Research And Analysis of Nonlinear Identification Adaptive Control of Fitness Using MATLAB Numerical Simulation

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Abstract. Aiming at the problems of non-linearity in physical exercise, difficulty in predictive model identification control, and difficulty in exercise in control target. A nonlinear identification adaptive control algorithm based on physical exercise is proposed, and a nonlinear identification adaptive control system based on physical exercise is established and simulated with MATLAB. Simulation results show that the recognition ability of physical exercise is strong, which improves the requirements of physical exercise quality, and has the advantages of simple control algorithm, high control accuracy and strong anti-interference ability.

Keywords: National Fitness, Nonlinear identification adaptive control, Research and analysis.

1. Introduction

If sports are strong, china will be strong, and if national games are prosperous, sports will be prosperous. Sports carry the dream of national prosperity and national rejuvenation [1-9]. According to the above data, the obesity detection rate of American students continues to rise, and the physical activity level of students continues to decline. Through the analysis of the current situation of students’ physique at home and abroad, it is found that physique decline is a global problem, which deserves the attention of researchers [10-19].

Most of them use the method of literature, but there is almost no investigation on the current situation of Gansu national fitness folk sports in this region [20-29]. I think that the research of national fitness promoting the high-quality development of sports industry should be combined with questionnaire survey, field survey and literature method, so as to provide more scientific and real data [30-32].

As an improved identification algorithm, Charcot's method is applied to nonlinear system, which overcomes the low accuracy of ordinary least squares method [33-36]. Moreover, the efficiency of the operation is greatly improved because the repeated filtering of the signal is removed, which is superior to the generalized least squares identification method [34-38]. In reference, the CMAC neural network
is used to model and control the system, which has the disadvantage that it is difficult to determine local minimum neural network [39-43].

A nonlinear identification adaptive control algorithm based on physical exercise is proposed, and a nonlinear identification adaptive control system based on physical exercise is established and simulated with MATLAB. Simulation results show that the recognition ability of physical exercise is strong, which improves the requirements of physical exercise quality, and has the advantages of simple control algorithm, high control accuracy and strong anti-interference ability.

2. Research objects and Research methods

2.1. Research objects
Taking the current situation of national fitness in Gansu Province as the research object, the main object is students, accounting for 78.27%. Only 16.37% of the adults, 3.05% of the children and 2.31% of the elderly. This paper mainly analyzes the background of "the development of national fitness in Gansu Province" and the ideas and ideas of system and mechanism reform and policy innovation of "promoting the high-quality development of sports industry".

2.2. Research methods
(1) Questionnaire survey method
   According to the research purpose and content needs, access to a large number of relevant information, the preliminary design of the questionnaire, after screening and adjustment, the main survey content involved in Gansu Provincial Sports Bureau responsible for National Fitness department managers.

   (2) Logical analysis
   Following the process of theoretical research, practical research, theoretical sublimation and guiding practice, this paper analyzes, summarizes and infers the survey results by combining qualitative and quantitative methods, and finally clarifies the views and finds out the countermeasures.

   Research on nonlinear identification control based on physical exercise, as is shown in Figure 1.

![Figure 1](image_url)

**Fig. 1** Research on nonlinear identification control based on physical exercise.

3. Nonlinear identification adaptive control based on physical exercise
In order to apply the linear control algorithm to control the nonlinear welding system, the feedback linearization method is adopted in this paper. The adaptive moving average control method is applied to the linear model (1) to realize the adaptive control of the laser welding process.
Suppose \( u(m-1) = \frac{-1}{b_1} \left[ b_2 \cdot u(m-2) + b_3 \cdot u(m-2) \cdot y(m-1) + b_4 \cdot u(m-3) \cdot y(m-2) + b_5 \cdot u(m-4) \cdot y(m-3) \right] \) (1)

The forgetting factor recursive least square method is used to estimate the real-time parameters. The mathematical model of controlled process can be described by controlled autoregressive moving average model (CARMA).

\[
a(q^{-1})y(t) = b(q^{-1})u(t-d) + c(q^{-1})e(t)
\]

(2)

\[
y(t) = g(q^{-1})u(t) + h(q^{-1})e(t)
\]

(3)

It can also be expressed as:

\[
y(t) = \varphi^T(t) \cdot \vartheta + e(t)
\]

(4)

The parameter vector \( \vartheta \) is \( \vartheta^T \):

\[
\vartheta^T = \begin{bmatrix} a_1, a_2, \cdots, a_n, b_1, b_2, \cdots, b_n, c_1, c_2, \cdots, c_n \end{bmatrix}
\]

(5)

The data information vector is as follows:

\[
\varphi^T(t) = \begin{bmatrix} -y(t-1), -y(t-2), \cdots, -y(t-n_s), \\
u(t-d-1), u(t-d-2), \\
\cdots, u(t-d-n_s), e(t-1), e(t-2), \cdots, e(t-n_s) \end{bmatrix}
\]

(6)

The so-called least square identification is to use the input and output data \( \{u(t), y(t)\} \) of the system to make the criterion function

\[
J(\vartheta) = \sum_{i=1}^{t} \left[ y(i) - \varphi^T(i) \cdot \vartheta \right]^2
\]

and get the estimation of the parameter \( \vartheta \).

\[
\hat{\vartheta}(t) = \hat{\vartheta}(t-1) + K(t) \{ y(t) - \varphi(t) \cdot \hat{\vartheta}(t-1) \}
\]

(7)

\[
K(t) = P(t) \cdot \varphi(t)
\]

(8)

\[
P(t-1) \cdot \varphi(t) \left( \lambda I + \varphi^T(t) \cdot P(t-1) \right) \varphi(t)
\]

(9)

\[
P(t) = \frac{1}{\lambda} \left( I - K(t) \cdot \varphi^T(t) \right) \cdot P(t-1)
\]

(10)

4. Moving average (MA)

Suppose that the mathematical model of controlled process can be described by controlled autoregressive moving average (CARMA) model. Consider the input-output model:
\[ a(q)y(k) = b(q)u(k) + c(q)e(k) \] (11)

When the following four conditions are satisfied, the moving average method can be used

\[ \det c = \det a = n \] (12)
\[ \det b = m \] (13)

\[ a, c \] are the first polynomials, where the zeros of polynomial K are in the unit circle

\[ \det(\text{det } a - \text{det } b) = 0 \] (14)

In steady state, the steady-state variance of output data is used as the objective function of control, and the performance index is \( J = E\{y^2(k)\} \); In the moving average control method, the output of the closed-loop system is designed to be of higher order, that is, the closed-loop poles are designed at the origin, where \( d \geq d_0 \).

\[ q^{d-1} \cdot b^* \cdot C = a \cdot R + b \cdot S \] (15)

Can be controlled:

\[ u(t) = -\frac{S}{R} y(t) \] (16)
\[ a \cdot y(t) = b \left( -\frac{S}{R} \right) y(t) + c \cdot e(t) \] (17)

Perhaps: \( y(t) = \frac{1}{a \cdot R + b \cdot R} \cdot \frac{e(t)}{\frac{q^{d-1} \cdot b^*}{a \cdot R + b \cdot R}} = \frac{R}{q^{d-1} \cdot b^*} \cdot e(t) = \frac{R}{q^{d-1} \cdot b^*} \cdot e(t) = \left( 1 + \frac{R}{q^{d-1} \cdot b^*} + \ldots + \frac{R}{q^{d-1} \cdot b^*} \right) \) (18)

Where: \( \text{deg } R = d - 1 \) when \( \text{deg } a - \text{deg } b^* = d \) is equal to \( a^* = 1 \), there is no zero cancellation & this simplest form will also be used in the following simulation.

5. Step of Nonlinear identification adaptive control based on physical exercise

(1) The forgetting factor recursive least square identifier is used to identify the real object. The input of the identifier is the input and output of the real object;

(2) The coefficients of the polynomial \( a, b, c \) are obtained by the identifier, so that the parameters of the controller can be adjusted on-line after time.

6. Experiment simulation and data analysis

This paper presents an algorithm of non-linear identification adaptive control based on physical exercise, establishes a control system of non-linear identification adaptive control based on physical exercise, and simulates it with MATLAB. Research on nonlinear identification control based on physical exercise, as is shown in Figure 2.
Nonlinear identification adaptive control for young people, nonlinear identification adaptive control for children, nonlinear identification adaptive control for the elderly, as are shown in Figure 3–Figure 5.

**Fig. 2** Nonlinear identification control based on physical exercise.

**Fig. 3** Nonlinear identification adaptive control for young people.

**Fig. 4** Nonlinear identification adaptive control for children.
Nonlinear identification adaptive control of physical exercise 1, nonlinear identification adaptive control of physical exercise 2, nonlinear identification adaptive control of physical exercise 3 and nonlinear identification adaptive control of physical exercise 4, as are shown in Figure 6–Figure 9.

**Fig. 5** Nonlinear identification adaptive control for the elderly.

**Fig. 6** Nonlinear identification adaptive control of physical exercise 1.

**Fig. 7** Nonlinear identification adaptive control of physical exercise 2.
7. Nonlinear identification adaptive control for young people
2- Nonlinear identification adaptive control for children
3- Nonlinear identification adaptive control for the elderly

Fig. 8 Nonlinear identification adaptive control of physical exercise 3.

Fig. 9 Nonlinear identification adaptive control of physical exercise 4.

The simulation results show that the identification method and control method are effective. At the same time, the simulation results also show that: physical exercise identification ability is strong, improve the quality of physical exercise requirements, and has the advantages of simple control algorithm, high control accuracy and strong anti-interference ability.

7. Summary
A nonlinear identification adaptive control algorithm based on physical exercise is proposed, and a nonlinear identification adaptive control system based on physical exercise is established and simulated with MATLAB. Simulation results show that the recognition ability of physical exercise is strong, which improves the requirements of physical exercise quality, and has the advantages of simple control algorithm, high control accuracy and strong anti-interference ability.

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References
[1] Xiong Fei. Interpretation of humanistic spirit of urban sports--Also on the shaping of urban sports concept in China [J]. Sports culture guide, 2007, (8).
[2] Yang Hao, Jiang Fugao. Comparison of Chinese and western sports culture [M]. Beijing: Social Science Literature Press, 2008, (10).
[3] Yu Haifeng et al. The theory of teenagers’ physical activity motivation abroad and Its Enlightenment on Physical Education [J]. Psychological science Science2008, 31(6): 1443-1445.
[4] Hu Xiaoming. Sports aesthetics [M]. Beijing: Higher Education Press, 2009, (4): 58-67.
[5] Lu Yuanzhen et al. National fitness and lifestyle [M]. Beijing: Beijing Sport University Press, 2001:75-82.
[6] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and Analysis on design and prediction model of table tennis racket based on absorbable injection molding double concave round table tennis [J]. Gansu science and technology, 2021,3,37 (5): 44-47.
[7] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and analysis of leg boasting device based on 30 degree tilt sports training [J]. Gansu science and technology, 2021,3,37 (6): 45-47.
[8] Zhang Wanjun, Zhang Feng, Zhang Jingxuan, et al. Method of cross coupling contour compensation with variable gain coefficient P for CNC machine tools [J]. Modular machine tools and automatic machining technology, 2021,08,154-158.
[9] Zhang Wanjun, Gou Xiaoping, Zhang Feng, et al. Based on the research and analysis of the income gap of rural residents in former Gansu, [J]. Gansu science and technology, 2021,2, V. 37 (3): 1-2.
[10] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and analysis of bipedal Runner Based on Sports assisted sports [J]. Gansu science and technology, 2021,2, V. 37 (4): 31-33.
[11] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and analysis of running robot control algorithm based on PID control [J]. Gansu science and technology, 2021, v.37 (11): 36-38.
[12] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and analysis of throwing trajectory curve control method based on shot put competition [J], 2021,5,37 (10): 30-32.
[13] Zhang Wanjun, Gou Xiaoping, Zhang Feng, et al. Based on the research and analysis of the income gap of rural residents in former Gansu, [J]. Gansu science and technology, 2021,2, V. 37 (3): 1-2.
[14] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and analysis of bipedal running device based on Sports Assistant [J]. Gansu science and technology, 2021,2, V. 37 (4): 131-33.
[15] Zhang Wanjun, Zhang Feng, Zhang Jingxuan, et, al. Research and analysis of nonlinear model identification control algorithm based on improved neural RBF for short term heatload forecasting of heat supply network[J].Earth and Environmental Science[J].Earth and Environmental Science, 2021,04,Vol,714 (2021) 042028.
[16] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and Analysis on the temperature and humidity performance of fruit guard apple bagging [J]. Gansu science and technology, 2021,4, V. 37 (4): 200238-43.
[17] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research and Analysis on a transparent anti hail apple bagging shell [J]. Gansu science and technology, 2021,6, V. 37 (4) 38-43.  
[18] Zhang Wanjun, Gou Xiaoping, Zhang Feng, Zhang Jingxuan, Zhang Jingyi, Zhang Jinyan. Impact of urbanization on temperature change trend in Lanzhou [J]. Gansu science and technology, 2020, v.36 (18): 71-73 + 79.
[19] Lu Yuanzhen. Comments on Chinese sports sociology [M]. Beijing: Beijing Sport University Press, 2003, (1): 277-322.
[20] Zhang Wanjun, Zhang Jingxuan, et, al. Optimization of identification structure parameters based on recursive maximum likelihood iteration [C]//Proceedings of the IEEE International Conference on Computers, Signals and systems. Dalian, 2018: 119-124.
[21] Han Xiangjing. Report on the living conditions of Chinese women in 2007 [M]. Beijing: Social Sciences Literature Press, 2007, (12): 117.
[22] Jinggeng Zhang, Wanjun Zhang, Feng Zhang, et, al Research and analysis of crop water demand model based on nonlinear identification of water fertilizer medicine integrated water saving irrigation[J].Earth and Environmental Science,2021,8,Vol. 042074:1-11.
[23] Jinggeng Zhang, Wanjun Zhang, Feng Zhang, et al. Research and analysis of adaptive nonlinear model identification control based on integrated irrigation of water, fertilizer and chemicals in greenhouse [J]. Earth and Environmental Science, 2021, 8, Vol. 452. 022061:1-11.

[24] Huoping Zhao, Wanjun Zhang and Xiaoping Gou, al. Research and analysis of on-line optimization algorithm of nonlinear model predictive control based on hydropower installation field [J]. Journal of Physics, 2020, 10, Vol. 1652: 2078-2088.

[25] Zhang Wanjun, Zhang Feng, Jingxuan, et al. Application of PLC in Pneumatic Measurement Control System [J]. Materials Science and Engineering, 2018, 8, Vol. 042074:1-11.

[26] Zhang Wanjun. An intelligent bagging robot system: cn207135689u [P]. 2018.

[27] Wu Minglong. Questionnaire statistical analysis practice - SPSS operation and application [M]. Chongqing: Chongqing University Press, Seventh Edition, July 2014.

[28] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Research on Simulation and Analysis of Monitoring Process of Hail-proof Apple Bagging Four-rotor Aircraft [J]. Materials Science and Engineering, 2019, 10, Vol. 612: 298-302.

[29] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Study on the Structure Design and Feasibility Analysis of Apple Inhaled Box Bags Based on Hailproof [J]. Earth and Environmental Science, 2018, 12, Vol. 252: 3826-3837.

[30] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Study on Quality Characteristics and Feasibility Analysis of Hailproof Plastic Bagging of 5000 Mu in Gansu [J]. Earth and Environmental Science, 2020, 3, Vol. 612: 2038-2040.

[31] Lai Yaxin. Parents' Sports expectation value belief and behavior involvement, children's perceived quality of parents' involvement and children's sports expectation value letter thinking about sports participation behavior [D]. Taiwan: Taiwan Institute of physical education, 2006.

[32] Xiang Mingqiang. Relationship between sports autonomy support and teenagers' extracurricular exercise [J]. Sports and science. 2014, 2 (35): 96-100.

[33] Gou Xiaoping. Handstand walking device: CN102641579B [P]. 2012.

[34] Zhao Bin, Gou Xiaoping, Wang Weixiang. Double concave round table tennis racket: CN201210373914[P]. 2012.

[35] Zhang Wanjun. Fruit pruning scissors: CN305145790S [P]. 2018.

[36] Zhang Wanjun. Fruit pruning scissors (automatic): CN304984483S [P]. 2019.

[37] Zhang Wanjun. Sugarcane peeler: CN304425040S [P]. 2017.

[38] Ding Weiwai, Mao Zhixiong. Application of self-determination theory in the promotion of middle school students' exercise behavior [J]. Journal of Beijing University of physical education 2014.5: 84-91

[39] Fu Guifang, Xiang Mingqiang. Construction of motivation path model for urban residents to participate in physical exercise [J]. Psychological science, 2013, 36 (5): 1048-1053.

[40] Gou Xiaoping, Zhang Wanjun, Zhang Feng, et al. Study and analysis of Bagging Fruit Characteristics Based on apple bagging* - Taking apple bagging in Southeast Gansu Province as an example [J]. Gansu science and technology, 2021, 4, V. 37 (4): 200238-43.

[41] Zhang Wanjun, Gou Xiaoping, Zhang Feng, et al. Research based on quantitative analysis of land use structure in Qingyang City [J]. Gansu science and technology, 2020, v.36 (19): 60-62.

[42] Dong Hongwei. Influence and reflection of family social capital on Teenagers' physical exercise consciousness and behavior [J]. Journal of Shenyang Institute of physical education, 2010, 29 (2): 33-37.

[43] Chen Baoling, Lu Yuanzhen. The influence of family on College Students' sports consciousness and behavior [J]. Sports culture guide, 2008100-103.