Human Body Motion Trajectory Tracking Control Based on Improved Genetic Algorithm

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Abstract

By accurately tracking the movement of human trajectory, we can effectively improve the accuracy of human path planning and autonomous positioning. The human system is a multivariable nonlinear system, and the traditional genetic algorithm is used to track the steady-state tracking error at the boundary layer by the trajectory tracking control of the motion trajectory. Aiming at the above problems, we propose an improved trajectory tracking control algorithm based on the improved genetic algorithm. The spatial model of the human movement trajectory is abstracted as the virtual world of the genetic population, and then we can obtain the grid structure model of the human movement space. In order to make the human trajectory control satisfy the matching condition of the genetic algorithm and reduce the error caused by the perturbation of the parameter, a tracking term of the tracking error is designed on the slip surface of the human motion trajectory. In this paper, the simulation results show that the proposed algorithm can be used to find the optimal path with fast convergence speed. The accuracy and convergence of human tracking control performance are better and the performance is superior.

Keywords: human body motion trajectory control, improved genetic algorithm.

1. INTRODUCTION

The main part of the sensing devices and other components is related to the outside environment and operating information perception according to a command signal sent by the control system, and a set position, speed and acceleration (Lacevic, 2007). The human control system can be divided into point control, continuous trajectory control and force control. In the process of walking and homework, people need to track and control the movement of human trajectory effectively (Yang, 2016). It can not only improve the accuracy of human path planning and autonomous positioning, but also improve the ability of people to avoid obstacles. Research on trajectory tracking control method is an important branch of human discipline, and the relevant algorithm has been the majority of experts in the field of human control attention (Zhou, 2014).

Traditional human motion trajectory tracking control algorithm, which is based on the particle filtering, is divided into the decomposition of trajectories and paths offset correction path tracking control algorithms and evolution algorithm based trajectory tracking control algorithm, wherein the human genetic algorithm-based control algorithm is more commonly used (Gath, 2001). A reinforcement learning algorithm based on neural network is proposed and applied to human trajectory correction and tracking control, which can be applied to the problem of obstacle avoidance. Reinforcement learning algorithms based on neural networks has a certain significance combined with intelligent control structure applied to the path of movement of people and trajectory tracking control algorithm to artificially model, but the model is not sufficiently detailed. In addition, it can fully reflect people's simultaneous localization and the path planning features, and the tracking control performance is not good (Vinodh, 2014).

In order to improve the human motion process to track the trajectory in real time, we propose a human motion trajectory tracking control algorithm based on the improved genetic algorithm (De Filippis, 2014). Firstly, the design of the human environment model and the parameter setting are constructed, and the attitude information control model under the motion state is designed. In order to solve the problem of steady-state tracking error in the boundary layer, we study the integral term of tracking error on the trajectory of human motion trajectory. The improved genetic evolutionary algorithm is used to improve the tracking algorithm of human motion.
trajectory. In addition, simulation results show that the algorithm has the advantages of improving the accuracy and the performance of human motion trajectory tracking control (Salari, 2014).

2. DESIGN OF HUMAN’S SPORTS ENVIRONMENT MODEL AND CONSTRUCTION OF PARAMETER SYSTEM

2.1 Design of Human Sports Environment Model

In this paper, we used to simulate the modeling of quantum genetic evolution system in microscopic field. The spatial coordinates of human motion trajectory are abstracted into the virtual world of genetic population by using the modeling method of bottom-up agent (Song J, 2011). The grid structure model of human motion space is shown in figure 1.

![Figure 1. The Grid Structure Model of Human Motion Space](image)

In the grid structure model of human motion space in figure 1, the human motion space can be expressed by a macroscopic and microscopic organic connection plane rectangular coordinate system (Silva L W T, 2014). The human path optimization and trajectory tracking control problem is usually composed of n decision variables. The multi-information fusion model is expressed as follows,

$$\min \ F(x) = [f_1(x), f_2(x), \ldots, f_m(x)]$$

s.t. \quad g_i \leq 0, \quad i=1,2,\ldots,q$$

$$h_j = 0, \quad j=1,2,\ldots,p$$

(1)

It can be seen that the person is a nonlinear system that requires a linearization of the human control equation. In the range of small angle, \( \sin \theta_p = \theta_p \) and \( \cos \theta_p = 1 \). Considering the nonlinear characteristics and uncertainties of the model, we obtain the human two-dimensional motion space \( V_2 \). The different parameters can be obtained as follows.

$$X_{RL} = R\theta_{RL}$$

$$X_{RR} = R\theta_{RR}$$

$$Y_p = L\cos \theta_p$$

$$Y_p = \theta_p L\sin \theta_p$$

$$X_{RR} + X_{RL} = 2R_{RM}$$

(2)

$$V_2 = \left\{ p(x, y) \mid x \in (0, width), y \in (0, height), x, y \in \mathbb{N} \right\}$$

(3)
Among them, width × height is the domain of the definition of the coordinates. Because the computer can only deal with the discrete information, the human environment of the human movement is also a nonlinear coupling of the discrete control system.

2.2 Human motion trajectory tracking control parameter description

Based on the construction of the grid structure model in the human movement space, the environmental parameter model of human trajectory tracking control is analyzed (Chen N, 2009). According to the classical genetic algorithm, people in the path planning can find the target point and move through the genetic evolution of the way. The sensor collects a certain amount of external data for information analysis and control. It is assumed that the posture quantization feature of the moving fuzzy logic control unit control system at time t is N random samples,

$$
\eta = \frac{a}{a+b+c} \left( \frac{E[M_A]}{E[V_A]} + \frac{E[M_B]}{E[V_B]} \right)
$$

Suppose that \(x_t\) is the motion information at time t in motion; \(w_t\) is the weight vector of \(w_i\) moment in longitudinal motion; \(d_{i,t} \), \(i = 0, ..., t\) is the linear disturbance data value measured at 0 to t time. Human motion and human motion trajectory control equations are expressed in discrete form. For the \(t = 0, 1, ..., k\) corresponding genetic evolution measurement \(Z_k = \{z_0, z_1, ..., z_k\}\), the zero potential surface is chosen as the plane of the two movements. The kinetic energy \(T\) and the potential energy \(V\) of the human control system are expressed as follows,

$$
T = \frac{1}{2} M_{RL} R^2 + \frac{1}{2} M_{RR} R^2 + \frac{1}{2} J_{RL} \theta^2
$$

$$
V = M_p gL \cos \theta_p
$$

$$
E[M_A] = E[V_A] = \frac{1-p}{p}
$$

In the formula, \(M\) is the obstacle to block the main direction in the trajectory of the human movement; \(V_A\) represents the measurement error; \(P\) is the human body center of the gravity. Through the above-mentioned human motion trajectory tracking control parameter description, the human motion trajectory tracking control provides the data foundation.

3. IMPROVED GENETIC CONTROL ALGORITHM

Based on the above-mentioned human space design and parameter setting, the human trajectory tracking control design is carried out (Abe A. 2016). Aiming at the shortcomings of the traditional methods, this paper presents a human motion trajectory tracking control algorithm based on the improved genetic algorithm. Firstly, we construct three state space equations in the virtual world of genetic space,

$$
\begin{align*}
\left( M_{RL} R^2 + J_{RL} + \frac{1}{4} M_p R^2 + \frac{R^2}{D^2} J_{pD} \right) \theta_{RL} + \left( \frac{1}{4} M_R^2 - \frac{R^2}{D^2} J_{pD} \right) \theta_{RR} &+ \frac{1}{2} MRL \theta_p = C_L \\
\frac{1}{2} MRL \theta_{RL} + \frac{1}{2} MRL \theta_{RR} + \left( J_{pD} + M_L^2 \right) \theta_p & = M_p g L \theta_p - \left( C_L + C_R \right)
\end{align*}
$$
Analysis of the control process can be seen that the state of the human body \( \delta \) and the state \( X_{RM} \) are uncorrelated. Thereby we can define the system tracking error \( ex = x - x_d \) where \( X_d, \theta_d \) are the reference signals. The human mobile position reliability expression is as follows,

\[
P(Y) = \frac{\exp\left\{-\beta \sum V(Y)\right\}}{\sum_y \exp\left\{-\beta \sum V(Y)\right\}}
\]

(9)

![Figure 2. Trajectory tracking control model](image)

As shown in figure 2, the trajectory tracking control model is given in details. According to the Bayesian theorem, it is necessary to design an integral term of the tracking error on the human motion trajectory in order to make the human trajectory control satisfy the matching condition of the genetic algorithm and the error caused by the parameter change. The genetic evolutionary switching control law of human trajectory can be written as an easy to understand the formula. The human system performs the trajectory tracking control under the action of the control law, and obtains the recursive calculation expression of the human mobile position reliability,

\[
P(y_{n3} \mid x_{n3}, \theta, \beta) \propto P(y_{n3} \mid x_{n3}, \theta) P(y_{n3} \mid \beta)
\]

(10)

The human trajectory is based on the quantum chromosome quantum to generate a new individual for the probability range and perform quantum coding. The measured data is independent of its past measured value.

\[
g(x_i, y_i \mid \mu_k, \sigma_k) = \prod_{k=1}^{K} \frac{1}{\sqrt{2\pi\sigma_k^2}} \exp \left\{ -\frac{(x_i - \mu_k)^2}{2\sigma_k^2} \right\}
\]

(11)

The control law of human trajectory tracking control is obtained as follows,

\[
u = u_{eqx} + u_{eqv} + u_{sw}
\]

(12)
The control error of the whole system is as follows,

\[ P(x_{wz}, y_{wz} | \Theta) = \prod_{x} \prod_{k} \alpha_k g(x_y, y_y | \mu_k \sigma_k^2) \]  

Through the above analysis, it can be seen that the improved genetic evolution algorithm is used to overcome the shortcomings of the conventional sliding mode control in the motion trajectory control with high error and no stability. According to the above algorithm, an improved human motion tracking control algorithm based on genetic evolution is proposed. The realization process of the improved algorithm is shown in figure 2.

4. SIMULATION EXPERIMENT AND RESULT ANALYSIS

In order to test the performance of the algorithm in the realization of human trajectory tracking control, the simulation experiment is carried out. The host used in this lab is configured as Pentium (R) DCPU 2.80GH, 2.79GHz, 2.00GB memory. The simulation scene of the human movement space is in the 300 × 300 two-dimensional plane as shown in figure 1. According to the simulation scene design, the trajectory tracking control is carried out. In the same simulation time, we can obtain the approximate shortest path between the starting point and the ending point of the genetic evolutionary coordinate. And we choose the parameters in accordance with the Wilensky model, that is, the size of the environment is select as 71 × 71, and the number of genetic evolution is set to 120. Then, we mark the model to find the shortest path to spend time, get genetic evolution control process and the human movement trajectory tracking location map as shown in figure 3.

![Image](image_url)

**Figure 3.** Improved tracking results of genetic algorithms

It can be seen from the results in figure 3 that the optimal path can be found at a faster convergence rate in the trajectory tracking control, and the accuracy and convergence of the path tracking control performance are better.

5. CONCLUSIONS

Aiming at the above problems, we propose an improved trajectory tracking control algorithm based on the improved genetic algorithm. The spatial model of the human movement trajectory is abstracted as the virtual world of the genetic population, and then we can obtain the grid structure model of the human movement space. In order to make the human trajectory control satisfy the matching condition of the genetic algorithm and reduce the error caused by the perturbation of the parameter, a tracking term of the tracking error is designed on the slip surface of the human motion trajectory. In this paper, the simulation results show that the proposed algorithm can be used to find the optimal path with fast convergence speed. The accuracy and convergence of human tracking control performance are better and the performance is superior.
REFERENCES


