Research and analysis of the control system based on sports running device to assist coaches to adjust speed adaptively

Bin Zhao¹, Decheng Liu¹, Jianping Liu¹& Wanjun Zhang²,³, *, Xiaoping Gou¹,
Feng Zhang¹
¹School of Physical Education, Longdong University, Qingyang 745000, China
²Gansu ZeDe Electronic Technology Company Limited, Gansu 741003, China
³Lanzhou Industry and Equipment Company Limited, Gansu 730050, China.

*Corresponding author e-mail: gszwj_40@163.com

Abstract. In this paper, an algorithm of adaptive speed control based on Sports runner assisted coach is proposed, and the control system based on Sports runner assisted coach adaptive speed regulation is established and simulated with MATLAB. The simulation results show that the test curve of the self-adaptive speed regulation of the sports running device is basically consistent with the actual situation of the auxiliary training device, with good stability and strong usability, which meets the requirements of sports running. At the same time, it also has a strong reference significance for the physical education teaching and training in other places.

Keywords: Sports runner; Adaptive speed regulation; Control system; Research and analysis.

1. Introduction
The speed regulation of sports auxiliary trainer has higher requirements for the dynamic characteristics and faster response speed of the system [1-3]. There are many uncertain factors in the climbing process of athletes. The speed regulation effect of the single closed-loop negative feedback control system [4-5] of the traditional control strategy is not ideal. Physical training assisted robots have been studied for decades in foreign countries, and many commercial mobile products have been launched so far.

The core of the driving part of the auxiliary robot studied in this paper is the BLDCM, which can meet the general functions of the upper and lower buildings, with lower cost and higher cost performance[6]. The commonly used speed control methods of BLDCM include PID control, cross coupling control [7-9], fuzzy control, optimal control[10], etc. Zhang Wanjun, professor level senior engineer, senior economist and doctor of Gansu Zede Electronic Technology Co., Ltd., has studied some model identification control systems [11] sports training assistant robots.

In this paper, an algorithm of adaptive speed control based on Sports runner assisted coach is proposed, and the control system based on Sports runner assisted coach adaptive speed regulation is established and simulated with MATLAB. The simulation results show that the test curve of the self-adaptive speed regulation of the sports running device is basically consistent with the actual situation of the auxiliary training device, with good stability and strong usability, which meets the requirements
of sports running. At the same time, it also has a strong reference significance for the physical education teaching and training in other places.

2. Algorithm of adaptive speed control

In order to simplify the research model, it is assumed that the three-phase winding of the motor is completely symmetrical, without considering eddy current and hysteresis loss. Its core is a BLDCM. In order to simplify the research model, it is assumed that the three-phase winding of the motor is completely symmetrical, without considering eddy current and hysteresis loss. Electronic torque generated by stator winding:

\[
\begin{align*}
U_a &= R_a i_a(t) + L_{aN} \frac{di_a}{dt} + L_{ab} \frac{di_b}{dt} - K_m \omega \sin(Z, \theta) \\
U_b &= R_b i_b(t) + L_{bN} \frac{di_b}{dt} + L_{ba} \frac{di_a}{dt} + K_m \omega \cos(Z, \theta)
\end{align*}
\]

In the formula: Among them, \(i_a\) and \(i_b\) are the two-phase winding current respectively; \(K_m\) is the back EMF coefficient; \(U_a\) and \(U_b\) are the terminal voltage; \(L_{aN}\) and \(L_{bN}\) are the self inductance of two-phase winding, generally \(L_{aN} = L_{bN} = L\); generally \(R_a = R_b = R\); \(\omega\) is the motor speed.

The rotor motion equation of two-phase hybrid stepping motor is as follows:

\[
T_e = J \frac{d\omega}{dt} + B \cdot \omega + T_L
\]

From formula (2): \(T_e\) is the electromagnetic torque; \(J\) is the moment of inertia; \(T_L\) is the load torque; \(B\) is the viscous damping coefficient.

\[
J \frac{d\omega}{dt} + B \cdot \omega + T_L + K_m i_a \cdot \sin(Z, \theta) - K_m i_b \cdot \cos(Z, \theta) = 0
\]

The torque equation of two-phase hybrid stepping motor is as follows:

\[
T_e = -K_m i_a \cdot \sin(Z, \theta) - K_m i_b \cdot \sin(Z, \theta - \frac{\pi}{2})
\]

Or it can be expressed by the inductance current equation

\[
T_e = \frac{1}{2} \sum \frac{\partial L_{ij}}{\partial \theta} i_j i_j + \frac{1}{2} \sum \frac{L_{jk}}{\partial \theta} i_j i_k \quad (j = a, b, c; k = a, b, c; j \neq k)
\]

\[
J \frac{d\omega}{dt} + B \cdot \omega + T_L + \begin{pmatrix} f' \cdot J + k_1 \cdot L'- \frac{L'}{k_i} \\ k_1 \cdot \omega + \frac{L'}{k_i} \end{pmatrix} + \begin{pmatrix} f' \cdot \omega + \frac{L'}{k_i} \end{pmatrix} + \begin{pmatrix} f' \cdot \omega + \frac{L'}{k_i} \end{pmatrix}
\]

\[
L_{ij} \quad \text{and} \quad L_{jk} \quad \text{are the self inductance and mutual inductance of each phase respectively, and the higher harmonic composed of average component and basic component is ignored.}
\]
3. Adaptive speed control system

The single closed-loop negative feedback control of the speed of BLDCM can ensure that the system has no static difference under the steady-state condition, but it can not control the current or torque dynamic process of the motor according to the needs, which is mainly used in the situation of low dynamic characteristics. The control system structure diagram of the driving part of the sports auxiliary trainer is shown in Figure.1.

![Fig. 1 Control system structure diagram of the driving part of the sports auxiliary training device.](image)

4. Experimental analysis and research

In this experiment, the rated speed of the motor is 3000r/min. When the reduction ratio is 1:150, the expected wheel speed is 20 R/min. The total weight of the sports assistive trainer is about 50 kg, and the weight of the crew is set to 80 kg. The sum of the masses is about 130kg, the gravity g is 130n, and the horizontal distance d from the supporting point of the connecting rod to the vertical line of the center of gravity of the sports auxiliary training device is about 0.1M. Therefore, in this simulation test, when no one is riding, the load torque of the motor is about 0.33n·m, and the load torque is about 0.87n·m when riding.

4.1. Matlab simulation

A control system based on the speed regulation of sports auxiliary trainer is simulated by MATLAB. Matlab simulation diagram, as shown in Figure.2.

![Fig. 2 Matlab simulation diagram.](image)

4.2. Comparison between test curve and actual curve of auxiliary trainer

The tracking accuracy (position) error curve of neuron adaptive PID control for sport assisted robot is shown in Figure 3-4.
The simulation results show that the test curve of the self-adaptive speed regulation of the sports running device is basically consistent with the actual situation of the auxiliary training device, with good stability and strong usability, which meets the requirements of sports running. At the same time, it also has a strong reference significance for the physical education teaching and training in other places.

4.3. Actual test experiment

The experiment was carried out by Gou Xiaoping, associate professor of physical education in Longdong college. The analysis of experimental data was carried out by Zhang Wanjun, senior engineer, senior economist and doctor of Zede Electronic Technology Co., Ltd. of Gansu Province. The photo of the actual test of the auxiliary trainer is shown in Figure 5.
5. Summary

In this paper, an algorithm of adaptive speed control based on Sports runner assisted coach is proposed, and the control system based on Sports runner assisted coach adaptive speed regulation is established and simulated with MATLAB. The simulation results show that the test curve of the self-adaptive speed regulation of the sports running device is basically consistent with the actual situation of the auxiliary training device, with good stability and strong usability, which meets the requirements of sports running. At the same time, it also has a strong reference significance for the physical education teaching and training in other places.

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