Research and analysis of maximum likelihood recursive identification algorithm based on physical exercise behavior of obese children

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Abstract. With the decrease of physical activity, children's health problem will become an urgent problem in building a well-off society in an all-round way. There are differences in the safe heart rate of children with different physique when they exercise. This paper studies the suitable heart rate of children with different physique. Based on a maximum likelihood recursive algorithm for obese children's physical exercise behavior, a model recognition system based on the maximum likelihood recursive algorithm for obese children's physical exercise behavior is established. Finally, through MATLAB simulation analysis, the results show that the model recognition of MLR algorithm is consistent with the actual results, and the simulation results verify the feasibility and effectiveness of MLR algorithm.

Keywords: Nonlinear system, maximum likelihood recursive identification, identification algorithm, research and analysis.

1. Introduction

The results of physical fitness and health test of Chinese students in 2020 show that: compared with 2015, the obesity rate of 7-18-year-old students increases from 5.9% to 10.1% for urban boys, from 3.0% to 4.9% for girls, from 1.6% to 3.7% for rural boys and from 1.2% to 2.4% for girls [1-3]. Among them, 7-12-year-old primary school students have the highest incidence of obesity, especially in Beijing, Shanghai, Nanjing and other major cities. It is a healthy and effective way for parents and teachers to have a deep understanding of the inducing factors, pathogenesis and clinical manifestations of children's simple obesity, and to take scientific exercise as the main and reasonable diet as the auxiliary to prevent and intervene children's simple obesity [4-7].

System identification, state estimation and control theory are three pillars of modern control theory. System identification is one of the branches, the three pillars are mutual penetration, mutual complement and mutual support. The control theory needs the mathematical model and state estimation technology of the controlled object to play a greater role [8-11].
At present, the development trend of identification is that it has stronger adaptability to nonlinear system, time-varying system and online identification [12-14] which makes the identification accuracy high, convergence fast, time less, global optimization ability and anti noise ability stronger.

In this paper, based on a maximum likelihood recurrence algorithm for obese children's physical exercise behavior, a model recognition system based on the maximum likelihood recurrence algorithm for obese children's physical exercise behavior is established. Finally, through MATLAB simulation analysis, the results show that the model recognition of the maximum likelihood recurrence algorithm for obese children's fitness heart rate is consistent with the actual results, and at the same time, it is simulated The real results verify the feasibility and effectiveness of the MLR algorithm.

2. Research object and method

2.1. Research object
In the data of the National Students' common diseases and influencing factors in the urban monitoring points of Qingyang city in 2016, stratified cluster random sampling method was used to select 2 primary schools, junior high schools and senior high schools. Grade 4~6 of primary schools and grade 1~3 of junior high schools were selected. 1526 students (512 of primary schools,514 of junior high schools and 50 of senior high schools) were selected by class as the unit 0;705 boys and 821 girls).

2.2. Research methods
The investigators were trained by CDC and the students completed the questionnaire independently. The effective rate of the questionnaire was 96.6% (1526/1579). The contents of the questionnaire include diet habit, exercise behavior and sleep.

3. Principle and method of maximum likelihood recurrence algorithm
In fact, newton Raphson method is a recursive method which can be used for on-line identification. But this method needs to collect a batch of L-length system input and output observation data every time, that is, each batch of data needs L times of observation, and then carry out a recurrence according to L times of observation data. In this section, we will discuss a recursive algorithm for calculating the parameter estimates for each observation. In essence, it is only an approximate maximum likelihood method.

Consider the following model

\[ A(z^{-1}) \cdot z(k) = B(z^{-1}) \cdot u(k) + D(z^{-1}) \cdot v(k) \]

(1)

In the formula: \( u(k) \) and \( v(k) \) are the input and output of the system; \( \{v(k)\} \) is the uncorrelated random noise sequence with the mean value of zero and variance \( \sigma_v^2 \). Order:

\[
\begin{align*}
A(z^{-1}) &= 1 + a_1 z^{-1} + a_2 z^{-2} + \cdots + e_n z^{-n_z} \\
B(z^{-1}) &= b_1 z^{-1} + b_2 z^{-2} + \cdots + b_n z^{-n_z} \\
D(z^{-1}) &= 1 + d_1 z^{-1} + d_2 z^{-2} + \cdots + d_n z^{-n_z} \\
\theta &= \left[a_1 \cdots a_n \right] \left[b_1 \cdots b_n \right] \left[d_1 \cdots d_n \right] \\
\end{align*}
\]

(2)

Then the maximum likelihood problem of the model (2) is to find the parameters, so that:

\[ J(\theta, k) \approx J(\theta, k-1) + \frac{1}{2} \nu^2(k) \]

(3)
In the formula:

\[
\begin{align*}
\frac{\partial v(k)}{\partial a_j} &= \left[ \hat{D}(z^{-1}) \right]^{-1} \cdot z^j \cdot z(k) = z^j \cdot z_j(k) \\
\frac{\partial v(k)}{\partial b_j} &= -\left[ \hat{D}(z^{-1}) \right]^{-1} \cdot z^j \cdot u(k) = z^j \cdot u_j(k) \\
\frac{\partial v(k)}{\partial d_j} &= \left[ \hat{D}(z^{-1}) \right]^{-1} \cdot z^j \cdot v(k) = -z^j \cdot \hat{v}_j(k)
\end{align*}
\] (4)

In the formula: \( z_j(k) \), \( u_j(k) \) and \( \hat{v}_j(k) \) represent the filtering values of \( z(k) \), \( u(k) \) and \( \hat{v}(k) \) respectively, meeting the following relationships:

\[
\begin{align*}
z_j(k) &= \left[ \hat{D}(z^{-1}) \right]^{-1} \cdot z(k) \\
u_j(k) &= \left[ \hat{D}(z^{-1}) \right]^{-1} \cdot u(k) \\
\hat{v}_j(k) &= \left[ \hat{D}(z^{-1}) \right]^{-1} \cdot \hat{v}(k)
\end{align*}
\] (5)

Or written:

\[
\begin{align*}
z_j(k) &= z(k) - \hat{d}_1 \cdot z_j(k-1) - \cdots - \hat{d}_n_z \cdot z_j(k-n_z) \\
u_j(k) &= u(k) - \hat{d}_1 \cdot u_j(k-1) - \cdots - \hat{d}_n_z \cdot u_j(k-n_z) \\
\hat{v}_j(k) &= \hat{v}(k) - \hat{d}_1 \cdot \hat{v}_j(k-1) - \cdots - \hat{d}_n_z \cdot \hat{v}_j(k-n_z)
\end{align*}
\] (6)

So the vector \( \mathbf{h}_j(k) \) is written as:

\[
\mathbf{h}_j(k) = [-z_j(k-1), \cdots, -z_j(k-n_z), u_j(k-1), \cdots, u_j(k-n_z), \hat{v}_j(k-1), \cdots, \hat{v}_j(k-n_z)]^T
\] (7)

Through the MATLAB simulation analysis, the results show that the method is suitable for children's running safety heart rate and physical quality. The simulation results verify the feasibility and effectiveness of the method.

4. Results and analysis

In this study, two sets of data were obtained by real-time measurement of the motion angle at the knee joint of the robot with motion capture instruments. The dotted line represents the planned gait trajectory and the solid line represents the measured gait trajectory.

Test experiment simulation diagram 1, 2 and 3, as is shown in Fig1, Fig.2 and Fig.3.
Figure 1. Test experiment simulation diagram 1.

Figure 2. Test experiment simulation diagram 2.

Figure 3. Test experiment simulation diagram 3.
Through MATLAB simulation analysis, the results show that the model recognition of the maximum likelihood recurrence algorithm for obese children's fitness heart rate is consistent with the actual results, and at the same time, it is simulated. The real results verify the feasibility and effectiveness of the MLR algorithm.

5. Summary
In this paper, based on a maximum likelihood recurrence algorithm for obese children's physical exercise behavior, a model recognition system based on the maximum likelihood recurrence algorithm for obese children's physical exercise behavior is established. Finally, through MATLAB simulation analysis, the results show that the model recognition of the maximum likelihood recurrence algorithm for obese children's fitness heart rate is consistent with the actual results, and at the same time, it is simulated. The real results verify the feasibility and effectiveness of the MLR algorithm.

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