer aided sports health monitoring system.

3 VIRTUAL REALITY TECHNOLOGY

3.1 Characteristics of Virtual Reality Technology

The 3D modeling function of virtual reality technology can create a virtual world with multiple senses such as sight, hearing, feeling and touch in the computer. This virtual world can be either completely fictional or a virtual representation of the real world.

With the improvement of scientific and technological level, virtual reality technology is also developing gradually. The changing trend of virtual reality technology development is summarized as shown in Figure 4: With the increase of time, the corresponding value of virtual reality technology shows a fluctuating change trend. According to the different changes, the development of virtual reality technology can be divided into five stages: (1) The birth stage of virtual reality technology. In this stage, with the increase of time, the corresponding value shows a trend of rapid improvement; (2) The peak of virtual reality technology, the value of this stage shows an N-type trend and the maximum value of the whole stage; (3) Trough period: virtual reality technology shows rapid decline and slow increase with the increase of time; (4) The climbing stage of virtual reality technology, the corresponding slope of the curve is approximately constant, indicating that the development of virtual reality technology gradually tends to be stable; (5) Production stage, the change in this stage is affected by time and other factors, and the change is relatively slow.

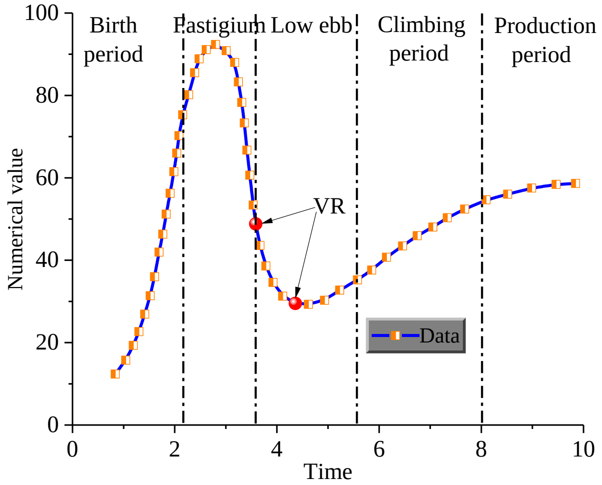

Figure 4: Development trend of virtual reality technology.

Virtual reality technology system includes the following kinds of monitoring systems: (1) operator action calculation and measurement system; (2) A simulation system composed of output devices; (3) the representation system of the execution and feeling of the action.

The advantages of virtual drill mainly include: (1) simulation: virtual drill environment is built on the basis of real drill environment. (2) Pertinence: with the help of virtual reality technology, trainees can place themselves in a variety of complex and emergent environments. (3) Security: the virtual training environment is far safer than the real one. The trainees can boldly try various training schemes in the virtual environment.

3.2 Types of Virtual Reality Technology

In practical application, virtual reality technology can be divided into four types: desktop system, immersive system, enhanced system and distributed system according to the different degrees of "Immersion" and "Inter-sensitivity".

(1) Desktop virtual reality system: Desktop VR system is to use ordinary computer or simple graphics workstation as the main equipment, the computer monitor as a window for users to experience the virtual world. The desktop system mainly uses computer software to build three-dimensional virtual space, and uses stereoscopic glasses, digital gloves, tactile and force feedback system to realize interaction. Desktop system has three characteristics: (a) the experiencer is not isolated from the real environment, and will be disturbed by the surrounding environment, and lacks the feeling of complete immersion and immersive. (b) Very low hardware requirements, the simplest desktop virtual reality system can be just a computer. (c) The system has some of the technical requirements of an immersive system.

(2) Immersive virtual reality system: Immersive VR system is the best form of IMMERSIVE and interactive VR system. Immersive systems generally use some hardware devices to isolate the experiencer from the real world, and close the experiencer's perception of sight, hearing, touch, smell, taste, etc., to form a completely virtual, highly immersive, realistic and vivid virtual environment.

(3) Augmented virtual reality system: Augmented VR system can realize the superposition of virtual environment and real environment. Some virtual objects or virtual elements can be added on the basis of the real world to enhance the cognition of the real world.

(4) Distributed virtual reality system: Distributed VR system is a combination of Internet technology. It can realize multiple users in different sites and locations to connect through the network, so that multiple different users participate in an environment at the same time, Interact and share information with other users through computers and their networks. Distributed systems are characterized by the ability of multiple people to experience a virtual world and work cooperatively. It is worth explaining that desktop virtual reality system has become the first choice of computer aided sports health monitoring system because of its relatively simple technology, low hardware requirements, strong practicability, low investment cost and wide application range.

4 DESIGN OF SPORTS HEALTH SYSTEM BASED ON COMPUTER AIDED

4.1 Exercise Health Data Collection

In order to better analyze the popularity of computer-aided sports monitoring system and draw the influence chart of computer-aided virtual reality technology on sports, it can be seen from Figure 5 that more than 60% of people show strong interest in this sports monitoring system. Only 3.54% of the people show strong dissatisfaction with the system, while more than 20% of the people are interested in it, and only 5.05% of the people are not interested in it, and about 8% of the people are not sure about it. Through statistical analysis, it can be seen that most people show strong interest in the computer-aided sports health monitoring system, indicating that the system is relatively popular.

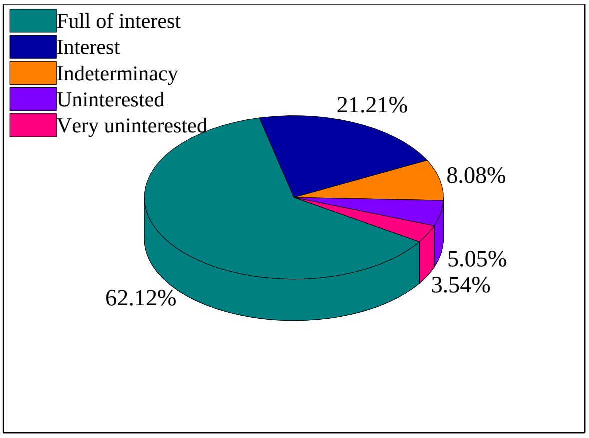

Figure 5: Influence of computer-aided virtual reality technology on motion.

In order to analyze the relationship between health status and gait parameters, 36 subjects' gait parameters were monitored during walking. In addition, the daily activity amount of pedestrians was evaluated based on their daily activity track, so as to provide guidance for people of all ages to participate in physical fitness exercise and strengthen physical function. The basic physical data of 36 subjects were statistically analyzed. The age, sex, height, weight and Body Mass Index (BMI) of the subjects were shown in Table 1. Independent sample T test was used to compare the mean values of basic data of the three groups of subjects, and the results showed that there was no significant difference between the mean values of height, weight and BMI of the three groups of subjects.

Grouping	Number	Sex	Age	Weight /kg	Height/m	BMI/(kg/m2)
Youth	12	man 6;woman 6	24±4	56.2±12	1.7±0.3	24
Middle	12	man 6;woman 6	44±4	62.4±10	1.6±0.2	23
Older	12	man 6;woman 6	68±10	58.7±11	1.5±0.1	24

Table 1: Sample basic materials.

Gait parameters covered by walking health monitoring are divided into time and space parameters. The time parameters include gait cycle, swing phase time, support phase time, swing phase time proportion, support phase time proportion, stride frequency and walking speed. The spatial parameters include stride length and peak thigh swing angle.

4.2 Analysis of Sports Health Monitoring

Statistical methods were used to analyze the correlation between the physical data of pedestrians based on height, weight and BMI and stride length, stride frequency, stride speed, gait cycle and phase, as well as thigh swing peak, and to process some gait parameters that were correlated with each other. The three groups of subjects were compared among groups, and the results were shown in table 2. The analysis showed that: (1) The gait cycle and supporting phase time of the young group were significantly shorter than those of the middle-aged group and the elderly group; (2) The peak values of step frequency and thigh swing Angle in the young and middle-aged groups were significantly higher than those in the old group.

Parameter	Youth	Middle	Older
Gait period	1.045±0.7	1.195±0.7	1.265±0.087
Swing phase	0.015±0.04	0.45±0.0.3	0.7845±0.032
Support phase	0.055±0.08	0.75±0.0.45	0.145±0.051
Proportion of oscillations	10.045±1.98	39.5±1.4	30.02±2.7
Support ratio	30.045±0.5	50.45±1.56	60.075±1.5
Stride frequency	56.045±0.2	46.45±0.6	38.26±0.71
Step number	2.055±0.712	1.125±0.3	1.034±2.13
Thigh swing peak	26.045±0.25	26.55±0.9	20.35±0.45

Table 2: Parameter correlation summary table.

The youth group was taken as an example to carry out relevant evaluation of parameters, and the distribution of gait parameters of subjects in the youth group was summarized as shown in Figure 6 :(1) the gait frequency corresponding to the youth group was the highest, which was twice of the corresponding number of steps. The results showed that step frequency was the main factor affecting exercise health monitoring among various parameters. With the gradual increase of number, the corresponding change of step frequency was small, and only the highest value appeared at number 12. (2) The parameter value of swing Angle is lower than the corresponding step frequency, but much higher than the corresponding step speed and step length. The trend of swing Angle is basically consistent with the trend of step frequency. (3) The parameter values of step speed and step length are relatively small and basically consistent, and the corresponding step length is slightly higher than the corresponding step speed; (4) From the perspective of each individual, the variation relationship of different parameters is step frequency > swing Angle > step length > step speed, indicating that the nature of the sample number of the youth group with different parameters is basically the same and has a good correlation.

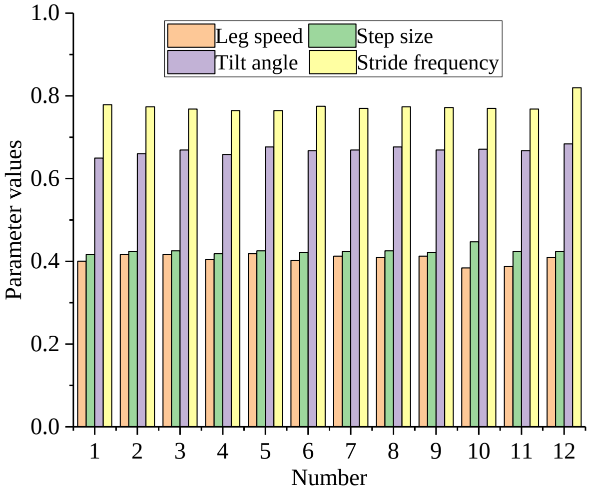

Figure 6: Distribution of parameter evaluation.

4.3 Analysis of Pedestrian Activity Data

In order to better analyze the activity rule of the sample in a week, the stride number of the subjects in a week was counted, as shown in Figure 7.

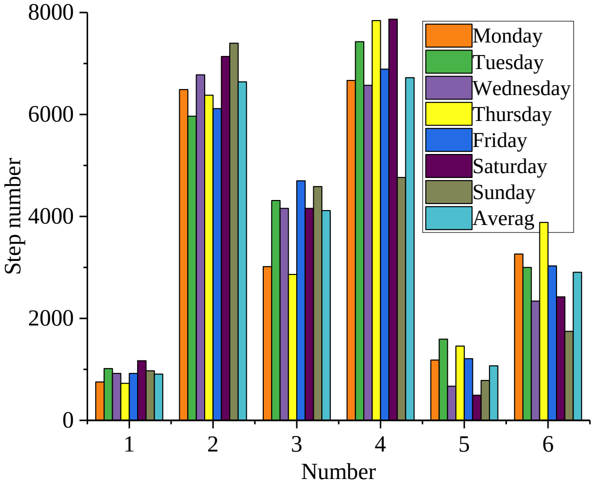

Figure 7: Activity distribution of samples in a week.

It can be seen from Figure 7 that the daily walking activities of the six subjects have significant differences. Measured from the change trend of stride number within a week, the daily walking amount of experimenter 1 and 2 changed little, indicating that the subjects' activity level had a good regularity. The subjects' daily walking amount fluctuated greatly from 3 to 6, indicating that the subjects' daily activity pattern was poor. In terms of daily average stride size, subjects 2 and 4 were significantly more active than subjects 1, 3, 5 and 6. It can also be seen from the average that the number of steps corresponding to experimenter 4 and experimenter 2 is basically the same and much higher than that of other experimenters, indicating that using the average as the measurement standard can better reflect the change rule of experimenters.

In order to better study the optimization model of sports health monitoring based on computer-aided virtual reality technology, different h values in the model were analyzed, as shown in Figure 8: It can be seen from the figure that the change curves of h_1 and h_2 are approximately a horizontal straight line, indicating that the change curves of h_1 and h_2 are relatively stable and insensitive to the number of iterations as the number of iterations increases. The curve corresponding to h_3 shows a different trend of change, with approximately a stable increase, indicating that its change in the number of iterations shows a linear increase trend, indicating that h_3 is highly sensitive to the number of iterations, so using h_3 as a parameter can better demonstrate the accuracy of the motion monitoring system.

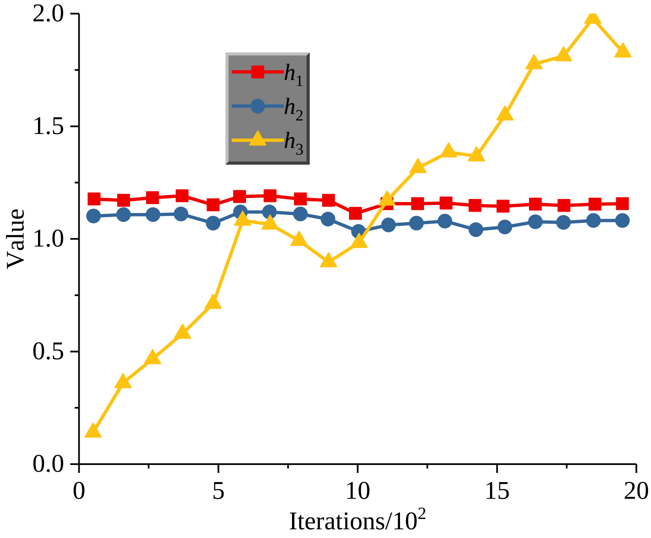

Figure 8: Performance of the optimization model under different *h* values.

5 CONCLUSION

Virtual reality technology can be divided into desktop system, immersive system, enhanced system and distributed system according to the different degrees of "Immersion" and "Inter-sensitivity". Among them, desktop virtual reality system has become the first choice of computer aided sports health monitoring system because of its relatively simple technology, strong practicability and wide application range. The youth group had the highest step frequency, which was twice of the corresponding step number, indicating that step frequency was the main factor affecting the exercise health monitoring among various parameters. The parameter value of swing Angle is lower than the corresponding step frequency, but much higher than the corresponding step speed and step length. The trend of swing Angle is basically consistent with the trend of step frequency. From the point of view of each individual, the variation relationship of different parameters is as follows: step frequency > swing Angle > step length > step speed. The corresponding change curve of h1 and h2 is approximately a horizontal straight line, indicating that the change curve of h1 and h2 is relatively stable and insensitive to the number of iterations as the number of iterations increases. However, the curve corresponding to h3 shows a different trend of change. The curve approximately increases steadily, indicating that h3 shows a linear increase trend of change in the number of iterations, indicating that h3 is highly sensitive to the number of iterations.

Xiangwen Zhao, https://orcid.org/0000-0002-5636-6023

REFERENCES

[1] Yoon, Y.-C.; Moon, D.-M.; Chin, S.: Fine Tactile Representation of Materials for Virtual Reality, Journal of Sensors, 20(15), 2020, 7296-7304. https://doi.org/10.1155/2020/7296204

[2] Junior, C.-L.-B.; Cardoso, A.; Júnior, E.-A.-L.; Silva, P.-C.; Silva, A.-C.: Designing virtual reality environments through an authoring system based on CAD floor plans: a methodology and case study applied to electric power substations for supervision, Energies, 14(5), 2021, 453-479. https://doi.org/10.3390/en14217435

[3] Rasheed, G.; Khan, M.; Malik, N.; Akhunzada, A.: Measuring Learnability through Virtual Reality Laboratory Application: A User Study, Sustainability, 13(19), 2021, 102-114. https://doi.org/10.3390/su131910812

[4] Ye, W.-N.; Li, Y.-H.: Design and Research of Digital Media Art Display Based on Virtual Reality and Augmented Reality, Mobile Information Systems, 22(15), 2022, 660-688. https://doi.org/10.1155/2022/6606885

[5] Yu, S.-N.; Han, J.-H.: Virtual reality platform-based conceptual design and simulation of a hot cell facility, The International Journal of Advanced Manufacturing Technology, 116(1), 2021, 487-505. https://doi.org/10.1007/s00170-021-07139-7

[6] Ibrahim, N.; Akin, E.: Virtual reality for electrical machine, International Journal of Scientific Research and Management, 9(5), 2021, 586-596. https://doi.org/10.18535/ijsrm/v9i05.ec01

[7] Fechter, M.; Schleich, B.; Wartzack, S.: Comparative evaluation of WIMP and immersive natural finger interaction: a user study on CAD assembly modeling, Virtual Reality, 26(1), 2022, 143-158. https://doi.org/10.1007/s10055-021-00543-0

[8] Georgiev, D.-D.; Georgieva, I.; Gong, Z.; Nanjappan, V.; Georgiev, G.-V.: Virtual reality for neurorehabilitation and cognitive enhancement, Brain Sciences, 11(2), 2021, 221-242. https://doi.org/10.3390/brainsci11020221

[9] Stasolla, F.; Matamala, G.-M.; Bernini, S.; Caffò, A.-O.; Bottiroli, S.: Virtual reality as a technological-aided solution to support communication in persons with neurodegenerative diseases and acquired brain injury during COVID-19 pandemic, Frontiers in Public Health, 8(6), 2021, 635-656. https://doi.org/10.3389/fpubh.2020.635426

[10] Zhong, H.; Wang, L.; Zhang, H.: The application of virtual reality technology in the digital preservation of cultural heritage, Computer Science and Information Systems, 18(5), 2021, 9-18. https://doi.org/10.2298/CSIS200208009Z