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*Research Article*

# Sports Training Intensity Information Fusion Method Based on Kinect Sensor

**Yan Huo**

*Department of Physical Education, Anhui University of Finance & Economics, Bengbu 233030, China*

Correspondence should be addressed to Yan Huo; 120080917@aufe.edu.cn

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In order to improve the information fusion effect of sports training intensity, this paper analyzes the information fusion process of Kinect sensor. In order to prevent the simulation platform from exceeding its working space and ensure that the sports athletes obtain a more realistic sense of motion, the adaptive washout algorithm can change the adaptive parameters online in real time according to the input athlete's acceleration and angular velocity and the current motion state of the simulation platform. Moreover, this paper uses Kinect as the input device and combines the human node model to identify the features of training intensity information. After constructing an intelligent system, the performance of the system of this paper is verified. The research results show that the sports training intensity information fusion method based on the Kinect sensor proposed in this paper has a good effect in sports training intensity information fusion.

## 1. Introduction

Data fusion analysis technology [1] is an automated information processing technology that avoids the shortcomings of individual information, takes advantage of global information, and makes use of the complementarity between multisource heterogeneous data. It makes the mass information analysis result more reliable and accurate through the computer. Data fusion analysis technology is mainly to collect multisource heterogeneous data from multiple sensors and filter, analyze, synthesize, evaluate, and predict redundant or complementary information according to certain criteria. After that, the management personnel will take corresponding actions according to the processing results [2]. In academia, data fusion is defined as an information processing process that automatically analyzes information obtained by various sensors in chronological order according to certain criteria and performs systematic evaluation and prediction for a certain purpose. According to the definition, the key to data fusion is the method used and the process of research, and the sensor is the cornerstone of information collection [3].

The main goal of data fusion analysis technology is to analyze the obtained data and finally come to a decision, and the correctness and security of the decision are the standard of measurement. There are many usage scenarios of data fusion analysis methods, such as image processing, signal processing, and network security field. The main purpose is to achieve target state assessment, target attribute recognition, behavioral intention analysis, situation assessment, threat analysis, etc. The main theoretical knowledge is pattern recognition, uncertainty theory, artificial intelligence, neural network, and decision theory. Data fusion provides an efficient data processing technology foundation for information processing systems and domestic and foreign combat management. Filtering out some redundant data can improve the processing efficiency of the system, while complementary multisource heterogeneous data ensures the accuracy of system analysis. Data fusion technology expands the time and space dimensions of data, improves the reliability of the system, increases the credibility of target or event determination, and reduces the uncertainty of information. The connectivity and real-time communication between each unit and the central server in the data processing system with multiple heterogeneous information sources, various processing platforms, and multiuser systems are verified. With the rapid development of network in the new century, the amount of data is huge, from TB level to PB level, which is called big data. Its data formats and types are diverse, such as web/database logs, images, voice and video, and coordinates, and data structures are also diverse, such as massive standardized, semistandardized, and nonstandardized network or sensor data, and data fusion technology has entered the new journey.

This paper analyzes the information fusion process of the Kinect sensor, combines the training intensity analysis process to research, analyzes the sports training intensity information fusion process, and proposes an intelligent information fusion system to provide a theoretical reference for subsequent sports training intensity information fusion.

## 2. Related Work

Reference [4] invented a massive data access method in a cloud computing environment. Literature [5] clarifies a data processing method and system that combines fast data and big data. The big data and fast data are classified and transmitted, and the rapidly generated data uses the process of distributed structure to perform high-speed operations, while big data is used for high-speed computing. It is transmitted first and then statistical analysis. Reference [6] invented a fusion system to classify massive data streams according to requirements and proposed methods such as data concept drift and trigger classification, which enhanced the scalability and accuracy of the system. Literature [7] invented a big data segmentation method, which selects data according to data-related partitions, selects classification according to data-independent partitions, uses dynamic models to complete data-independent partitions, calculates the weights of different categories of data-independent partitions, and finally establishes a mathematical model. This method guarantees the speed and quality of data segmentation. Reference [8] proposed a method and system for network resource evaluation based on big data. A large amount of data is collected through stochastic models, then data mining technology is used to filter noise, and a part of simple data and its values are obtained through the K-means algorithm, so as to obtain relevant indicators and evaluate the resource quality of the analyzed system according to the obtained indicators. In Reference [9], aiming at the common limitations of existing wireless network mobile user positioning methods (including GPS, AOA, TSOA, and TOA), an improved fusion analysis method is used to enhance the accuracy of location assessment in wireless networks. Reference [10] gives a comprehensive and detailed introduction to the current state of multisensor data fusion and conducts an in-depth study of its concept, efficiency, challenges, and existing methods. Reference [11] proposed two Bayesian data analysis methods in different situations for the distributed target detection problem in sensor networks. The decision of local sensors was transmitted to the fusion center, and the optimal Bayesian theory was used for fusion analysis. Perform performance analysis experiments on sensors with different numbers and locations. Reference [12] introduced the multisensor data analysis technology into the IDS, carried out the hierarchical analysis of data, information, and knowledge for the system, and finally regarded the fusion analysis as an important stage of the IDS. Reference [13] uses artificial intelligence technology to fuse information from different intrusion detection sensors to provide a decision engine for the Intelligent Intrusion Detection System (IIDS), which uses fuzzy cognitive graphs (FCMs) and fuzzy rule-based causal knowledge. The method was obtained and successfully introduced into IIDS of CCSR (the Center for Computer Security Research). Reference [14] introduced the MapReduce architecture under the Hadoop platform and introduced the MapReduce algorithm based on data mining, machine learning, and similarity join. In the context of big data, the literature [15] proposed an improved K-means algorithm suitable for different structured big data because the K-means clustering algorithm cannot effectively deal with the combination of structured and unstructured data. Reference [16] analyzes the web logs in the network, calculates the possibility and success of attack behaviors according to the existing vulnerability of the server, and finally evaluates the performance of each server according to the D-S evidence theory. Reference [17] designed a framework with a certain ability to process big data. The parallel Apriori algorithm based on MapReduce uses a large number of computers for data distribution and effectively handles large-scale data. Reference [18] proposed a regression algorithm based on parallel prediction of large datasets, which effectively reduces the time for predicting datasets while maintaining a high accuracy. Reference [19] proposed a MapReduce-based Apriori algorithm and FP-growth algorithm, but this method scans the database more frequently, and the number of candidate sets is relatively large in the process of the algorithm. In the process of massive data processing, in order to solve the problem of database access and storage, literature [20] proposed a horizontal storage model, and submitted the I/O performance during data processing

## 3. Sports Training Intensity Information Fusion Filter

The structure of the adaptive washout algorithm is roughly the same as the classic washout algorithm, and its structure is shown in the figure. The algorithm is based on the classic washout algorithm and uses model reference adaptive theory to improve it. In order to prevent the simulation platform from exceeding its working space and at the same time to ensure that the sports athletes obtain a more realistic sense of movement, the adaptive washout algorithm can change the adaptive parameters online in real time according to the input acceleration and angular velocity of the athletes and the current motion state of the simulation platform.

The adaptive washout algorithm is divided into frequency adaptive washout algorithm and gain adaptive washout algorithm according to the different adaptive parameters. Since the frequency self-adaptive washout algorithm has many self-adaptive parameters, a large amount of calculation, and is not easy to program, while the gain self-adaptive washout algorithm has a simple form and few self-adaptive parameters, so this paper chooses the gain self-adaptive washout algorithm. In the gain adaptive algorithm, its adaptive filter can change the parameter gain of the filter in real time according to the current motion state of the athletes and the simulation platform, so as to prevent the simulation platform from exceeding the working space and enable the athletes to obtain a more realistic sense of movement.

The acceleration adaptive high-pass filter is composed of adaptive gain, linear high-pass filter and adaptive algorithm. Its principle structure is shown in Figure 1. The linear high-pass filter is a third-order high-pass filter. The transfer function of the acceleration adaptive high-pass filter is

$$\frac{a_h(s)}{a(s)} = \frac{ks^3}{\left(s^2 + 2\xi_h\omega_h s + \omega_h^2\right)(s + \omega_m)}. \tag{1}$$

In the formula, $k$ is the adaptive gain.

The above formula is written as a differential equation in the form

$$a_h = ka - c_1 v_h - c_2 x_h - c_3 \int x_h \, dt. \tag{2}$$

In the formula, $v_h$ is the speed signal output by the adaptive high-pass filter, and $x_h$ is the displacement signal output by the filter, $c_1 = 2\xi_h\omega_h + \omega_m$, $c_2 = 2\xi_h\omega_h\omega_m + \omega_h^2$, $c_3 = \omega_h^2\omega_m$.

The value of adaptive gain $k$ is between 0 and 1 and can be adjusted in real time according to the current input acceleration and the position of the platform. For example, when the input acceleration signal is small or the simulation platform is close to the neutral position, the gain $k$ should be as close to 1 as possible. When the input acceleration signal is large or the analog platform is close to the limit position, in order to prevent it from exceeding the limit, it is necessary to reduce the adaptive gain to reduce its output. To this end, the construction cost function is [20]

$$J = \frac{1}{2}\left[W_1(a_h - a)^2 + W_2{v_h}^2 + W_3{x_h}^2 + W_4\left(\int x_h \, dt\right)^2 + W_5(k - k_0)^2\right]. \tag{3}$$

In the formula, $W_1$ is the weight coefficient of the acceleration fidelity term, $W_2$ is the weight coefficient of the speed penalty term, $W_3$ is the weight coefficient of the displacement penalty term, $W_4$ is the weight coefficient of the displacement integral penalty term, $W_5$ is the weight coefficient of the adaptive gain penalty term, and $k_0$ is the initial value of the adaptive gain, which is generally 1.

In the cost function, the effect of the acceleration fidelity term is to improve the fidelity of the washout algorithm and ensure that the dynamic simulation is more realistic. The function of speed penalty, displacement penalty, and displacement integral penalty is to limit the speed and displacement of the simulation platform, prevent the platform from exceeding the limit, and make the simulation platform return to the neutral position as soon as possible. In order to make the adaptive gain change around its initial value, an adaptive gain penalty term is added.

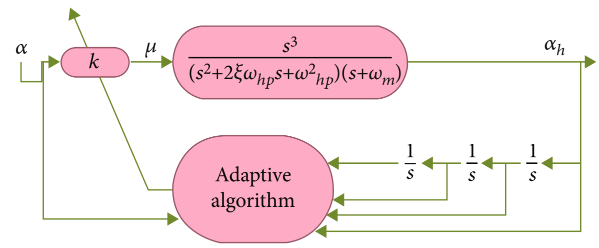



Figure 1: The structure of the acceleration adaptive high-pass filter.

At present, there are many methods for solving the cost function, such as the gradient method, Newton-Raphson method, and conjugate gradient method. This paper chooses the gradient method to solve the cost function. The gradient method searches in the negative gradient direction on the surface formed by the cost function $J$ until $J$ reaches the minimum value.

According to the gradient method to calculate the minimum value of the cost function, the rate of change of the adaptive gain is [21]

$$\dot{k} = -G\frac{\partial J}{\partial k}. \tag{4}$$

In the formula, $\dot{k}$ is the adaptive gain change rate, and $G$ is the adaptive search step size.

By obtaining partial derivatives of $k$ at both ends of formula (3), we can obtain

$$\frac{\partial J}{\partial k} = W_1(a_h - a)\frac{\partial a_h}{\partial k} + W_2 v_h \frac{\partial v_h}{\partial k} + W_3 x_h \frac{\partial x_h}{\partial k} + W_4 \int x_h \, dt \frac{\partial \int x_h \, dt}{\partial k} + W_5(k - k_0). \tag{5}$$

By substituting formula (5) into formula (4) and performing the pull transformation, the adaptive gain can be obtained as

$$k = \frac{G}{s + GW_5}\left[-W_1(a_h - a)\frac{\partial a_h}{\partial k} - W_2 v_h \frac{\partial v_h}{\partial k} - W_3 x_h \frac{\partial x_h}{\partial k} - W_4 \int x_h \, dt \frac{\partial \int x_h \, dt}{\partial k} + W_5 k_0\right]. \tag{6}$$

At the same time, taking the partial derivatives of $k$ at both ends of formula (2), respectively, we can get [22]

$$\frac{\partial a_h}{\partial k} = a - c_1\frac{\partial v_h}{\partial k} - c_2\frac{\partial x_h}{\partial k} - c_3\frac{\partial \int x_h \, dt}{\partial k}. \tag{7}$$

So far, the function of the acceleration adaptive high-pass filter can be realized by formula (2), formula (6), and formula (7). First, the acceleration $a$ of the filter input is multiplied by the initial value of the adaptive gain and input to the linear high-pass filter. Through formula (2), the response of each movement amount such as output acceleration, velocity, and displacement can be obtained, and the response of each partial derivative term can be obtained by formula (7). After getting the response of the above variables, the adaptive gain $k$ can be obtained by combining formula (6). In this way, the input of the linear high-pass filter in the next cycle of filtering can be calculated, and by repeating the above steps, the adaptive high-pass filtering function of the acceleration signal can be realized.

The angular velocity adaptive high-pass filter is similar to the acceleration adaptive high-pass filter. It consists of three parts: adaptive gain, linear high-pass filter, and adaptive algorithm. Its structure is shown in Figure 2. Among them, the linear high-pass filter adopts a second-order high-pass filter. The transfer function is still formula (13). The transfer function of the adaptive high-pass acceleration filter is

$$\frac{\omega_h(s)}{\omega(s)} = \frac{ks^2}{s^2 + 2\xi_h\omega_h s + \omega_h^2}. \quad (8)$$

In the formula, $k$ is the adaptive gain.

The above formula is written as a differential equation in the form

$$\omega_h = k\omega - c_1\alpha_h - c_2\int \alpha_h \, dt. \quad (9)$$

In the formula, $\alpha_h$ is the angle signal output by the adaptive high-pass filter, $c_1 = 2\xi_h\omega_h$, $c_2 = {\omega_h}^2$.

In the same way, the adaptive gain of the angular velocity adaptive high-pass filter can be continuously adjusted between 0 and 1 according to the current input angular velocity and the attitude of the platform to ensure a better dynamic simulation effect of the simulation platform. When the input angular velocity signal is too small or the attitude angle of the simulated platform is close to zero, the adaptive gain is as close to 1 as possible. When the input angular velocity signal is too large or the attitude angle of the simulation platform is too large, in order to prevent the platform from exceeding the limit, it is necessary to reduce the adaptive gain to reduce its output. To this end, the construction cost function is

$$J = \frac{1}{2}\left[W_1(\omega_h - \omega)^2 + W_2\alpha_h^2 + W_3\left(\int \alpha_h \, dt\right)^2 + W_4(k-k_0)^2\right]. \quad (10)$$

In the formula, $W_1$ is the weight coefficient of the angular velocity fidelity term, $W_2$ is the weight coefficient of the angle penalty term, $W_3$ is the weight coefficient of the angle integral penalty term, $W_4$ is the weight coefficient of the adaptive gain penalty term, and $k_0$ is the initial value of the adaptive gain, which is generally 1.

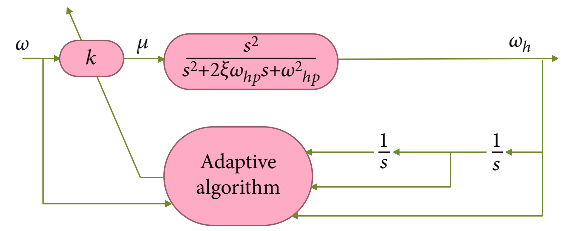



Figure 2: The structure of the angular velocity adaptive high-pass filter.

In the cost function, the effect of the angular velocity fidelity term is to improve the fidelity of the washout algorithm and ensure that the dynamic simulation is more realistic. The function of the angle penalty item is to limit the attitude angle of the simulation platform and prevent the platform movement from exceeding the limit. The function of the angle integral penalty is to make the simulation platform return to the neutral position as soon as possible. In order to make the adaptive gain change around its initial value $k_0$, an adaptive gain penalty term is added. Similarly, for solving the cost function of the angular velocity adaptive high-pass filter, the gradient method is still used. If the gradient method is used to solve the cost function, the rate of change of the adaptive gain is

$$\dot{k} = -G\frac{\partial J}{\partial k}. \quad (11)$$

In the formula, $\dot{k}$ is the adaptive gain change rate, and $G$ is the adaptive search step size.

$$\frac{\partial J}{\partial k} = W_1(\omega_h - \omega)\frac{\partial \omega_h}{\partial k} + W_2\alpha_h\frac{\partial \alpha_h}{\partial k} + W_3\int \alpha_h \, dt\frac{\partial \int \alpha_h \, dt}{\partial k} + W_4(k-k_0), \quad (12)$$

$$k = \frac{G}{s + GW_4}\left[-W_1(\omega_h - \omega)\frac{\partial \omega_h}{\partial k} - W_2\alpha_h\frac{\partial \alpha_h}{\partial k} - W_3\int \alpha_h \, dt\frac{\partial \int \alpha_h \, dt}{\partial k} + W_4k_0\right], \quad (13)$$

$$\frac{\partial \omega_h}{\partial k} = \omega - c_1\frac{\partial \alpha_h}{\partial k} - c_2\frac{\partial \int \alpha_h \, dt}{\partial k}. \quad (14)$$

So far, the function of the angular velocity adaptive high-pass filter can be realized by formula (9), formula (13), and formula (14). First, the angular velocity $\omega$ input by the filter is multiplied by the initial value of the adaptive gain and input to the linear high-pass filter. Through formula (9), the response of each movement amount such as output angular velocity and angle can be obtained, and the response of each partial derivative term can be obtained by formula (14). After obtaining the response of the above variables, the adaptive gain $k$ can be obtained by combining formula (13), so that the input of the linear high-pass filter can be calculated for the next period of filtering. By repeating the

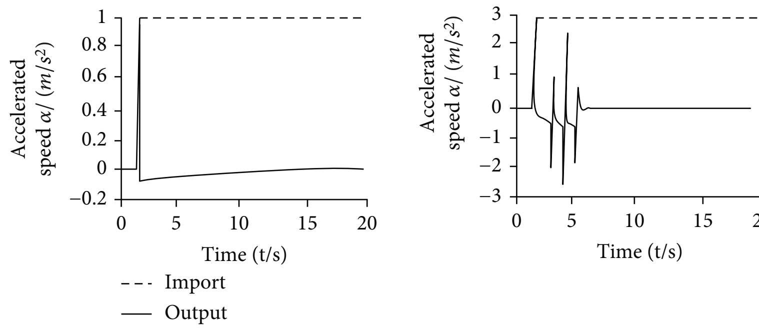
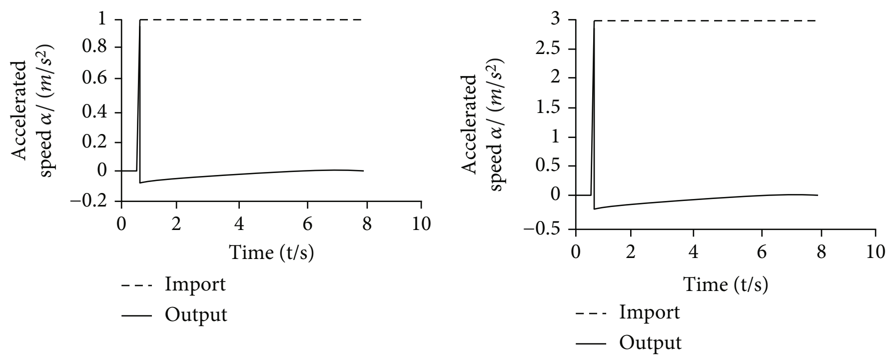



Figure 3: The response of the adaptive algorithm under different amplitude step inputs.




(a) Step input for $\alpha = 1\,\mathrm{m/s^2}$

(b) Step input for $\alpha = 4\,\mathrm{m/s^2}$

Figure 4: The response of the improved adaptive high-pass filter under different amplitude step inputs.

above steps, the adaptive high-pass filtering function of the angular velocity signal can be realized.

For an acceleration adaptive high-pass filter, a step signal is used as the input. When the input amplitude increases to a certain extent, the output of the filter will become oscillating and diverging. As shown in Figure 3, when the step signal is $a = 1\,\mathrm{m/s^2}$, the output tends to be stable. When the step signal is $a = 3\,\mathrm{m/s^2}$, the output appears as oscillation and divergence.

This paper first analyzes the stability of the adaptive high-pass filter using the Hurwitz stability criterion, which analyzes the stability of linear systems, and finds the reasons for the unstable output. After that, the algorithm is improved so that the adaptive gain has nothing to do with the input amplitude. Therefore, it is ensured that the output will not become divergent due to the increase of the input amplitude, false hints are reduced, and the authenticity and stability of the dynamic simulation are improved.

This paper takes the third-order adaptive high-pass filter of the high-pass acceleration channel as an example to analyze the adaptive washout algorithm. Since the filter is a nonlinear time-varying system, it must be linearized first, and then, its stability can be judged by the Hurwitz stability criterion. If the adaptive high-pass filter is linearized, its form needs to be transformed. First, formula (13) is transformed into the following form:

$$k = \frac{G(W_5 k_0 - u)}{s + GW_5}. \tag{15}$$

In the formula, $u = W_1(a_h - a)(\partial a_h/\partial k) + W_2 v_h(\partial v_h/\partial k) + W_3 x_h(\partial x_h/\partial k) + W_4 \int x_h\,dt(\partial \int x_h\,dt/\partial k)$.

Substituting formula (15) into formula (1), the transfer function of the acceleration adaptive high-pass filter can be obtained as

$$\frac{a_h}{a} = \frac{G(W_5 k_0 - u)s^3}{\left(s^2 + 2\xi_h\omega_h s + \omega_h^2\right)(s + \omega_m)(s + GW_5)}. \tag{16}$$

Formula (16) is written as a differential equation in the form

$$\begin{aligned} G(W_5 k_0 - u)a = \dot{a}_h &+ (2\xi_h\omega_h + \omega_m + GW_5)a_h \\ &+ \left(\omega_m GW_5 + 2\xi_h\omega_h GW_5 + 2\xi_h\omega_h\omega_m + \omega_h^2\right) \\ &\cdot \int a_h\,dt + \left(2\xi_h\omega_h\omega_m GW_5 + \omega_h^2 GW_5 + \omega_h^2\omega_m\right) \\ &\cdot \iint a_h\,dt^2 + \omega_h^2\omega_m GW_5 \iiint a_h\,dt^3. \end{aligned} \tag{17}$$

Formula (17) is organized into the following form:

$$\dot{a}_h + d_3(t)a_h + d_2(t)\int a_h\,dt + d_1(t)\iint a_h\,dt^2 + d_0(t)\iiint\int a_h\,dt^3 = d(t). \tag{18}$$

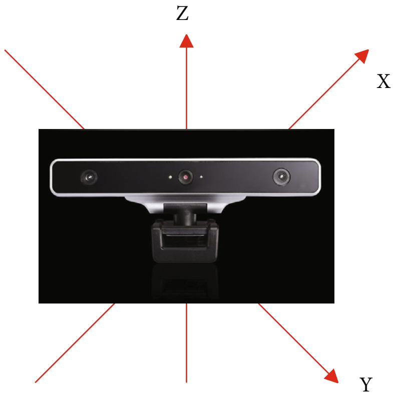



Figure 5: Coordinate system under Kinect.

In the formula,

$$\begin{aligned} d_0(t) &= \omega_h^2\omega_m GW_5 + GW_4\frac{\partial \int x_h\,dt}{\partial k}a; \\ d_1(t) &= 2\xi_h\omega_h\omega_m GW_5 + \omega_h^2 GW_5 + \omega_h^2\omega_m + GW_3\frac{\partial x_h}{\partial k}a; \\ d_2(t) &= \omega_m GW_5 + 2\xi_h\omega_h GW_5 + 2\xi_h\omega_h\omega_m + \omega_h^2 + GW_2\frac{\partial v_h}{\partial k}a; \\ d_3(t) &= 2\xi_h\omega_h + \omega_m + GW_5 + GW_1\frac{\partial a_h}{\partial k}a; \\ d(t) &= G\left(W_5k_0 + W_1\frac{\partial a_h}{\partial k}\right)a. \end{aligned} \tag{19}$$

Equation (18) is a time-varying linear differential equation, and its features are not easy to analyze. However, when the input signal is constant, that is, after a long enough time, the partial derivative terms in the coefficients of the differential equation and the constant terms tend to be constant, that is,

$$\begin{aligned} &\lim_{t\to\infty}\frac{\partial a_h(t)}{\partial k} = \lim_{s\to 0} s\frac{\partial a_h(s)}{\partial k} = \lim_{s\to 0} s\frac{s^3}{\left(s^2+2\xi_h\omega_h s+\omega_h^2\right)(s+\omega_m)}\frac{r}{s} = 0, \\ &\lim_{t\to\infty}\frac{\partial v_h(t)}{\partial k} = \lim_{s\to 0} s\frac{\partial v_h(s)}{\partial k} = \lim_{s\to 0} s\frac{r^3}{\left(s^2+2\xi_h\omega_h s+\omega_h^2\right)(s+\omega_m)}\frac{r}{s} = 0, \\ &\lim_{t\to\infty}\frac{\partial x_h(t)}{\partial k} = \lim_{s\to 0} s\frac{\partial x_h(s)}{\partial k} = \lim_{s\to 0} s\frac{r^3}{\left(s^2+2\xi_h\omega_h s+\omega_h^2\right)(s+\omega_m)}\frac{1}{ss^2} = 0, \\ &\lim_{t\to\infty}\frac{\partial\left(\int x_h\,dt\right)(t)}{\partial k} = \lim_{s\to 0} s\frac{\partial\left(\int x_h\,dt\right)(s)}{\partial k} \\ &\quad = \lim_{s\to 0} s\frac{s^3}{\left(s^2+2\xi_h\omega_h s+\omega_h^2\right)(s+\omega_m)}\frac{r}{s}\frac{1}{s^3} = \frac{r}{\omega_h^2\omega_m}. \end{aligned} \tag{20}$$

Therefore, the coefficients and constant terms of the differential equations will also tend to be constants. At this time, the system represented by formula (18) can be

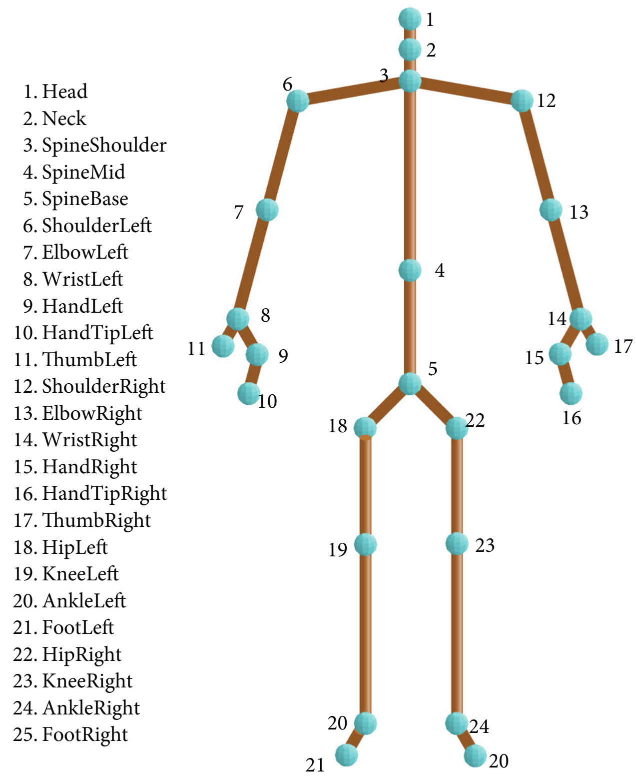



Figure 6: The names of the 25 joint points of the human body in the second generation of Kinect.

regarded as a linear time-invariant system:

$$\dot{a}_h + d_3a_h + d_2\int a_h\,dt + d_1\iint a_h\,dt^2 + d_0\iiint a_h\,dt^3 = d. \tag{21}$$

Then, the feature equation of this closed-loop system is

$$D(s) = s^4 + d_3s^3 + d_2s^2 + d_1s + d_0 = 0. \tag{22}$$

According to the Hurwitz stability criterion, the necessary and sufficient conditions for the system to remain stable are as follows:

(1) Each coefficient is positive

(2) The main determinant composed of the coefficients of the feature equation of the system is

$$\Delta = \begin{vmatrix} d_3 & d_1 & 0 & 0 \\ 1 & d_2 & d_0 & 0 \\ 0 & d_3 & d_1 & 0 \\ 0 & 1 & d_2 & d_0 \end{vmatrix} \tag{23}$$

All subdeterminants on its main diagonal are positive.

Through the above analysis, it can be known that the stability of the acceleration adaptive high-pass filter is related to the input amplitude. An input with an excessively large

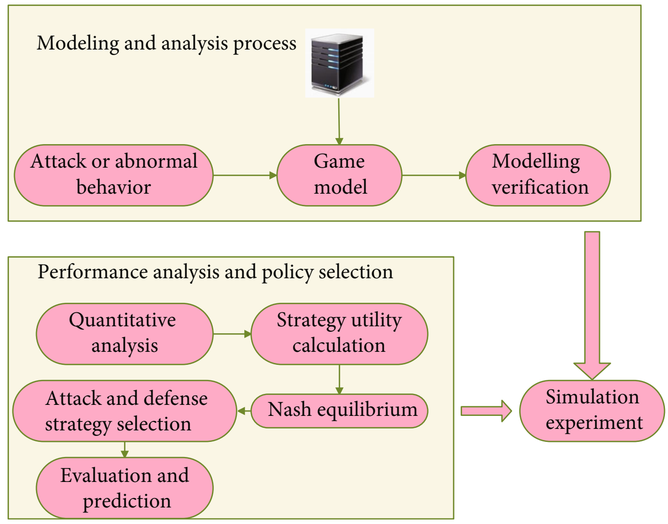



Figure 7: Decision-level fusion analysis method.

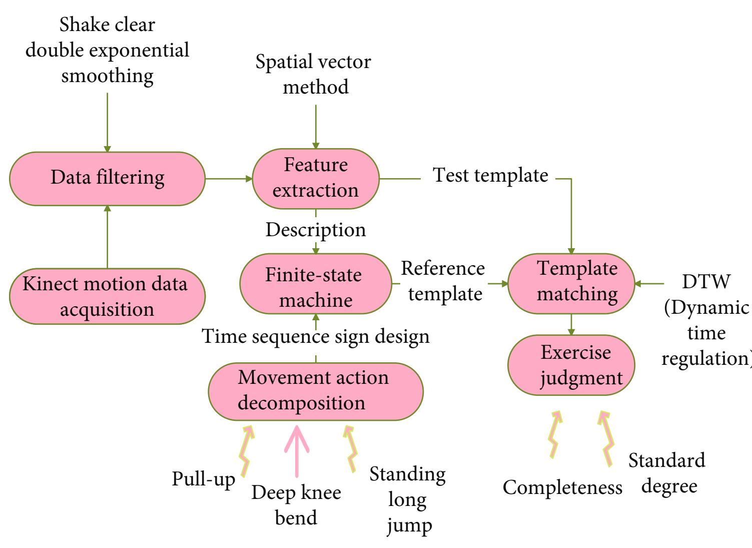



Figure 8: The framework of the motion recognition algorithm.

amplitude will make the system unable to meet the condition (2), which will cause the system to oscillate and diverge.

The analysis shows that for an adaptive high-pass filter, the adaptive gain is related to the amplitude of the input signal and affects the stability of the system, that is, the same adaptive high-pass filter. When the input signal amplitude is small, its output is stable. However, when the input amplitude increases to a certain extent, the output becomes oscillating and diverging.

In order to overcome this shortcoming of the traditional adaptive filter, it needs to be improved so that the amplitude of the input signal does not affect the adaptive gain. The improvement plan is to normalize and replace the adaptive law with the following formula:

$$\dot{k} = -G \sum_{i=1}^{5} W_i \frac{e_i(\partial e_i/\partial k)}{\alpha + (\partial e_i/\partial k)^2}. \tag{24}$$

$\alpha > 0$ is introduced to avoid possible division by zero. $e_i$ ($i = 1, 2, \cdots, 5$) can be obtained by writing Equation (3) as follows:

$$J = \frac{1}{2}\left[W_1(a_h - a)^2 + W_2 v_h^2 + W_3 x_h^2 + W_4\left(\int x_h \, dt\right)^2 + W_5(k - k_0)^2\right] = \frac{1}{2}\sum_{i=1}^{5} W_i e_i^2. \tag{25}$$

In order to limit the parameter adjustment rate within a certain range, the saturation feature is introduced, namely,

$$\dot{k} = -G\text{sat}\left(\sum_{i=1}^{5} W_i \frac{e_i(\partial e_i/\partial k)}{\alpha + (\partial e_i/\partial k)^2}, \beta\right). \tag{26}$$

In the formula, $\beta > 0$, and

$$\operatorname{sat}(x, \beta) = \begin{cases} -\beta, & x < -\beta, \\ x, & -\beta < x < \beta, \\ \beta, & x > \beta. \end{cases} \quad (27)$$

The improved adaptive washout algorithm is simulated, as shown in Figure 4.

It can be seen from Figure 4 that after the above correction, the gain of the adaptive washout algorithm has nothing to do with the input amplitude, so as to ensure that the output will not become divergent due to the increase of the input amplitude, which improves the stability of the washout algorithm. In addition, since the composition of the cost function is not changed, and the dimension of the gain itself is 1, this normalization process makes the gain more in line with its physical meaning.

## 4. Sports Training Intensity Information Fusion Method Based on Kinect Sensor

After Kinect "sees" the three-dimensional world through the camera, it uses computer graphics vision technology to first separate the human body from the background image and identify various parts of the human body. Furthermore, it extracts human bone features and joint point data and generates three-dimensional (3D) spatial coordinate data containing 25 joint points of the human body. The Kinect coordinate system in this study is shown in Figure 5. The name of each joint point and its position in the human body are shown in Figure 6.

Decision-level fusion is the fusion and dissemination of the uncertainty of each partial fusion result. After analyzing the current situation of data fusion at home and abroad, the deficiencies of decision-level data fusion are summarized. (1) The core of the decision-level fusion system is to conduct a comprehensive analysis of the decision results of the multisensor system, and most of the local results are inaccurate and not detailed, and some are contradictory, which greatly increases the risk of the fusion system. This time, synthesizing the analysis results of local sensors in the case of a large amount of conflicting information has become a problem that the cloud monitoring system must solve. (2) The amount of data collected by the cloud monitoring system is large, the data structure is complex, and there are many types of data. The existing decision-level fusion analysis methods all need to preprocess the original data, which is expensive. Therefore, fast and efficient fusion analysis for big data has become a "bottleneck" restricting decision-level fusion. The design of the analysis method proposed in this paper is shown in Figure 7.

In view of the analysis of the requirements for the use of this system, combined with the relevant research of previous scholars, this paper believes that the extraction of the temporal and spatial signs of the movement at different times during the movement process is the guarantee of the recognition accuracy. After that, this paper uses the template matching method of the sequential signs of movement and action connection as the motion recognition method of this system. The overall framework is shown in Figure 8.

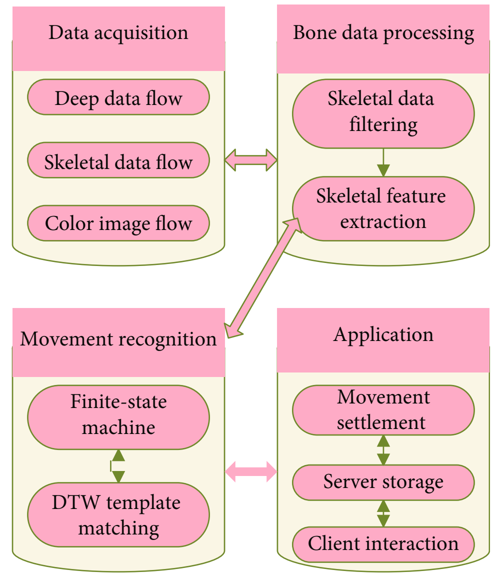



FIGURE 9: The flow of the motion recognition algorithm.

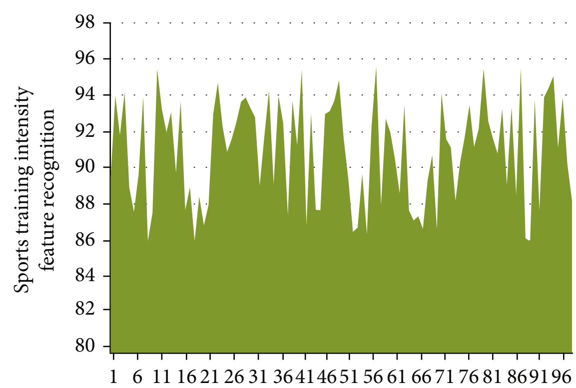



FIGURE 10: The effect of sports training intensity feature recognition.

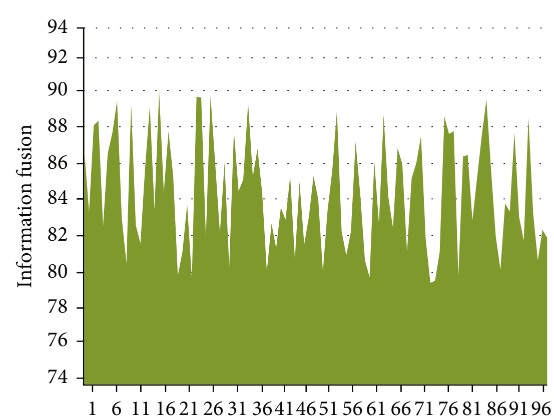



FIGURE 11: Information fusion effect of sports training intensity information fusion method based on Kinect sensor.

The flow of the motion recognition algorithm is shown in Figure 9.

Data collection: the algorithm accepts the real-time data stream collected by Kinect, including depth data stream, bone data stream, color image stream, and bone data stream, which will be used in the subsequent motion recognition process. In addition, other data will be used for client interaction and storage at the application layer. Bone data processing: the algorithm first uses the combined filtering method of jitter removal and double exponential smoothing to filter the data from the bone data stream collected by the algorithm. The smooth bone data lays the foundation for the smooth output of bone features. Then, the space vector method is used to extract the joint angle features of the bone data. Motion recognition: after the bone data is processed, a motion finite state machine template based on joint angle features is established for different motions. The DTW template matching algorithm is matched with real-time motion data to perform the motion recognition of the formulated motion. Application: for the above motion recognition, it only recognizes a periodic action in the motion process. It is also necessary to continuously recognize and settle the movement process, and the client needs to do the main interactive feedback according to different finite state machine states. Finally, the data is stored on the server for use by other applications.

After constructing the above system, the system is tested and verified. This paper uses Kinect and performance sports training intensity identification, mainly through action analysis.

After constructing the above system, the system is tested and verified. In this paper, Kinect is used to identify the features of sports training intensity, which is mainly identified through action analysis. Firstly, the results of the identification of sports training intensity features are counted as shown in Figure 10. Secondly, the effect of fusion of Kinect sensor and exercise training intensity information is counted, as shown in Figure 11.

From the above research, it can be seen that the sports training intensity information fusion method based on the Kinect sensor proposed in this paper has a good effect in sports training intensity information fusion.

## 5. Conclusion

Data fusion is similar to the process of human self-energy analysis. The data collected by the sensor system is first obtained. This information is generally time-varying, uncertain, incomplete, redundant, complementary, and so on. Then, it preprocesses and comprehensively analyzes this information and rationally optimizes and combines all the collected data based on the redundancy and complementarity of multidimensional physical features such as space, time, pop, and frequency spectrum. As a result, it obtains more accurate information about the detected environment and targets, improves the recognition ability of the system, and ensures the correct and effective operation of the system. This paper analyzes the Kinect sensor's information fusion process, combined with the training intensity analysis process to study, analyzes the sports training intensity information fusion process, and proposes an intelligent information fusion system to provide a theory for subsequent sports training intensity information fusion. Through research, it can be seen that the sports training intensity information fusion method based on the Kinect sensor proposed in this paper has a good effect in sports training intensity information fusion.

## Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

## Conflicts of Interest

The author declares no competing interests.

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