Zhang, J.; Du, P. (2022) Analysis of college students' sports data based on convolutional neural network algorithm. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 22 (86) pp. 436-454
DOI: https://doi.org/10.15366/rimcafd2022.86.015

ORIGINAL

Analysis of College Students' Sports Data Based on Convolutional Neural Network Algorithm

Junfang ZHANG[1], Peng DU[2*]
[1] School of Mathematics and Computer Science, Hengshui College, Hengshui, 053000, China
[2] School of Electronic and Information Engineering, Hengshui College, Hengshui, 053000, China
Email: hsxy_zjf@163.com

UNESCO Code / UNESCO Code:
Council of Europe classification / Council of Europe classification:

Recibido 26 de marzo de 2021 **Received** March 26, 2021
Aceptado 26 de marzo de 2022 **Accepted** March 26, 2022

Abstract

In order to improve the analysis effect of college students' sports and health data, this paper combines convolutional neural network algorithm to analyze college students' sports and health data, and explores the correlation between college students' sports and health. Moreover, this paper proposes a new dimension expansion method, which uses the least squares principle and the Kronecker product method to transform the algorithm into a data-driven way. In addition, this paper uses the fusion of time-frequency data and time-distance data as the input data of the network, and designs a CNN-LSTM network to automatically extract the movement behavior characteristics of college students contained in the spectral data.Finally, through data analysis, this paper verifies that the college student sports and health data analysis system based on the convolutional neural network algorithm has certain effects.

Keywords. convolutional neural network, college students, sports, health

1. INTRODUCTION

Physical health is the basis for ensuring that the construction of the talent system has a stable extension, and it is also the main evaluation standard for consolidating the comprehensive quality of college students. For the implementation of sports, it should be analyzed based on three aspects: competitive sports, mass sports and performance sports. Only in this way can we ensure stable and healthy development based on the characteristics of various sports in the sports environment. Moreover, within the overall spiritual quality construction system, a more diversified psychological coordination environment is provided to build a benign extension platform for a positive and confident talent environment.

A healthy lifestyle can ensure that college students have a good overall balance in terms of physical and quality conditions, and determine the effective care of time concept and physical quality conditions through a perfect schedule of work and rest. However, in the actual investigation, it can be clearly found that among the existing college students, irregular work and rest, irregular diet and lack of exercise have become common conditions, and the probability of obesity and myopia caused by this has increased year by year, and even has become serious. It affects the construction of students' personal spiritual quality system.

Based on the emergence of this situation, it can be seen that after college students enter the independent campus environment, their self-discipline ability has seriously declined, because they cannot impose strict requirements on themselves, which has led to serious confusion in time planning and even slack in homework. and the continuous decline of physical fitness (Kravchuk, Sanzharova, Golenkova, & Katrechko, 2020). It can be seen that in the process of implementing the maintenance of the health system for college students, such bad lifestyle habits should be strictly controlled to ensure that everyone can have a unified quality to build an environment, so as to ensure the effective construction of a lifestyle. Secondly, there should be strict constraints on the attendance of sports courses, to ensure that a certain number of absenteeism conditions will be punished, so as to urge students to exercise accordingly. Finally, in the process of building the school curriculum system, students can be organized for morning running and sports competitions, which can indirectly improve the physical quality of college students (Okun & Mulyk, 2017).

The campus environment is a transition period for college students to initially enter the society. Under the influence of this environment, students are extremely easily led to join the group environment of smoking and drinking, which not only threatens the students' own health, but is also influenced by the long-term environment. This will affect their own quality and image conditions, thus laying down hidden dangers for the subsequent development of social relations. Therefore, in such an environment, schools should crack down on smoking and drinking, and effectively implement the harm caused by such behaviors, so as to ensure that students have the ability to resist (Politko, 2018).

Effective comprehensive quality construction is the core of the existing talent system construction, and it is also the premise to ensure the effective construction of subsequent students' own functions. Among them, there are many reasons for psychological problems, but they are still closely related to the examination-oriented education. From childhood to adulthood, students grow up in the stereotyped thinking of "success by fractions". From childhood to adulthood, they only know how to study. Their extracurricular life is basically occupied by various cram schools, and they have no time to contact the society. The problem is also solved by the parents, their task is to study hard and get a good score (Chang, 2021). In this way, after entering the university, students need to solve many problems by themselves, such as teacherstudent relationship, classmate relationship, etc. Some students cannot handle these relationships, which will lead to psychological problems (Silva & Clemente, 2017).

Everything has two sides. We cannot deny the effect of any kind of sports on promoting physical health. As long as sports are scientific and reasonable, within a certain "quantity" range, it may have a positive effect on promoting physical health. , but excessive exercise can cause certain damage to the body. Therefore, people should strictly control the amount of exercise while doing sports, and at the same time master some necessary exercise principles (Ariani, 2021). There are many test indicators of physical health, but form and function are the most direct and simple indicators. Form is the proportion of each part of the body. Through targeted exercises, we can change the muscle fibers in the relevant areas to create a healthy shape. Function is the working ability of the eight major systems of the human body. Sports is the best means to promote the all-round development of human body functions. Any kind of sports is not only the external limb movement we see, but also a variety of internal systems. Corresponding changes, such as long-term endurance training, can improve the ability of the respiratory system to transport oxygen and carbon dioxide. Sports can make various systems develop in an all-round way at the original level (Z. L. Kozina et al., 2017).

Physical activity not only improves a person's biological condition, but also eliminates the negative effects of maladaptation. When encountering unsatisfactory things, some people will hold it in their stomachs, sulking themselves, and finally lead to physical and mental damage, while sports people mostly use sports to adjust themselves when encountering unsatisfactory things. In order to express their emotions by running hard and yelling on the court (Titova et al., 2018).

Long-term physical activity can exercise college students' will quality and self-confidence, and their self-confidence and psychological resistance to pressure can be continuously improved, which is more obvious in some endurance events and competitive events. Some team projects can also enhance the communication ability between college students, and at the same time cultivate the team cooperation ability of college students, which is most vividly shown in today's popular outreach training (Chernykh, Mulik, & Okun, 2019).

Long-term adherence to aerobic exercise can make the heart develop, the myocardial contractility can be enhanced, and the stroke volume can be increased, so that the heart can meet the blood supply with fewer beats, and the heart can get adequate rest, thereby reducing the burden on the heart. The blood vessel wall will be properly thickened and its elasticity will be enhanced to facilitate blood circulation, thereby reducing blood pressure, ensuring the supply of oxygen and nutrients needed by the human body, preventing arteriosclerosis, and thus preventing hypertension and coronary heart disease (Prontenko et al., 2017).

Many sports, such as aerobics, martial arts routines, etc., are varied and require quick coordinated and accurate responses to improve the function of the nervous system (Sarafyniuk, Syvak, Yakusheva, & Borejko, 2019).

There are two types of emotions, one is positive and the other is negative. Exercise can produce cerebrospinal peptides, which stimulate the hypothalamus, thereby producing happy emotions. Regular physical exercise can play a positive role in people's emotions, thereby making people's psychology healthier (Artiuh et al., 2018).

Physical activity has been reported in many countries to prevent and treat mental illness. Many doctors agree that physical activity can treat depression. Clinical observations show that some low-intensity aerobic activities such as jogging and walking are very effective in preventing and treating depression, reducing symptoms and stretching body and mind (Shalar et al., 2019).

Sports can enhance people's opportunities for contact. The awareness of exercising together, competing together, communicating with each other, and solidarity and cooperation in sports (especially group sports) is more significant, which naturally improves people's social adaptability (Fachrezzy, Hermawan, Maslikah, Nugroho, & Sudarmanto, 2021).

Fatigue is divided into physical fatigue and mental fatigue, which are related to people's physical and psychological aspects. People who often participate in sports understand that when fatigued, low-intensity exercise can help the body recover better, and appropriate and active exercise can make people feel Excited, with a good mood, thus playing a role in eliminating fatigue (Kons, Franchini, & Detanico, 2018).

The new physical education syllabus requires that the physical education courses in colleges and universities should be based on quality education, health, and adherence to people-oriented. Characteristics and other issues, the concept of lifelong sports has not been implemented in the physical education courses of college students. It is manifested that college students lack the awareness of physical exercise, so when college students stop physical education, their physical health will decline (Z. Kozina et al., 2019).

The current physical education system does not pay enough attention to college students, and the environment and system are not perfect for college students to participate in physical exercise. More services and support should be provided for students in terms of venues, equipment, fitness consultation and campus culture (Zalyapin, Isaev, Bakhareva, & Aminova, 2019). This paper combines the convolutional neural network algorithm to analyze the sports and health data of college students, explores the correlation between college students' sports and health, and provides a reference for college students to better achieve sports health.

2. New model of multi-rate sampling system and its LQR controller design

A multi-rate sampling system is considered, and only the multi-rate characteristic is the period mismatch between the input and output. We assume that for the state variables, $x(t)$ has a sampling period of $p_s h$, and the zero-order holder of the system has a period of $p_u h$ for the system input. The multi-rate sampling system G adopted is as follows:

$$\dot{x}(t) = A_c x(t) + B_c u(t), \quad (1)$$

Among them, $x(t)$ is the state variable of the system and there is $x \in R^n$. $u(t)$ is the input to the system and there is $u \in R^m$. A_c and B_c are system matrices with suitable dimensions. Matrix (1) is discretized with the time period as h, and an equivalent linear discrete system G_d can be obtained as follows:

$$x(k+1) = Ax(k) + Bu(k), \quad (2)$$

Among them, there is $A = e^{Ach}$ and $B = \int_0^h e^{A_c \tau d\tau B_c}$. A dynamic output feedback controller can be designed. We plan to use other scaling methods to deal with the problem of multi-rate sampling systems, and then design a state feedback controller in this scaling method.

$N = p_s \times p_u$ is defined. Then, in time period Nh, it can be found that:

$$\begin{aligned} x(1) &= Ax(0) + Bu(0), \\ x(2) &= Ax(1) + Bu(1), \\ &\vdots \\ x(N+1) &= Ax(N) + Bu(N). \end{aligned} \quad (3)$$

From this we define a new state variable $\overline{x}$ and a new system input $\overline{u}$ here as follows:

$$\overline{x}(k) = \begin{bmatrix} x(kN-N+s) \\ x(kN-N+2s) \\ \vdots \\ x(kN) \end{bmatrix}, \overline{u}(k) = \begin{bmatrix} u(kN) \\ u(kN+p) \\ \vdots \\ u(kN+N-p) \end{bmatrix} \quad (4)$$

Among them, there is $p = p_u$ and $s = p_s$, and the initial state has

$$\overline{x}(0) = [0 \cdots x(0)^T]^T$$

Moreover, the expansion method represented by the above variables is used to discretize the multi-rate sampling system G(1) with the period Nh, and its equivalent linear discrete time-invariant system can be obtained.

$$\bar{x}(k+1) = \bar{A}\bar{x}(k) + \bar{B}\bar{u}(k), \quad (5)$$

Among them, the correlation matrix parameters are expressed as follows:

$$\bar{A}=\begin{bmatrix} 0 & \cdots & 0 & A^{s} \\ 0 & \cdots & 0 & A^{2s} \\ \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & A^{N} \end{bmatrix},\bar{B}=\begin{bmatrix} \bar{B}_{s1} & \bar{B}_{s2} & \cdots & \bar{B}_{1\frac{N}{P}} \\ \bar{B}_{2s1} & \bar{B}_{2s2} & \cdots & \bar{B}_{2s\frac{N}{P}} \\ \vdots & \vdots & \ddots & \vdots \\ \bar{B}_{N1} & \bar{B}_{N2} & \cdots & \bar{B}_{N\frac{N}{P}} \end{bmatrix}$$

$$\bar{B}_{ij}=\begin{cases} \sum_{k=1}^{p} A^{i-jp+k-1}+B & (if \quad i>jp+p) \\ 0 & (if\ i<jp) \\ \sum_{k=1+jp-i}^{p} A^{i-jp+k-1}+B & (other) \end{cases} \quad (6)$$

We are going to design a state feedback controller as follows:

$$\bar{u}(k)=-k\bar{x}(k). \quad (7)$$

From the controller formula (7) and the system $\bar{G}$ (5), it can be found that the controller (7) utilizes the data collected by the system in the time period $[(kN-N+1)h, kNh]$. Then, the span period of the system input of the controller output is $[kNh, (kN+N-p)h]$.

The goal is to design a data-driven learning algorithm to automatically optimize the controller parameters. However, this kind of controller generally chooses the LQR controller. Therefore, for the multi-rate system (1) and its equivalent discrete system $\bar{G}$ (5), its cost function is set as shown below, and the decay factor is given as γ.

At the same time, there is a premise in the design of LQR controller in general, that is, the controlled system is fully controllable. Therefore, all the algorithms proposed in this chapter have a premise dependency, that is, the multi-rate sampling system is a fully controllable controlled system.

$$\begin{aligned} J &= \sum_{k=0}^{\infty}\gamma^{k}\left(x^{T}(k)Qx(k)+u^{T}(k)Ru(k)\right) \\ &= \lim_{N\to\infty}\left(\bar{x}^{T}(N)\bar{Q}\bar{x}(N)+\sum_{k=0}^{N-1}\gamma^{k}\left(\bar{x}^{T}(k)\bar{Q}\bar{x}(k)+\bar{u}^{T}(k)\bar{R}\bar{u}(k)\right)\right). \end{aligned} \quad (8)$$

Therefore, it can be described as designing a data-driven reinforcement learning algorithm so that the multi-rate sampling system (1) has a controller that can be continuously optimized over a period of time to finally minimize the objective cost function J (8).

First, the design of the learning algorithm is not considered, and in this section we intend to provide the design algorithm of the optimal controller (LQR) for the multi-rate sampling system (1) under the new dimension expansion method. Based on the cost function J, the required cost function is defined in the following way

$$V(\bar{x}(k)) = \sum_{i=k}^{\infty} \gamma^{i-k} \gamma(\bar{x}(i), \bar{u}(i)), \quad (9)$$

Among them, $\gamma(\bar{x}(i), \bar{u}(i))$ can be regarded as the reward and punishment function of reinforcement learning theory.

$$\gamma(\bar{x}(i), \bar{u}(i)) = \bar{x}^T(i)\bar{Q}\bar{x}(i) + \bar{u}^T(i)\bar{R}\bar{u}(i) \quad (10)$$

Therefore, it can be found that the value function (9) can be rewritten as follows:

$$V(\bar{x}(k)) = \gamma(\bar{x}(k), \bar{u}(k)) + \sum_{i=k+1}^{\infty} \gamma^{i-k} \gamma(\bar{x}(i), \bar{u}(i)) \quad (11)$$

At the same time, it can be found that the structures of formula (9) and formula (11) can satisfy the Bellman equation:

$$V(\bar{x}(k)) = \gamma(\bar{x}(k), \bar{u}(k)) + \gamma V(\bar{x}(k+1)). \quad (12)$$

At the same time, for the expanded discrete system $\bar{G}$ (5), such a value function can also be described in a quadratic way

$$V(\bar{x}(k)) = \bar{x}^T(k)P\bar{x}(k) \quad (13)$$

The quadratic form in formula (13) is utilized, then Bellman equation (12) can be expressed in the following way:

$$\bar{x}^T(k)P\bar{x}(k) = \gamma(\bar{x}(k), \bar{u}(k)) + \gamma\bar{x}^T(k+1)P\bar{x}(k+1) \quad (14)$$

A Hamiltonian function $H(\bar{x}(k), \bar{u}(k), \lambda(k))$ is defined that behaves as:

$$H = \gamma(\bar{x}(k), \bar{u}(k)) + \lambda(k)^T \left(\gamma V\bar{x}(k+1) - V(\bar{x}(k))\right) \quad (15)$$

Therefore, when this Hamiltonian function equation is solved, the optimal control rate can be obtained. That is, the following equation holds:

$$\partial H(\bar{x}(k), \bar{u}(k), \lambda(k))/\partial \bar{u}(k) = 0$$
$$\partial H(\bar{x}(k), \bar{u}(k), \lambda(k))/\partial \bar{x}(k) = \lambda(k) - \lambda(k+1) \quad (16)$$

So far, the parameter calculation of the optimal feedback controller for system $\bar{G}$ (5) can be expressed by the following formula:

$$k^* = (\bar{R} + \gamma\bar{B}^T P\bar{B})^{-1}\gamma\bar{B}^T P\bar{A}, \quad (17)$$

Among them, P is the Riccati equation, and the solution of the algebraic Riccati equation (ARE) is:

$$\gamma\bar{A}^T P\bar{A} - P - \gamma^2\bar{A}^T P\bar{B}(\bar{R} + \gamma\bar{B}^T P\bar{B})^{-1}\bar{B}^T P\bar{A} + \bar{Q} = 0 \quad (18)$$

Now, LQR controllers for multi-rate sampling systems are discussed in more depth. We carefully observe the structure of matrix $\bar{A}$, and we can find that matrix $\bar{A}$ is singular.In order to solve this problem here, the following matrix transformation is given first.

$$\bar{A} = [0 \quad F], F^T = [\bar{A}_1^T, \bar{A}_2^T],$$
$$\bar{B}^T = [\bar{B}_1^T, \bar{B}_2^T], \bar{A}_2 = A^N, N_0 = N - 1,$$
$$\bar{B}_1 = \begin{bmatrix} \bar{B}_{s1} & \bar{B}_{s2} & \cdots & \bar{B}_{s\frac{N}{P}} \\ \bar{B}_{2s1} & \bar{B}_{2s2} & \cdots & \bar{B}_{2s\frac{N}{P}} \\ \vdots & \vdots & \ddots & \vdots \\ \bar{B}_{N_01} & \bar{B}_{N_02} & \cdots & \bar{B}_{N_0\frac{N}{P}} \end{bmatrix}, \bar{A}_1 = \begin{bmatrix} A^s \\ \vdots \\ A^{N-1} \end{bmatrix},$$
$$\bar{B}_2 = \begin{bmatrix} \bar{B}_{N1} & \bar{B}_{N2} & \cdots & \bar{B}_{N\frac{N}{P}} \end{bmatrix}.$$
$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix}, U = P\bar{B}(\bar{R} + \gamma\bar{B}^T P\bar{B})^{-1}\bar{B}^T P, \quad (19)$$

Among them, $\bar{B}_{ij}$ can be found in formula (6). We set the matrices Q_1, $Q_2 \in \mathbb{R}^{N\times N}$ to have suitable dimensions, and set $\bar{Q}$ to be

$$\bar{Q} = diag\{Q_1, Q_2\} \quad (20)$$

Next, the above matrix is transformed using transformation (19), and we set γ = 1, then the Ricardi equation (ARE) (18) can be transformed into the following formula:

$$\begin{bmatrix} 0 \\ F^T \end{bmatrix} P[0 \quad F] - P - \begin{bmatrix} 0 \\ F^T \end{bmatrix} U[0 \quad F] + \begin{bmatrix} Q_1 & 0 \\ 0 & Q_2 \end{bmatrix} = 0 \quad (21)$$

From formula (21), there is $P_{12} = P_{21}^T = 0$ and $P_{11} = P_{11}^T = Q_1$. At the same time, it can be found that when formula (21) is established, the following formula will also be established

$$F^T PF = P_{22} + F^T UF + Q_2 = \bar{A}_1^T Q_1 \bar{A}_1 + \bar{A}_2^T P_{22} \bar{A}_2. \quad (22)$$

We set

$$\tilde{P} = P_{22}, \tilde{S} = \bar{A}_1^T Q_1 \bar{B}_1, \tilde{A} = \bar{A}_2, \tilde{B} = \bar{B}_2,$$
$$\tilde{Q} = Q_2 + A_1^T Q_1 A_1, \tilde{R} = \bar{R} + \gamma\bar{B}^T Q_1 \bar{B}_1. \quad (23)$$

Thereby, formula (24) can be obtained, and the matrix P_{22} can be obtained by using the following formula (24) simultaneously.

$$\tilde{A}^T \tilde{P}\tilde{A} - \tilde{P} - \tilde{L} + \tilde{Q} = 0,$$
$$\tilde{L} = \left(\tilde{A}^{\bar{T}} \tilde{P}\tilde{B} + \tilde{S}\right)\left(\tilde{R} + \tilde{B}^T \tilde{P}\tilde{B}\right)^{-1}\left(\tilde{B}^T \tilde{P}\tilde{A} + \tilde{S}^T\right) \quad (24)$$

According to P_{22} and $P_{11} = Q_1$ obtained from formula (22), the control law of the optimal controller can be obtained as:

$$K = (\bar{R} + \bar{B}^T P\bar{B})^{-1}\bar{B}^T P\bar{A} \quad (25)$$

So far, through formulas (19) to (25), the optimal control law design method of the multi-rate sampling system under the new dimension expansion mode can be obtained, which is summarized as the following algorithm.

Algorithm 1 The fast LQR control solution algorithm of the multi-rate sampling system under the expanded dimension method (4) is:

(1) Through the multi-rate sampling system (1), the new dimension expansion method (4) is used to obtain its equivalent linear discrete time-invariant system $\bar{G}$ (5).

(2) Formula (23) is utilized to transform the complex system matrix contained in system (5) into a matrix form that can be directly solved by the ARE equation.

(3) P_{22} is obtained by solving the ARE equation (24).

(4) The control law is obtained by solving the formula (25) $K = (\bar{R} + \bar{B}^T P \bar{B})^{-1} \bar{B}^T P \bar{A}$.

Note 3 From the structure of the controller (25), it can be found that the structure of $\bar{A}$ causes the structure of the controller to have such a situation $K = [0 \quad K_m]$. This also means that the only valid application part of all controllers is the K_m part. At this time, when Algorithm 1 is used, formula (24) can be directly used to obtain the controller gain K_m. Correspondingly, according to the structure of the expanded system input $\bar{u}(k)$, it can be clearly found that the controller can count and calculate the output of the controller from kNh to $(kN + N - p)h$ in the time period.

Algorithm 2 The online policy iteration algorithm of the multi-rate sampling system is:

(1) Through the multi-rate sampling system (1), the new dimension expansion method (4) is used to obtain its equivalent linear discrete time-invariant system.

(2) The system is initialized, the initial iteration value j = 0 is set, and the system is run with an initial control law, which has the characteristics that can make the system stable. The control law is expressed as $\bar{u}^0(k) = K_0 \bar{x}(k)$.

(3) $P_{11}^{j+1} = Q_1$ is set, then the formula can be used to solve the iterative matrix P^{j+1}.

$$x^T(k) P^{j+1} \bar{x}(k) = r\left(\bar{x}(k), \bar{u}^j(k)\right) + \gamma \bar{x}^T(k+1) \bar{x} \quad (26)$$

(4) The control law K^{j+1} is updated by formula $K^{j+1} = \left(\bar{R} + \gamma \bar{B}^T P^{j+1} \bar{B}\right) \gamma \bar{B}^T P^{j+1} \bar{A}$.

(5) Whether the norm difference between the control laws satisfies $\left\|K^{j+1} - K^j\right\|_2 \leq \in$ is judged, and $\in$ is a small threshold. If it is satisfied, we stop iterating. If it is not satisfied, we set j = j+1 and go back to the third step.

At this time, the controller is the optimized controller. If the norm difference between the controllers before and after the update does not meet the psychological expectations, further iterations are required.

On the basis of Algorithm 2, an offline algorithm is obtained. We re-describe the discrete time-invariant system $\bar{G}$,

$$\bar{x}(k+1) = \bar{A}_k\bar{x}(k) + \bar{B}\left(\bar{u}(k) + K^j\bar{x}(k)\right) \quad (27)$$

Among them, there is $\bar{A}_k = \bar{A} - \bar{B}K^j$. Meanwhile, $\bar{u}(k)$ of formula (27) here is the system input of the execution control law, not the system input of the iterative control law. The system input output by the iterative target control law is $\bar{u}^j(k) = -K^j\bar{x}(k)$, and as the iteration progresses, the controller and the system input are also iterated at the same time. However, the system input produced by this iteration does not produce actual data. With the combination of $\bar{u}^j(k) = -K^j\bar{x}(k)$ and $\bar{x}(k+1) = (\bar{A} - \bar{B}K^j)\bar{x}(k)$ considered, formula (26) in Algorithm 2 can be equivalent to the following formula:

$$\bar{x}^T(k)\bar{Q}\bar{x}(k) + \bar{x}^T(k)\left(K^j\right)^T\bar{R}K^j\bar{x}(k) = \\ \bar{x}^T(k)P^{j+1}\bar{x}(k) + \gamma\bar{x}^T(k)\left(\bar{A} - \bar{B}K^j\right)^T P^{j+1}\left(\bar{A} - \bar{B}K^j\right)^T\bar{x}(k) \quad (28)$$

Then, according to formula (28), the following formula (29) can still be deduced:

$$\bar{x}^T(k)P^{j+1}\bar{x}(k) - \gamma\bar{x}^T(k)\bar{A}^T P^{j+1}\bar{A}\bar{x}(k) = \\ \bar{x}^T(k)\bar{Q}\bar{x}(k) + \gamma\bar{x}^T(k)\left(\bar{B}K^j\right)^T P^{j+1}\bar{B}K^j\bar{x}(k) + \\ \bar{x}^T(k)\left(K^j\right)\bar{x}(k) - 2\gamma\bar{x}^T(k)\left(\bar{B}K^j\right)^T P^{j+1}\bar{A}\bar{x}(k) \quad (29)$$

For an offline algorithm, the system state variables can be obtained by formula (27). Then, in the next step, polynomials are added to both sides of formula (29), which can be directly equivalent to formula (30) below.

$$\bar{x}^T(k)P^{j+1}\bar{x}(k) - \gamma\bar{x}^T(k+1)\bar{A}^T P^{j+1}\bar{x}(k+1) \\ = \bar{x}^T(k)\bar{Q}\bar{x}(k) + \bar{x}^T(k)\left(K^j\right)^T RK^j\bar{x}(k) \\ -2\gamma\left(\bar{u}k + K^j\bar{x}(k)\right)^T\bar{B}P^{j+1}\bar{A}\bar{x}(k) \\ +\gamma\left(\bar{u}k + K^j\bar{x}(k)\right)^T\bar{B}P^{j+1}\bar{B}\left(\bar{u}k - K^j\bar{x}(k)\right) \quad (30)$$

From this equivalent formula (30), the offline policy iteration algorithm 3 for multi-rate sampling systems can be derived.

Algorithm 3 The offline policy iteration algorithm of the multi-rate sampling system is:

(1) Through the multi-rate sampling system (1), the new dimension expansion method (44) is used to obtain its equivalent linear discrete time-invariant system $\bar{G}$ (5).

(2) The system is initialized, the initial iteration value j = 0 is set, and the system is run with an initial control law, which has the characteristics that can make the system stable. The control law is expressed as $\bar{u}(k) + K\bar{x}(k)$.

(3) The matrix P^{j+1} is solved by formula (30). Among them, there is $P^{j+1} = Q_1$, and the data needed to solve is $\bar{x}(k), \bar{x}(k+1), \bar{u}(k), K^j$.

(4) The control law K^{j+1} is updated by formula $\bar{x}(k)K^{j+1} = (\bar{R} + \gamma\bar{B}^T P^{j+1}\bar{B})\gamma\bar{B}^T P^{j+1}\bar{A}$.

(5) Whether the norm difference between the control laws satisfies $\|K^{j+1} - K^j\|_2 \leq \in$ is judged, and $\in$ is a small threshold. If it is satisfied, we stop iterating. If it is not satisfied, we set j = j+1 and go back to the third step.

The following matrix transformations are required:

$$vec(a^T W b) = (b^T \oplus a^T)vec(W) \quad (31)$$

Among them, vec(A) is the vectorization of matrix A, that is, the column vector of matrix expansion by column. $\oplus$ is the Kronecker product. At the same time, we set

$$\bar{A}\bar{x}(k) = \begin{bmatrix} 0 & \bar{A}_1 \\ 0 & \bar{A}_2 \end{bmatrix} \begin{bmatrix} \bar{x}_1(k) \\ \bar{x}_2(k) \end{bmatrix} \quad (32)$$

$P_{11} = Q_1$ is set, and the formula (30) can proceed to the derivation transformation of the formula as follows:

$$\begin{aligned} &\bar{x}^T(k)\bar{Q}\bar{x}(k) + \bar{x}^T(k)(K^j)^T\bar{R}K^j\bar{x}(k) = \\ &\bar{x}_1{}^T(k)\bar{Q}_1\bar{x}_1(k) - \gamma\bar{x}_1{}^T(k+1)\bar{Q}_1\bar{x}_1(k+1) + \\ &\bar{x}_2{}^T(k)P_{22}^{j+1}\bar{x}_2(k) - \gamma\bar{x}_2{}^T(k+1)P_{22}^{j+1}\bar{x}_2(k+1) + \\ &2\gamma\left(\bar{u}k + K^j\bar{x}(k)\right)^T(\bar{B}_1\bar{Q}_1\bar{A}_1 + \bar{B}_2P_{22}^{j+1}\bar{A}_2)\bar{x}_2(k) + \\ &\gamma\left(\bar{u}k + K^j\bar{x}(k)\right)^T\bar{B}P^{j+1}\bar{B}\left(\bar{u}k - K^j\bar{x}(k)\right) \quad (33) \end{aligned}$$

$\bar{r}(\bar{x}(k))$ is defined as follows:

$$\begin{aligned} \bar{r}(\bar{x}(k)) = &\bar{x}^T(k)\bar{Q}\bar{x}(k) + \bar{x}^T(k)(K^j)^T\bar{R}K^j\bar{x}(k) - \\ &\bar{x}_1{}^T(k)\bar{Q}_1\bar{x}_1(k) - \gamma\bar{x}_1{}^T(k+1)\bar{Q}_1\bar{x}_1(k+1) \quad (34) \end{aligned}$$

The Kronecker product is used, that is, formula (31), formulas (33) and (34) can be combined to derive as

$$\begin{aligned} &\bar{r}(\bar{x}(k)) = \\ &\left(\bar{x}_2{}^T(k)\right) \oplus \bar{x}_2{}^T(k) - \bar{x}_2{}^T(k+1) \oplus \bar{x}_2{}^T(k+1)vec(P_{22}^{j+1}) \\ &+2\gamma\left(\bar{x}_2{}^T(k)\right) \oplus \left(\bar{u}k + K^j\bar{x}(k)\right)^T vec(\bar{B}_1\bar{Q}_1\bar{A}_1) \\ &+2\gamma\left(\bar{x}_2{}^T(k)\right) \oplus \left(\bar{u}k + K^j\bar{x}(k)\right)^T vec(\bar{B}_2P_{22}^{j+1}\bar{A}_2) \end{aligned}$$

$$+\gamma\left(\bar{u}k+K^j\bar{x}(k)\right)^T\oplus\left(\bar{u}k+K^j\bar{x}(k)\right)^T vec\left(\bar{B}P^{j+1}\bar{B}\right) \quad (35)$$

It can be seen from formula (33) that this formula equation contains a total of $n^2+N^2m^2/p^2+Nmn/p+(N-1)(N-p)mn/p$ unknown parameters. Therefore, for solving such equations, at least $n^2+N^2m^2/p^2+Nmn/p+(N-1)(N-p)mn/p$ sets of data are required to update the control strategy. Then, we set such an integer to satisfy $s\geq n^2+N^2m^2/p^2+Nmn/p+(N-1)(N-p)mn/p$. Next, these matrices are defined:

$$\Phi^j=\left[\bar{r}\left(\bar{x}(k)\right)^T \quad \bar{r}\left(\bar{x}(k+1)\right)^T \quad \cdots \quad \bar{r}\left(\bar{x}(k+s-1)\right)^T\right]$$

$$\psi=\begin{bmatrix} M_{(xx)1} & M_{(xu)1} & M_{(uu)1} \\ M_{(xx)2} & M_{(xu)2} & M_{(uu)2} \\ & & \\ M_{(xx)s} & M_{(xu)s} & M_{(uu)s} \end{bmatrix} \quad (36)$$

Among them, there is

$$M_{(xx)i}=\bar{x}_2^T(k+i-1)\oplus\bar{x}_2^T(k+i-1)$$
$$-\bar{x}_2^T(k+i)\oplus\bar{x}_2^T(k+i)$$
$$M_{(xu)i}=2\gamma\begin{pmatrix}\bar{x}_2^T(k+i-1)\oplus\left(\bar{u}(k+i-1)\right)\\+K^j\bar{x}(k+i-1)^T\end{pmatrix}$$
$$M_{(uu)i}=\gamma\begin{pmatrix}\bar{u}(k+i-1)-K^j\bar{x}(k+i-1)^T\\\oplus\left(\bar{u}(k+i-1)\right)+K^j\bar{x}(k+i-1)^T\end{pmatrix} \quad (37)$$

Some unknown parameter matrices are defined as follows:

$$W_1^{j+1}=P_{22}^{j+1}, W_2^{j+1}=\bar{B}_1^TQ_1\bar{A}_1+\bar{B}_2^TP_{22}^{j+1}\bar{A}_2$$
$$W_3^{j+1}=\bar{B}^TP^{j+1}\bar{B} \quad (38)$$

Then formulas (34) to (38) are combined to have the following formula:

$$\psi^j\left[vec\left(W_1^{j+1}\right)^T \quad vec\left(W_2^{j+1}\right)^T \quad vec\left(W_3^{j+1}\right)^T\right]^T=\Phi^j \quad (39)$$

Then, based on formula (39), formula (34) can be solved by least squares method:

$$\left[vec\left(W_1^{j+1}\right)^T \quad vec\left(W_2^{j+1}\right)^T \quad vec\left(W_3^{j+1}\right)^T\right]^T=\Phi^j$$
$$=\left(\left(\psi^j\right)^T\psi^j\right)\left(\psi^j\right)^T\Phi^j \quad (40)$$

By solving the above formula (40), W_1^{j+1}, W_2^{j+1} and W_3^{j+1} can be obtained. Therefore, such a controller gain can be solved by the following formula.

$$K=\left(R+W_3^{j+1}\right)^{-1}\left[0 \quad W_2^{j+1}\right] \quad (41)$$

Algorithm 4 The data-driven controller parameter optimization algorithm for multi-rate sampling system based on Bellman equation is:

(1) Through the multi-rate sampling system (1), the new dimension expansion method (4) is used to obtain its equivalent linear discrete time-invariant system $\bar{G}$ (5).

(2) The system is initialized, the initial iteration value j = 0 is set, and the system is run with an initial control law, which has the characteristics that can make the system stable. The control law is expressed as $\bar{u}(k) = K\bar{x}(k) + e(k)$. Among them, e(k) is exploratory noise.

(3) We use the least squares method to solve the matrices W_1^{j+1}, W_2^{j+1}, and W_3^{j+1} through formula (39) and formula (40).

(4) The control law K^{j+1} is updated by formula $K = \left(R + W_3^{j+1}\right)^{-1}\left[0 \quad W_2^{j+1}\right]$.

(5) Whether the norm difference between the control laws satisfies $\left\|K^{j+1} - K^j\right\|_2 \leq \in$ is judged, and ∈ is a small threshold. If it is satisfied, we stop iterating. If it is not satisfied, we set j = j+1 and go back to the third step.

3. Analysis of college students' sports and health data based on convolutional neural network algorithm

In order to meet the needs of college students' sports and health data analysis in various environments, this paper uses the fusion of time-frequency data and time-distance data as the input data of the network. Moreover, this paper designs a CNN-LSTM network to automatically extract the human motion behavior features contained in the spectral data to improve the generalization ability of the model and train the behavior classifier. The structure of the deep learning networkin this paper is shown in Figure 1.

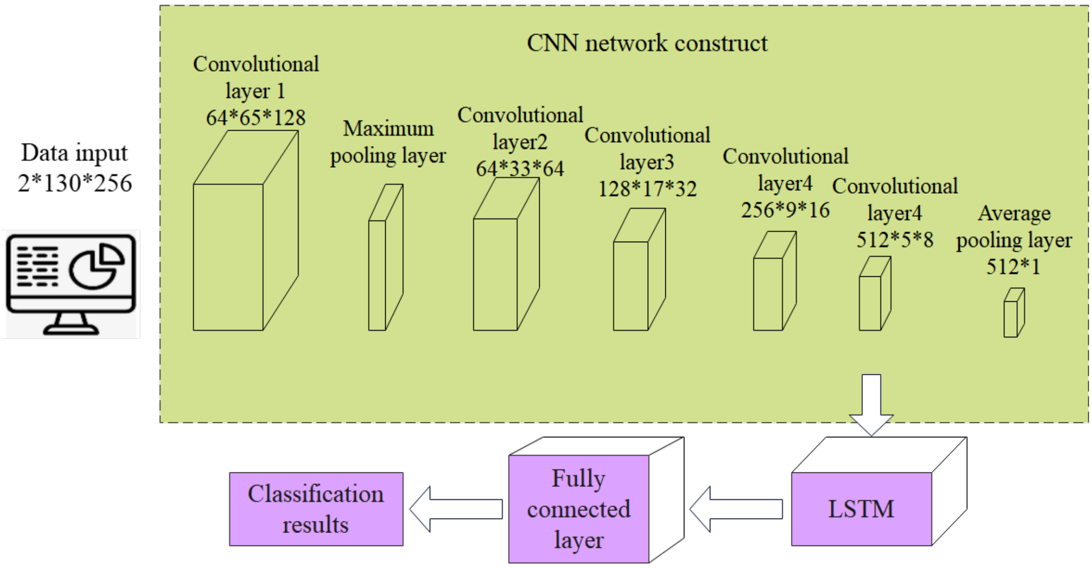

Figure 1. Deep learning network structure

The Xception-LSTM network structure is a parallel combination of Xception and LSTM pre-trained on ImageNet. As shown in Figure 2,after network training, the algorithm adopts transfer learning, and uses the model parameters pre-trained on the ImageNet database as the initialization parameters of Xception.

First, all the convolutional block parameters of the Xception network do not change, and the algorithm only trains the LSTM network. The algorithm then trains the entire Xception-LSTM model. After that, the algorithm fine-tunes the network parameters according to the collected gait image dataset to improve the model accuracy and generalization ability.

Finally, the algorithm uses the neural network attention mechanism to merge the two features generated by Xception and LSTM to obtain the fully connected layer feature FC, which is fused in series with the knee joint angle and GRF data after feature normalization, as shown in Figure 3.

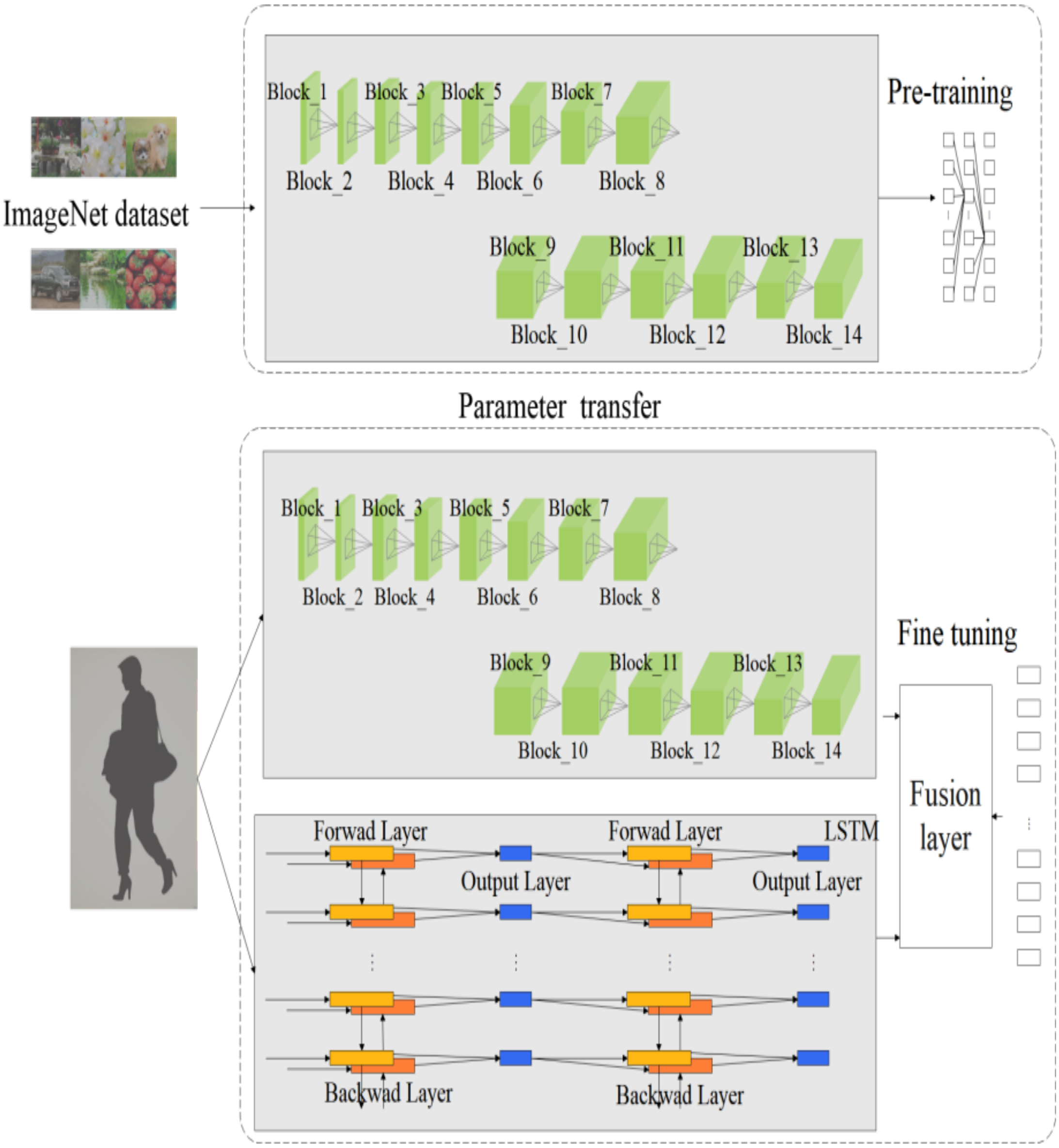

Figure 2. Xception-LSTM network structure

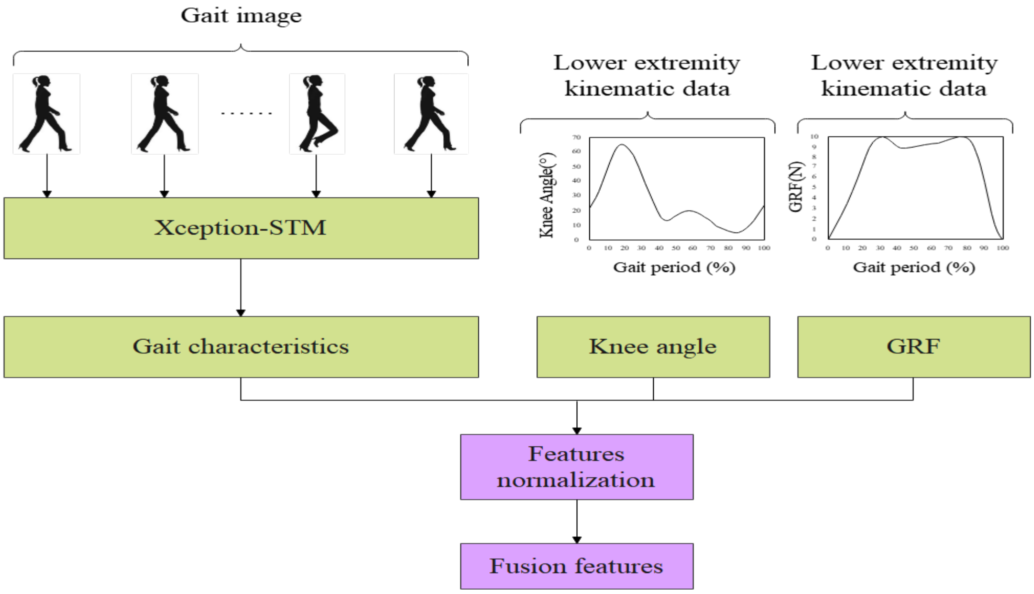

Figure 3. Xception-LSTM feature extraction and feature fusion

The convergence effect of the controller in the iterative process of Algorithm 2 is shown in Figure 4. At the same time, the controllers of the three iterative processes are compared with each other. They are the controllers before the iteration, after the third iteration and when the iteration is completed. The results are shown in Figure 5.

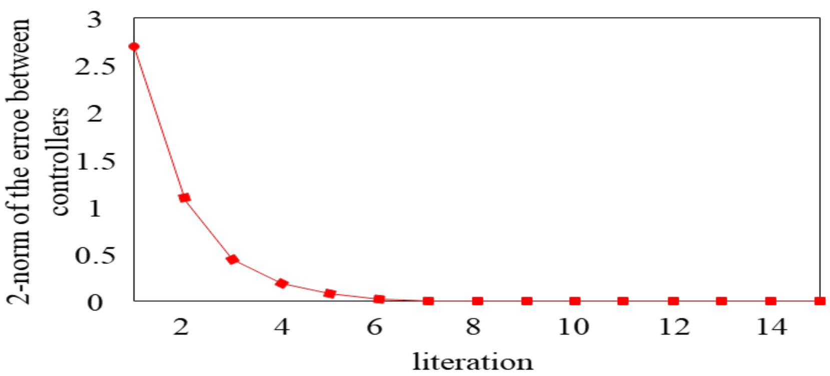

Figure 4. Convergence effect of the controller in the iterative process of Algorithm 2

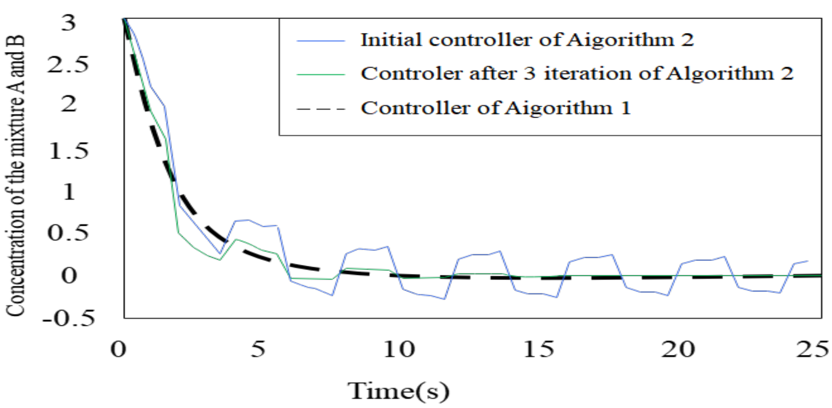

Figure 5. Convergence of system state variables in each iterative stage of Algorithm 2

Figure 6 shows the convergence of the controller in Algorithm 3. It can be clearly concluded from the figure that after 7 iterations, the norm difference is very small and converges to 0. It can be said that the effect will be slightly slower than Algorithm 2, but the convergence task is also successfully completed.

Figure 7 shows the state variable convergence state of the system in the state of Algorithm 3. It can be found that with the convergence of the controller, the effect of the controller is getting better and better, and it has been close to keeping up with the optimal LQR controller in about 3 seconds.

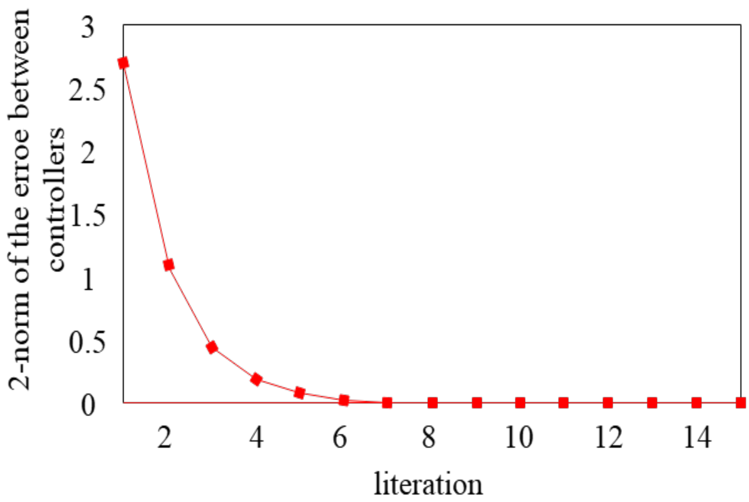

Figure 6. Convergence effect of the controller in the iterative process of Algorithm 3

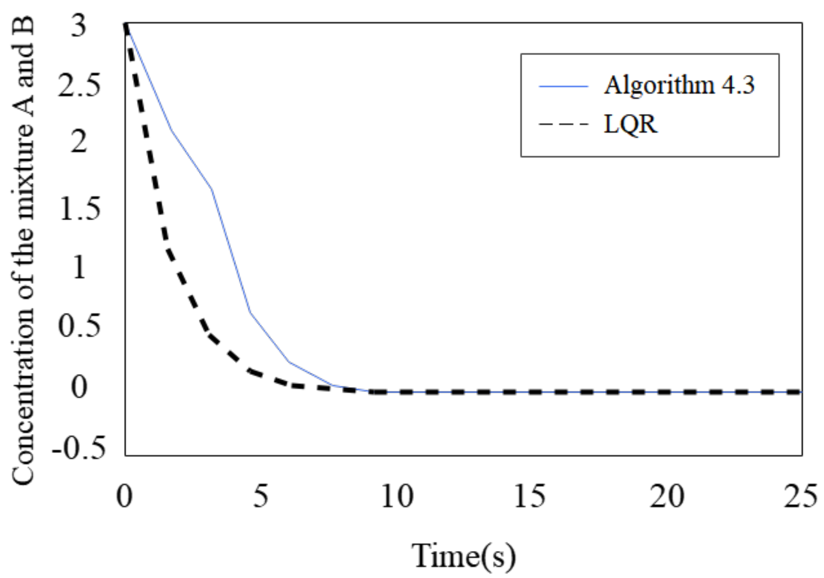

Figure 7. Convergence of system state variables in each iterative stage of Algorithm 3

By running Algorithm 4, the controller convergence effect can be obtained as shown in Figure 8, Algorithm 4 can still help the system to gradually optimize to the optimal controller that its actual system should have on the basis of input and output data.

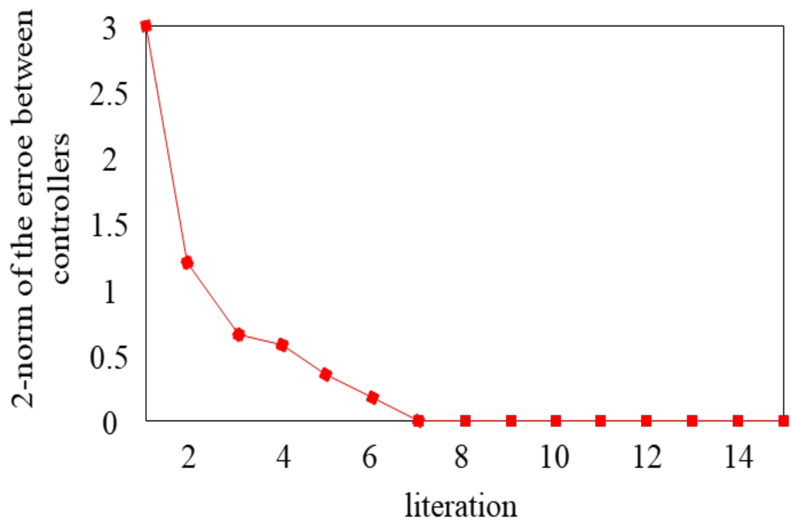

Figure 8. Convergence effect of the controller in the iterative process of Algorithm 4

Algorithm 2 can well complete the function of the online convergence algorithm. Algorithm 3 can complete the convergence off-line well, so that the controller converges successfully during the running process, which proves its effectiveness and shows that it is also a way to find the optimal controller of the system.

Finally, a controller initialized with a system with uncertain initial parameters gradually converges to the optimal LQR controller of the original system under Algorithm 4, which only uses output and input data. This proves the effectiveness and usability of its algorithm.

On the basis of the support of the above algorithms, the effect of the college student sports and health data analysis system based on the convolutional neural network algorithm proposed in this paper is verified, and the statistical data results are shown in Table 1.

Table 1. Statistical table of the effect of the college student sports and health data analysis system based on convolutional neural network algorithm

Number	System verification	Number	System verification	Number	System verification
1	88.05	13	87.52	25	88.34
2	84.55	14	89.98	26	86.57
3	88.92	15	89.87	27	85.22
4	87.08	16	90.80	28	83.08
5	86.46	17	85.17	29	83.40
6	89.93	18	88.27	30	89.34
7	87.28	19	88.06	31	83.91
8	84.44	20	83.85	32	87.16
9	90.68	21	87.85	33	86.45
10	87.35	22	85.64	34	84.10
11	86.50	23	90.70	35	85.56
12	87.55	24	89.77	36	88.91

Through the above data analysis, it is verified that the college student sports and health data analysis system based on the convolutional neural network algorithm has certain effects.

4. Conclusion

In the process of maintaining the actual health system, the definition of health terms in the existing education system still remains on the analysis of disease factors, thus ignoring the mental health and social health conditions of college students. This not only affects the effectiveness of the overall quality construction of college students, but also hinders the development of college students' ideological development, thus affecting the stability of the social and economic construction environment, and bringing great hidden dangers to the extension of the subsequent urban functional system.Therefore, it is necessary to build a perfect health maintenance system for college students according to the existing needs of urban economic construction, and make it clear that the three-dimensional health concept of talents can be effectively implemented, so as to ensure the perfect implementation of actual health work.This paper combines the convolutional neural network algorithm to analyze the college students' sports and health data, explores the correlation between college students' sports and health, and through data analysis verifies that the college students' sports and health data analysis system based on the convolutional neural network algorithm has a certain effect.

REFERENCES

Ariani, L. P. T. (2021). The effect of repetition sprint training method combined with the level of physical fitness toward the speed of 100 meter run. *International Journal of Engineering, Science and Information Technology, 1*(3), 59-63.

Artiuh, V., Kozina, Z. L., Koval, V., Safronov, D., Fomin, S., & Novikov, Y. O. (2018). Influence of application of special means of development of equilibrium and precision-target movements on the level and structure of psychophysiological indicators, physical and technical readiness of archers. *Health, sport, rehabilitation, 4*(4), 4-13.

Chang, G. (2021). Retracted article: urban air pollution diffusion status and sports training physical fitness measurement based on the Internet of things system. *Arabian Journal of Geosciences, 14*, 1-11.

Chernykh, T., Mulik, V., & Okun, D. (2019). Study of the level of physical fitness of young acrobat athletes at the initial stage of training. *Slobozhanskyi herald of science and sport, 7*(5 (73)), 27-30.

Fachrezzy, F., Hermawan, I., Maslikah, U., Nugroho, H., & Sudarmanto, E. (2021). Profile physical fitness athlete of slalom number water ski. *International Journal of Educational Research and Social Sciences (IJERSC), 2*(1), 34-40.

Kons, R. L., Franchini, E., & Detanico, D. (2018). Relationship between physical fitness, attacks and effectiveness in short-and long-duration judo matches. *International journal of performance analysis in sport, 18*(6), 1024-1036.

Kozina, Z., Sobko, I., Ulaeva, L., Safronov, D., Boichuk, Y., Polianskyi, A., & Protsevskiy, V. (2019). The impact of fitness aerobics on the special performance and recovery processes of boys and girls 16-17 years old engaged in volleyball. *International journal of applied exercise physiology, 8*(1), 98-113.

Kozina, Z. L., Cieslicka, M., Prusik, K., Muszkieta, R., Sobko, I., Ryepko, O., . . . Korol, S. (2017). Algorithm of athletes' fitness structure individual features' determination with the help of multidimensional analysis (on example of basketball). *Physical education of students*(5), 225-238.

Kravchuk, T., Sanzharova, N., Golenkova, J. V., & Katrechko, I. (2020). Influence of means of parterre gymnastics on physical fitness of young athletes in acrobatic rock and roll. *Health, sport, rehabilitation, 6*(3), 19-25.

Okun, D., & Mulyk, K. (2017). Investigation of the relationship between the indicators of physical preparedness and the basic technique elements of young water-slalom athletes. *Slobozhanskyi herald of science and sport*(5 (61)), 69-71.

Politko, O. (2018). Model characteristics of physical development and special physical preparedness of swimmers 12–15 years old. *Slobozhanskyi herald of science and sport*(2 (64)), 37-40.

Prontenko, K., Griban, G., Prontenko, V., Bezpaliy, S., Bondarenko, V., Andreychuk, V., & Tkachenko, P. (2017). Correlation analysis of readiness indicators of athletes and their competitive results in kettlebell sport.

Sarafyniuk, L., Syvak, A., Yakusheva, Y. I., & Borejko, T. (2019). Correlations of cardiointervalographic indicators with constitutional characteristics in athletes of mesomorphic somatotype. *Biomedical and biosocial anthropology*(35), 17-22.

Shalar, O., Strykalenko, Y. A., Huzar, V., Andrieieva, R., Zhosan, I., & Bazylyev, S. (2019). Influence of the maximum force indicators on the efficiency of passing the distance in academic rowing.

Silva, B., & Clemente, F. M. (2017). Physical performance characteristics between male and female youth surfing athletes. *The Journal of sports medicine and physical fitness, 59*(2), 171-178.

Titova, A., Chorniy, O., Dolgov, A., Gladyr, T., Slatvinskiy, A., Yarovenchuk, V., & Buchii, I. (2018). Parameters of biochemical control as a criteria of adaptive changes in the organism of athletes with various fitness levels engaged in the conditions of power fitness. *Ukrainian Journal of Medicine, Biology and Sports, 3*(2), 278-283.

Zalyapin, V. I. i., Isaev, A. P., Bakhareva, A. S., & Aminova, A. S. (2019). Modelling the spectral characteristics of the circulatory system of athletes-skiers. *Journal of Computational and Engineering Mathematics, 6*(4), 57-68.