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Research on core strength training of aerobics based on artificial intelligence and sensor network

Liqiang Jia¹ and Lingshu Li^{2*}

* Correspondence: yanding19671@163.com

²Department of Physical Education,
Shanghai International Studies
University, Shanghai 200083, China
Full list of author information is
available at the end of the article

Abstract

The traditional training system based on case teaching is according to the analysis of past competitions and training cases to carry out the strength training of aerobics special movements. The training results can not be evaluated intelligently and accurately, and the performance of dynamic analysis is poor. To address this problem, the core training system of strength quality of aerobics special movements based on artificial intelligence is designed to realize the intelligent training of the strength quality of aerobics special movements. Through the study of fuzzy paradigm system, intelligent functions such as optimization and decision-making of intelligent fuzzy network are realized. The design system architecture framework includes the modules of sensor, receiver, database, and analysis decision. The core chip of the system is the main control module of Atmega1280 MCU for man-machine interaction, so as to realize the comprehensive training of the strength quality of aerobics special movements. Information collection module is used to collect information on strength training information such as instrument, movement, and language. The problem of phase distortion in signal transmission process is processed by FIR filter. Through information management module, trainee information management and training results statistics and queries are implemented. In the system software part, the system software structure diagram and system startup and landing procedure are given. By analyzing the working process of the module, the strength of aerobics special movements is analyzed. Experimental results show that the designed system can achieve real-time and stable strength training for aerobics special movements and improve training efficiency.

Keywords: Artificial intelligence, Strength quality, Human-machine interaction, Signal acquisition, Wireless network

1 Introduction

Aerobics is to show the ability of athletes to perform complex and high-intensity exercises continuously under the accompaniment of music and through the perfect completion of difficult movements. As the basis and key link of excellent aerobics exercise, special strength training has become an important topic of scientific research [1]. The general requirement of aerobics for strength is to have a good waist and abdomen power and explosive force on the upper, lower extremities, and whole body. The whole set of aerobics exercises are characterized by operation movement, transition movement, and difficulty movement. These technical movements have high requirements for the upper and lower extremities. Because competitive aerobics competition is carried out within a certain period of time required by rules, it has a fairly high demand for athletes' strength and endurance. So in strength training, we must pay attention to strength endurance, especially speed, strength, and endurance training [2]. Therefore, the competitive aerobics athlete special strength training is analyzed and discussed in this paper. This paper presents a fuzzy normal form algorithm, which is an intelligent fuzzy network model composed of fuzzy system of input, state, and output. The fuzzy system can be replaced by a neural network, fuzzy fusion rules, fuzzy identifiers, etc., and the given knowledge or experience can be learned by determining their weight factors and/or coefficients.

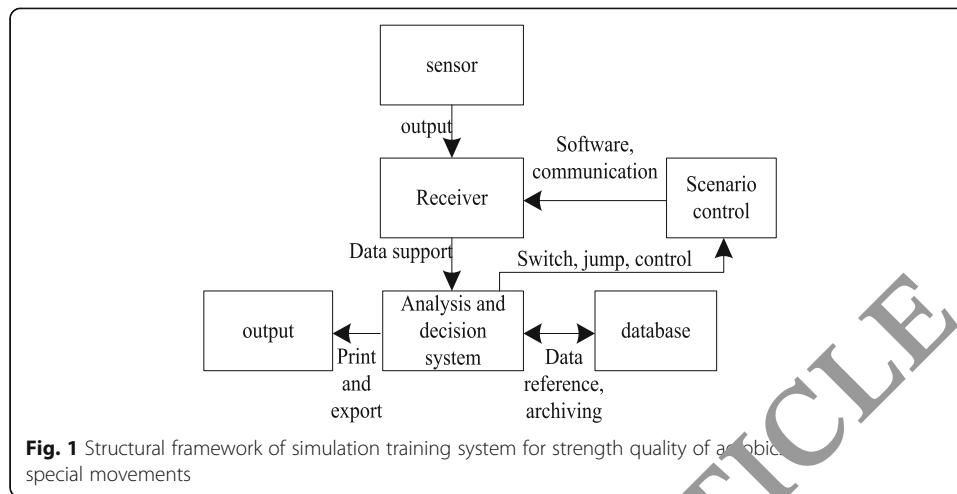
The strength training method is a series of methods and means of specialized biological modification to the human body's motor system in order to improve the ability of muscle work [3]. The traditional strength training method is based on the analysis of past competitions and training cases, lacking of real-time analysis, and poor training efficiency [4]. Artificial intelligence is a kind of computer science and technology, which includes robot, language, image recognition, and expert system. At present, artificial intelligence technology is widely used in the field of aerobics in China, which is of great significance for enhancing the training quality of aerobics athletes and assisting the coaches to make reasonable sports plans. Therefore, the core training system of strength quality of aerobics special movement based on artificial intelligence is proposed, and the real-time, stable, and efficient training of strength quality of aerobics special movement is realized.

The rest of this paper is organized as follows. Section 2 discusses the core training of strength quality of aerobics special movements based on artificial intelligence, followed by experimental analysis designed in section 3. Section 4 concludes the paper with summary and future research directions.

2 Methods

2.1 System structure framework

In this paper, the design of core training of strength quality of aerobics special movements includes hardware design and software design. Hardware design is to build and connect the whole system of all equipment and the design of simulation equipment [5]. Software design is to solve the problem that all hardware can be combined into a unified system through a software system. Through the software control or the corresponding software operation, the training of the special strength training simulation system is satisfied [6]. The structural framework of the simulation training system for strength quality of aerobics special movements is shown in Fig. 1.



In Fig. 1, the system architecture framework includes the modules of sensor, receiver, database, and analysis, and decision. At the beginning of the training, the trainer starts the video projection, and the trainee makes the situation judgment according to the real scene of the video, decides which technical movement to use, and trains for strength quality of the set of technical movements. At this time, sensors collect all kinds of training instruments, equipment, special movements, and strength quality information, and transmit them to the receiver in time. By using analysis and judgment module, the aerobics special action is analyzed. Data and information about aerobics special movements are stores in the database. The training system realizes the analysis and training of the strength quality of aerobics special movement by collecting, processing, storing, and analyzing information. It is a kind of artificial intelligence analysis process, and especially the analysis and judgment module is a key artificial intelligence analysis process. By using the judgment module, the aerobics special movement is analyzed autonomously and real-time [7]. It plays an important role in enhancing the quality of core training of aerobics special movements.

2.1 Design of system function modules

According to the overall structure of the system and the function target of the system, the functional modules of the system are divided into the main control module, the scenario control module, the information acquisition module, the judgment module, and the information management module.

The main control module runs in the master computer and is responsible for human-machine interaction [1]. Human-machine interaction performance is also an embodiment of artificial intelligence in this system. The realized comprehensive training of strength quality includes the subject setting before training, the data processing in the training process (processing, recording, and adjusting the situation change of the input information of the strength of the special movement), and the evaluation of the results after the training.

The main controller selects the Atmega1280 microcontroller, which is an 8-bit microcontroller with low energy consumption, high performance, and abundant on-chip resources. Atmega1280 single-chip microcomputer contains 86 I/O, 16 analog signal input interfaces, 4 serial ports, and EEPROM storage chips, as well as JTAG simulation, so as to facilitate the programming of the system.

By collecting the signals of various training instruments, competition instruments, special movements, and language control, the judgment and training of the trainees' correct use of training instruments, competition instruments, special movements, and strength qualities is realized. In order to ensure that the system does not have phase distortion in the signal transmission of data communication, signal processing, and image processing, the FIR filter is used in the information acquisition module. There are three main applications of FIR filter: distributed algorithm, serial algorithm, and parallel algorithm. The design of information acquisition module in this paper uses a distributed algorithm of FIR filter. The structure of the FIR filter is shown in Fig. 2. The inner product of the input x of the FIR filter and the coefficient h is the output y .

$$y = \langle h, x \rangle = \sum_{n=0}^{N-1} h(n)x(n) = h(0)x(0) + h(1)x(1) + \dots + h(N-1)x(N-1) \quad (1)$$

$X(n)$ is described with $B+1$ bit complement, which is expressed as

$$x(n) = -2^B x_B(n) + \sum_{b=0}^{B-1} x_b(n) 2^b \quad (2)$$

where the coefficient h is known constant. The inner product y is expressed as

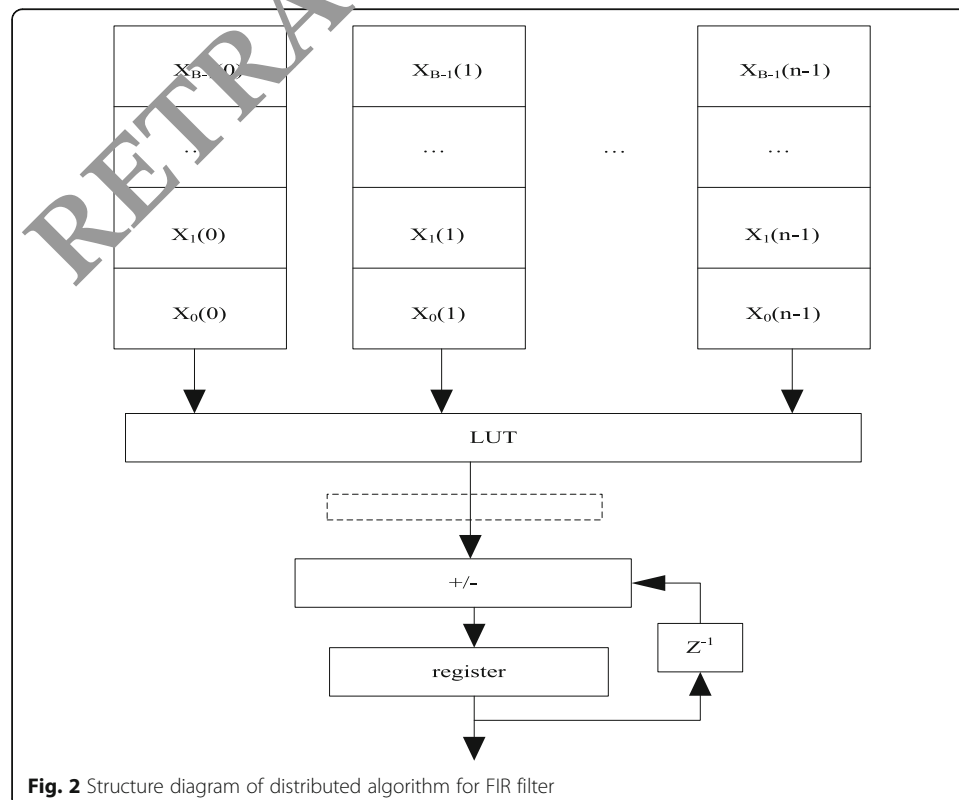


Fig. 2 Structure diagram of distributed algorithm for FIR filter

$$x(n) = -2^B h(n) x_B(n) + \sum_{b=0}^{B-1} h(n) \sum_{N=0}^{N-1} x_b(n) 2^b \quad (3)$$

The addition calculation is carried out to $\sum_{b=0}^{B-1} h(n) \sum_{N=0}^{N-1} x_b(n) 2^b$, which is expressed as

$$\begin{aligned} \sum_{b=0}^{B-1} h(n) \sum_{N=0}^{N-1} x_b(n) 2^b &= h(0)(x_{B-1}(0)2^{B-1} + \\ & x_{B-2}(0)2^{B-2} + \cdots + x_0(0)2^0) + \\ & h(1)(x_{B-1}(1)2^{B-1} + x_{B-2}(1)2^{B-2} + \\ & \cdots + x_0(1)2^0) + \cdots + \\ & h(n-1)(x_{B-1}(n-1)2^{B-1} + \\ & (x_{B-2}(n-1)2^{B-2} + \cdots + \\ & x_0(n-1)2^0)) = \\ & (h(0)x_{B-1}(1) + h(1)x_{B-1}(1) + \cdots + \\ & h(n-1)x_{B-1}(n-1))2^{B-1} + \\ & (h(0)x_{B-2}(0) + h(1)x_{B-2}(1) + \cdots + \\ & h(n-1)x_{B-2}(n-1))2^{B-2} + \cdots + \\ & (h(0)x_0(0) + h(1)x_0(1) + \cdots + \\ & h(n-1)x_0(n-1))2^0 \end{aligned} \quad (4)$$

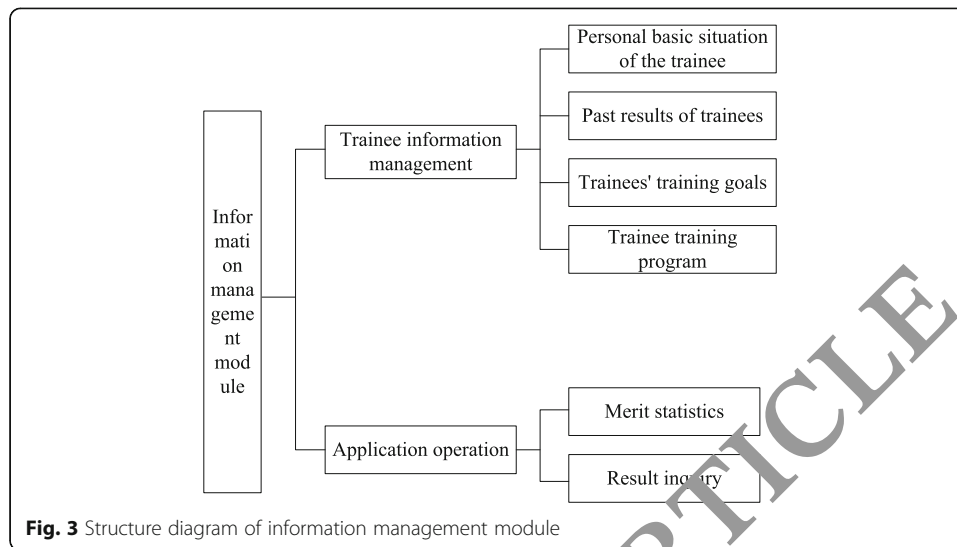
To simplify Eq. (4),

$$y = -2^B h(n) x_B(n) + \sum_{b=0}^{B-1} 2^b(n) \sum_{n=0}^{N-1} h(n) x_b(n) \quad (5)$$

The information management module is necessary for the output of training result data [8]. The system consists of two parts: trainee information management and training performance statistics inquiry. The functions include personnel basic information management, and query, statistics, and printing of training results. The trainees' information management training results are automatically stored in the database, which can be displayed on the screen in real-time, and queried, counted, and printed at any time. In this paper, the information management module is used to carry out artificial intelligence analysis on the related information of strength training for aerobics special movements. Through the statistics of the information management and training results of the trainees, the trainees and trainers can have an intuitive understanding of the training results, quickly obtain feedback information, and facilitate the guidance of training. Figure 3 shows the structure of information management module.

2.3 Software design

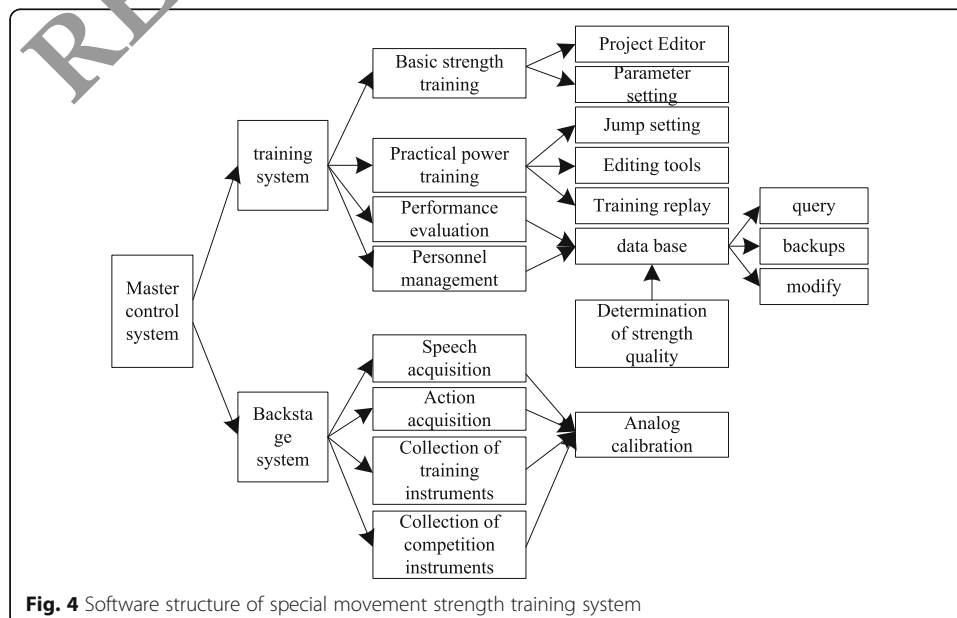
Taking training subject as an object, the simulation training software of strength quality of the special movement of aerobics athletes is divided into basic subject, real scene subject, subject video examination and evaluation module, and other auxiliary functional module [3]. Each subsystem is an independent module. The system uses the

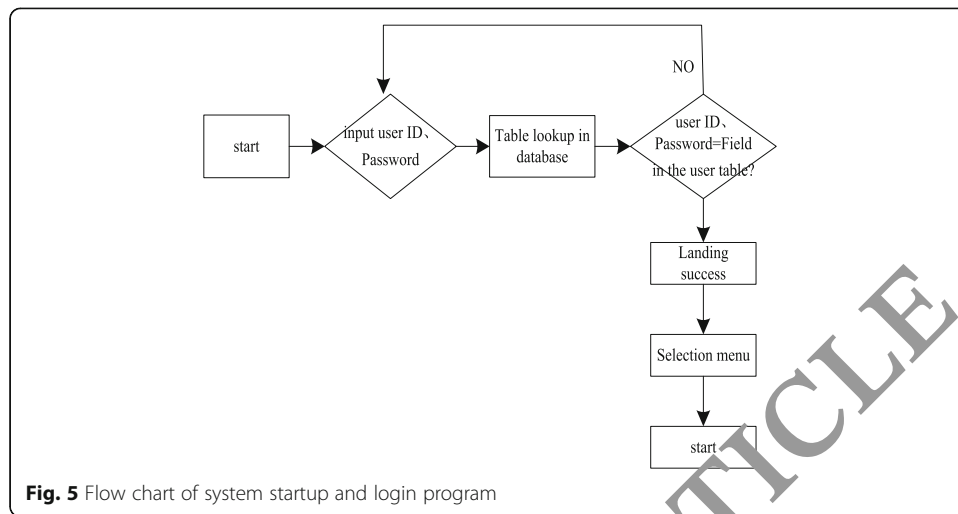


subject as a common carrier (custom structure) to interact with the data [9]. Figure 4 shows the software structure of the special movement strength training system.

The main control program runs in the master computer, and is mainly responsible for the comprehensive training of all subjects. As the core of the whole training system, the main control program also needs to consider the functions of system protection, data encryption, and so on [10]. The program module signal collection program running in the background is the middle-ware of other interactive devices, such as the integrated machine of camera and projector.

The running of startup and login program of most system tool software is taken as reference [11]. This system software startup and landing program design need to fill in the user name and the corresponding password. All user names, passwords, and other

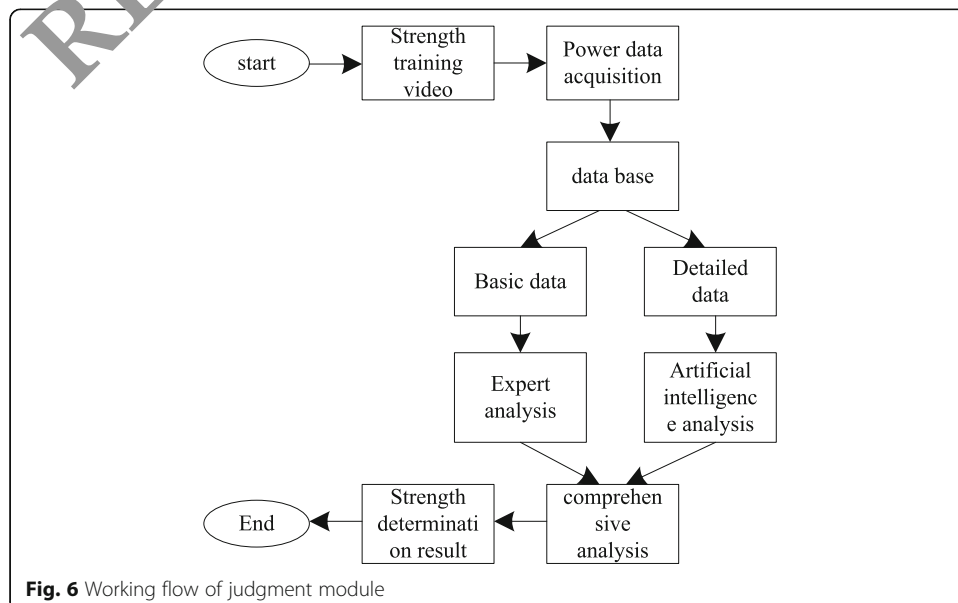




data information are saved in the user data file of the system database. Figure 5 shows the flow chart of system startup and login program.

The judgment module includes a detailed analysis of the overall strength control of aerobics athletes and the control of the overall strength [12, 13]. The basic process is shown in Fig. 6. The main steps include the selection of strength training video, strength data acquisition, strength data experts, and artificial intelligence analysis [12, 14]. The selection of strength training video is the initial and important step of strength training analysis, which determines the reliability and persuasiveness of strength training structure.

In this paper, JSP page is used as a user interface. It includes the main functional interfaces such as training subjects, performance evaluation, and other auxiliary functional interface such as system login and user rights management. In order to reduce the complexity of the page and improve its efficiency [15, 16], all business processes are excluded while displaying the user interface through JPS pages, and Java scripts are not involved at the same time [17, 18].



3 Experiment

The experiment is carried out to verify the time delay performance of the core training system based on artificial intelligence [19, 20]. Using the proposed system, the training system based on event-driven programming and the training system based on case teaching, 100 strength training tests for an aerobics athlete are carried out to record and compare the transmission delay of different training systems. The comparison results are shown in Table 1.

It is clearly evident from the Table 1 that the transmission delay of the proposed training system is small, and far lower than the transmission delay of the other two training systems. It shows that the transmission delay of the proposed system is low and the real-time performance is good. To verify the simulation efficiency of the proposed system, the method of measuring the time consuming of aerobics special movement simulation is adopted to test the stability and rapid movement simulation of the proposed system. The training movements of 15 aerobics athletes are taken as samples, and the training movements of these athletes are simulated with the proposed system, the training system based on event-driven programming, and the training system based on case teaching [21, 22]. The time consuming is recorded and shown in Table 2.

Figure 7 is the time consuming for movement simulation of three systems.

It is clearly evident from Table 2 that the time consuming of the proposed system is less, about within 1.32 s, and as the number of movement simulations increases, the system simulation tends to be stable and maintains at 1.24 s, with an average time of 1.27 s. The motion simulation system based on event-driven programming always fluctuates from 1.63 s to 1.84 s. The time consuming of the training system based on event-driven programming always fluctuates between 1.63 s and 1.84 s. The time consuming of the training system based on case teaching is longer. Through the above experimental results, it can be found that the system is efficient in movement simulation, and can shorten the simulation time of aerobics special movement.

In order to verify the stability of the proposed system, the average outage probability of strength quality training of special movement for different systems is compared. The comparison results are shown in Fig. 8.

It is clearly evident from Fig. 8 that under the condition of the average SNR less than 16 dB, the average outage probability of the proposed system is smaller than that of the

Table 1 Transmission delay of different training systems (ms)

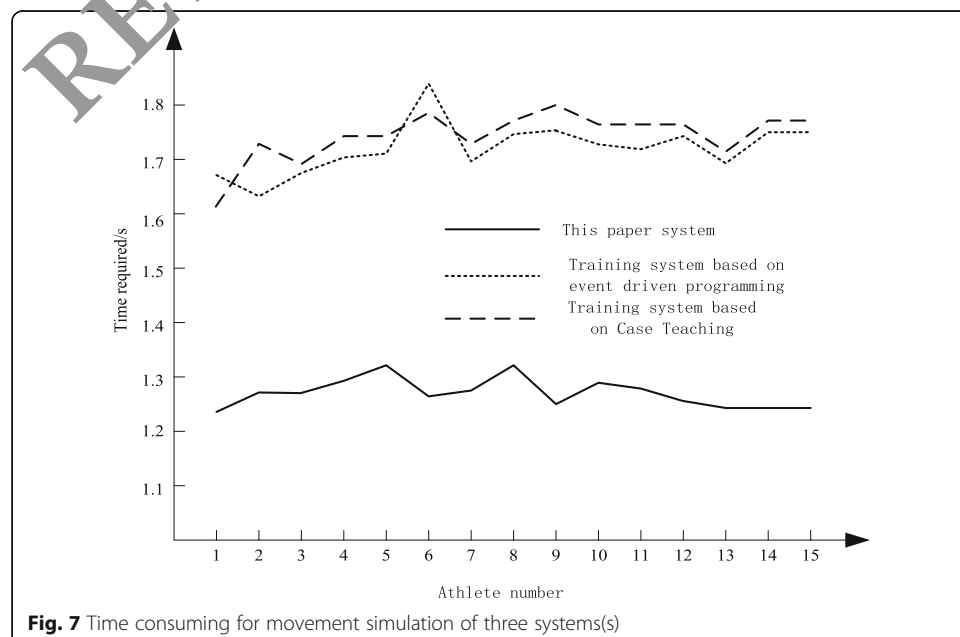
Experiment times	The proposed system (ms)	Training system based on event-driven programming (ms)	Training system based on case teaching (ms)
10	14.28	25.08	27.27
20	10.05	29.13	24.68
30	12.36	33.57	29.55
40	17.51	38.61	17.64
50	13.87	19.89	30.16
60	11.44	21.86	37.51
70	15.02	44.09	30.22
80	17.97	55.27	41.37
90	12.88	33.45	29.28
100	16.06	22.48	21.77

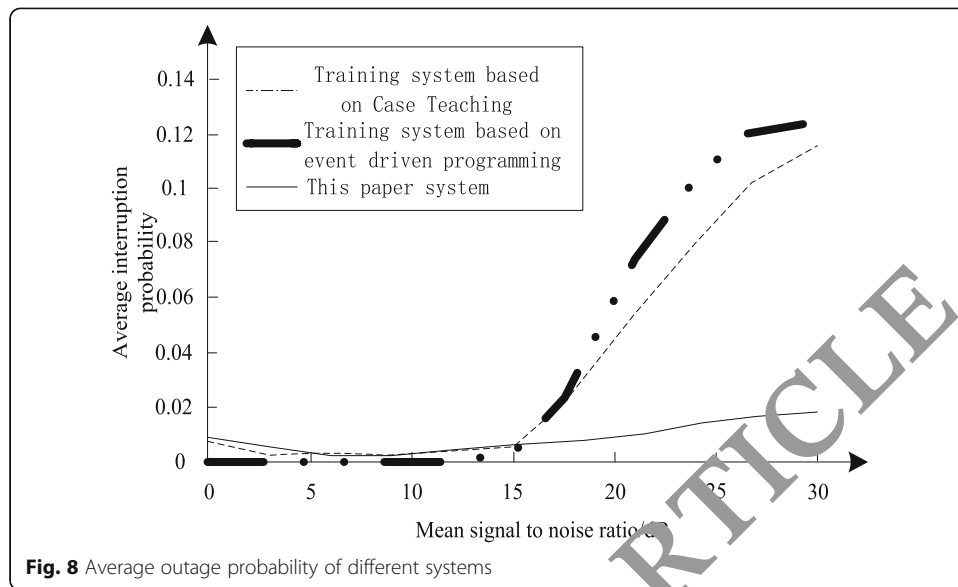
Table 2 Time consuming for movement simulation of different systems (s)

Athlete number	The proposed system (s)	Training system based on event-driven programming (s)	Training system based on case teaching (s)
1	1.24	1.67	1.62
2	1.27	1.63	1.73
3	1.27	1.67	1.69
4	1.29	1.71	1.74
5	1.32	1.72	1.74
6	1.26	1.84	1.79
7	1.27	1.69	1.73
8	1.32	1.75	1.77
9	1.25	1.76	1.80
10	1.29	1.73	1.76
11	1.27	1.72	1.76
12	1.26	1.74	1.76
13	1.24	1.66	1.71
14	1.24	1.75	1.77
15	1.24	1.75	1.77
Average	1.27	1.72	1.74

other two systems. When the average SNR is greater than 16 dB, the outage probability of the three systems increases with the increase of the average SNR, but the average outage probability growth curve of the proposed system is slow and obviously lower than the other two systems. It shows that the proposed system has good stability.

In order to verify the memory consumption performance of the proposed system, the proposed system, the system based on event-driven programming, and the system based on case teaching are used to analyze the data analysis of five groups of special

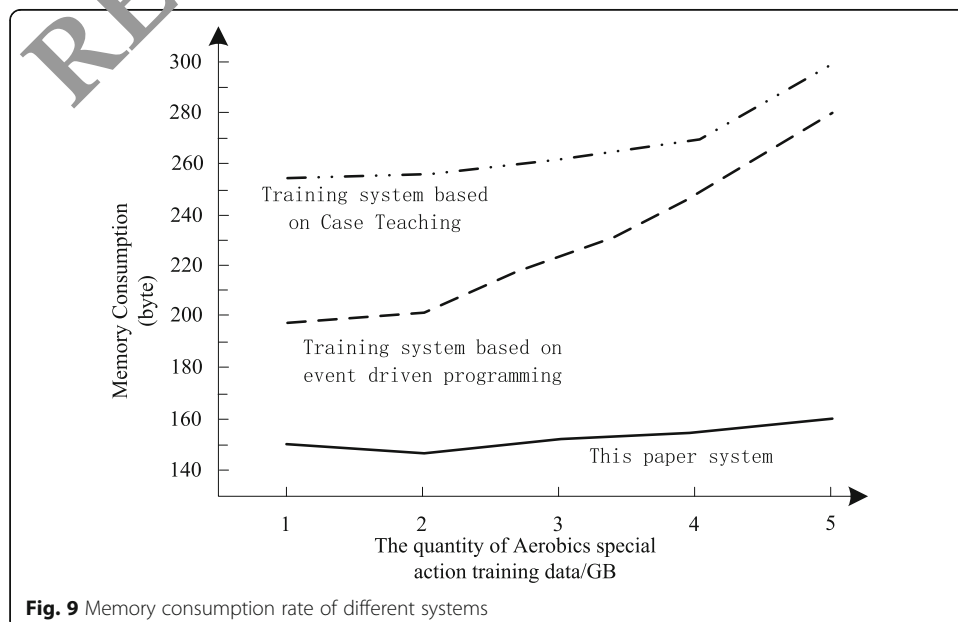
**Fig. 7** Time consuming for movement simulation of three systems(s)

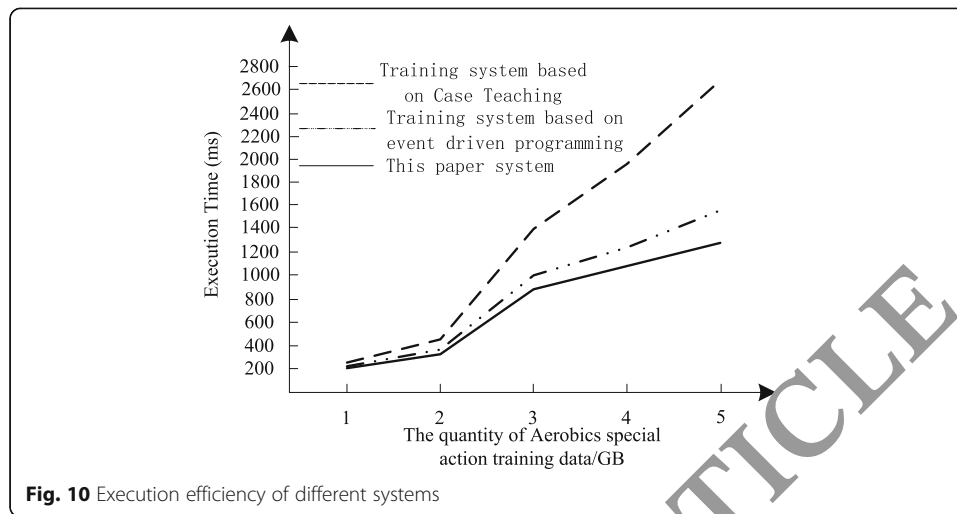


movement strength training. The consumed memory space in different systems is compared [16] and the results are shown in Fig. 9.

It is clearly evident from Fig. 9 that the memory consumption of the training system based on case teaching is largest. The training system based on event-driven programming has larger memory consumption, while the memory consumption of the proposed system is lower than the other two systems. It shows that by using the proposed system to analyze the strength training data of special movements, the memory consumption is smaller.

In order to verify the execution efficiency of the proposed system, the proposed system, the system based on event-driven programming, and the system based on case teaching are used to analyze the data analysis of five groups of special movement

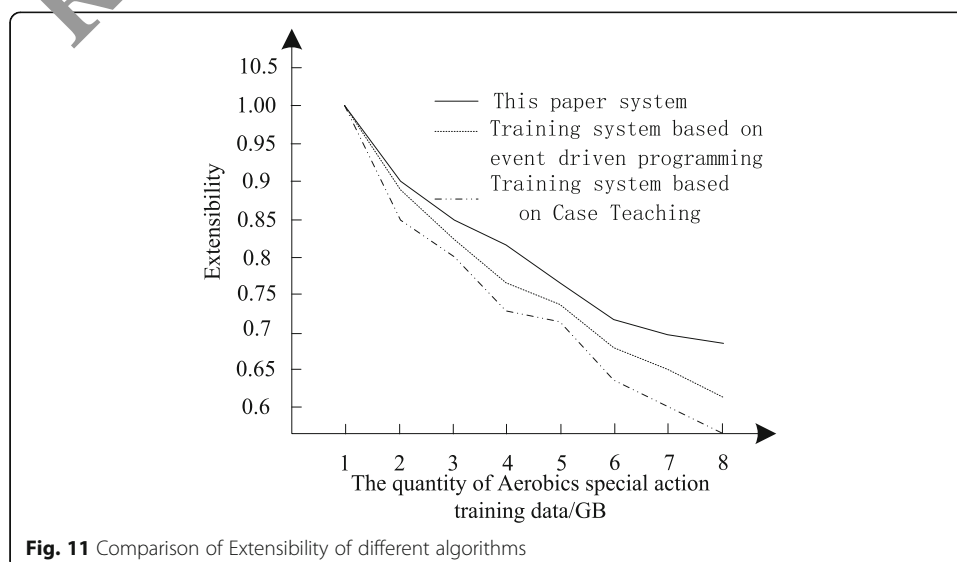


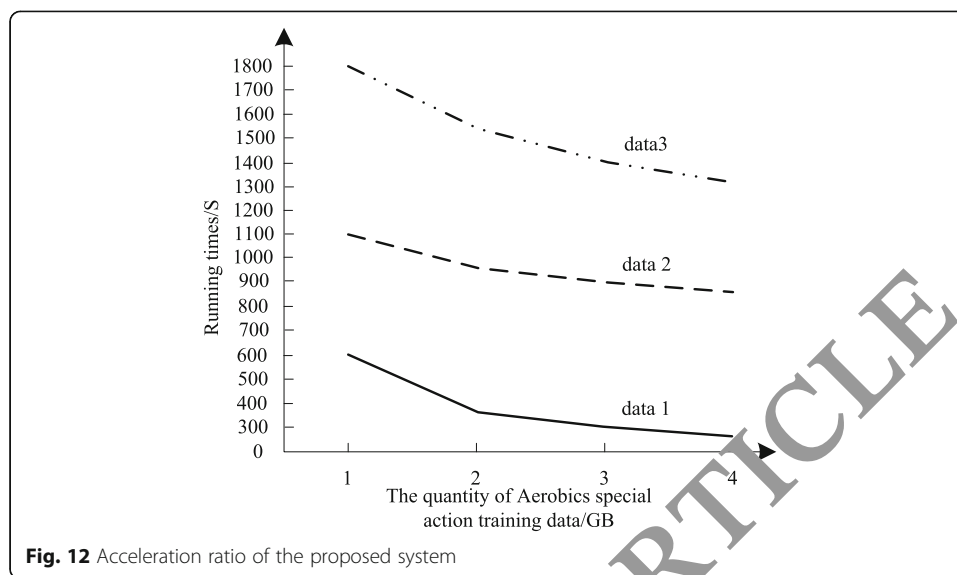


strength training. The execution time in the MapReduce environment is compared. The results are shown in Fig. 10.

As shown in Fig. 10, for the training data analysis of five groups of special movement strength, the running time of the training system based on event-driven programming is lower than the running time of the training system based on case teaching. The running time of the proposed system is lower than that of the training system based on event-driven programming. Experimental results show that the three systems can carry out data analysis of the special movement strength training, but the efficiency of the proposed system is the best.

The scalability of the proposed system is verified, that is, when the data of specific movement strength training is more, it is verified whether it can process larger scale data. The extensibility of the proposed algorithm is verified by using data set of specific movement strength training (from 160 MB to 1280 MB) and comparing it with the training system based on case teaching and the training system based on event-driven programming. The results are shown in Fig. 11.





It is clearly evident from the Fig. 11 that the proposed system has achieved better scalability than the training system based on event-driven programming and the training system based on case teaching. The extensibility values of the three systems are higher than 0.69, 0.62, and 0.55, respectively. The results show that the proposed system has excellent scalability and adaptability for processing large-scale dataset.

In order to verify the acceleration ratio performance of the proposed system, the proposed system, the training system based on event-driven programming, and the training system based on case teaching are compared and analyzed in the same environment. First, the acceleration ratio performance of the proposed system is evaluated with the constant size of the three groups of real special movement strength training data, and the experimental results are shown in Fig. 12. Secondly, the acceleration ratio performance of the three systems is compared, and the results are shown in Table 3.

As shown in Fig. 12, in the data analysis of the special movement strength training, the proposed system can complete the analysis normally. Especially when the data node gradually increases, the running time of the proposed system is reduced proportionally. From Table 3, it can be seen that the execution time of the proposed system is much

Table 3 Comparison of acceleration ratio performance of different systems

Data	Different systems	Running time/ms
Data 1	The proposed system	446
	Training system based on event-driven programming	768
	Training system based on case teaching	824
Data 2	The proposed system	1082
	Training system based on event-driven programming	1322
	Training system based on case teaching	1407
Data 3	The proposed system	1790
	Training system based on event-driven programming	2288
	Training system based on case teaching	2369

lower than that of the other two systems. The results show that the proposed system has good acceleration ratio performance and can effectively improve analysis efficiency.

The training effect of this system is analyzed from five aspects: the simulation of the instrument, the time consuming of the system simulation, the importance of the training content, the accuracy of the power simulation, and the analysis of the information content. The expert evaluation method is used to evaluate the results of the analysis of 15 groups of samples in Table 2 for the proposed system, the training system based on event-driven programming, and the training system based on case teaching. The evaluation score are shown in Tables 4, 5, and 6.

Through the above experimental results, it can be observed that the results of the special movement obtained with the proposed system are good in all aspects. From the comparison results of the instrument simulation, it can be seen that the average score of the proposed system is 96.9 points. The score of the training system based on event-driven programming is 75.3 points, and the score of the training system based on case teaching is only 64.3 points. The average score of the importance of the training content of the proposed system is 93.7 points. The score of the training system based on the event-driven programming is 61.1 points and the training system based on case-based training system is 49.7 points. It shows that the content of the proposed system is more important for the training of the special movement strength quality. The scores of simulation time consumption, strength simulation accuracy, and analysis information content of the proposed system are 93.1 points, 93.3 points, and 93.7 points, respectively. The score of the proposed system is far superior to the training system based on event-driven programming and the training system based on case teaching. It shows that the proposed system is very effective in the core training of the strength quality of aerobics special movement.

Table 4 Evaluation score of the proposed system analysis results (points)

Athlete number	Instrument simulation	System simulation time	The importance of training content	Power simulation accuracy	Analysis of information content
1	97	97	98	91	95
2	97.3	99	94	92	96
3	98.3	99	95	94	94
4	95.6	97	91	90	93
5	94.3	98	93	95	94
6	96.7	98	90	93	91
7	95.6	94	97	94	92
8	96.7	97	94	91	94
9	98.6	98	95	94	97
10	93.7	94	91	95	94
11	95.7	96	92	93	95
12	98.7	99	93	96	93
13	99.7	95	94	94	91
14	97.6	97	95	95	95
15	98.4	98	94	93	92
Average score	96.9	97.1	93.7	93.3	93.7

Table 5 Evaluation score of training system analysis results based on event driven programming (points)

Athlete number	Instrument simulation	System simulation time	The importance of training content	Power simulation accuracy	Analysis of information content
1	78.5	63	59	70	66
2	74.5	66	60	76	66
3	79.2	70	62	78	67
4	75.3	62	60	70	69
5	74.7	61	61	76	71
6	73.4	66	62	75	63
7	74.1	69	58	78	66
8	79.76	65	59	69	70
9	76.2	70	60	72	67
10	71.4	66	66	75	68
11	69.7	69	65	70	64
12	75.5	66	62	73	64
13	75.4	68	60	71	63
14	79.7	69	62	74	37
15	72.1	62	60	74	65
Average score	75.3	66.1	61.1	73.3	64.4

Table 6 Evaluation score of training system analysis result based on case teaching (points)

Athlete number	Instrument simulation	System simulation time	The importance of training content	Power simulation accuracy	Analysis of information content
1	61.4	52	46	60	56
2	63.2	55	45	66	66
3	61.4	50	55	58	57
4	65.3	52	60	60	62
5	64.7	51	45	56	61
6	63.4	55	52	55	63
7	63.3	60	48	58	56
8	68.6	56	47	64	60
9	66.2	57	50	58	57
10	61.4	55	46	55	62
11	62.7	53	55	60	66
12	65.7	55	46	53	64
13	63.4	50	48	56	58
14	62.7	56	52	52	56
15	65.8	52	50	57	55
Average score	64.3	53.9	49.7	57.9	59.9

4 Results and discussion

Through the design of the core training system of strength quality of aerobics special movement based on artificial intelligence, the problems of poor real-time performance and low efficiency in the traditional training system can be solved. The core training of strength quality of aerobics special movement based on artificial intelligence is achieved, and has the advantages of high efficiency, and good stability and real-time. It provides a basis for improving the strength quality of aerobics special movement, and has important application value.

Abbreviations

MCU: Microprogrammed control unit

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Authors' contributions

Liqiang Jia wrote the entire article. Lingshu Li is responsible for the experimental simulation. The author(s) read and approved the final manuscript.

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The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication

All authors agree to submit this version and claim that no part of this manuscript has been published or submitted elsewhere.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Physical Education, East China University of Political Science and Law, Shanghai 201620, China.

²Department of Physical Education, Shanghai International Studies University, Shanghai 200083, China.

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