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Optimization for Kinematics Accuracy Reliability of Beating-up Mechanism of High-speed Rapier Loom

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Abstract

The problems of reliability, stability and kinematics accuracy of domestic high-speed rapier loom are urgent to be solved. For the limitations of used methods of solving kinematics accuracy reliability, the mathematical solution model and index of kinematics accuracy reliability of beating-up mechanism were established based on the geometrical principle of reliability index. The particle swarm optimization was improved. Then using improved particle swarm optimization, the kinematics accuracy reliability of beating-up mechanism of high-speed rapier loom was optimized. The computational precision and effectiveness of solving are both improved. Thus a new valid method is provided for the solution of kinematics accuracy reliability of beating-up mechanism of high-speed rapier loom.

Keywords: Beating-up Mechanism; Kinematics Accuracy Reliability; Conjugate Cams; Reliability Index; Improved Particle Swarm Optimization

1 Introduction

With the development of high-speed rapier loom, its high precision, high speed and high automation have become more and more important. Kinematics accuracy reliability has been gradually emphasized. However, its theories and methods are still very deficient. At the present, the main study methods are Taylor expansion method [1], Monte-Carlo method [2], function substitution method [3] and probability density evolution method [4]. The Taylor expansion method is a common method to solve kinematics accuracy reliability. This method which needs to get the first order and higher order partial derivative of the state functions generally is difficult to solve high-dimension and advanced non-linear problems. For the research on reliability theory of beating-up mechanism of high-speed rapier loom shown as Fig. 1, it is very essential to search for high-precise, fast, effective and easy handled methods to solve the kinematics accuracy reliability. Combined with the advantages of particle swarm optimization including easy parameter setting, fast convergence speed and high precision, a new method of solving the kinematics accuracy reliability of high-speed rapier loom was proposed by improving the basic particle swarm optimization with

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introducing inertia weight parameter, and the kinematics accuracy reliability of conjugate cams beating-up mechanism was analyzed and tested.

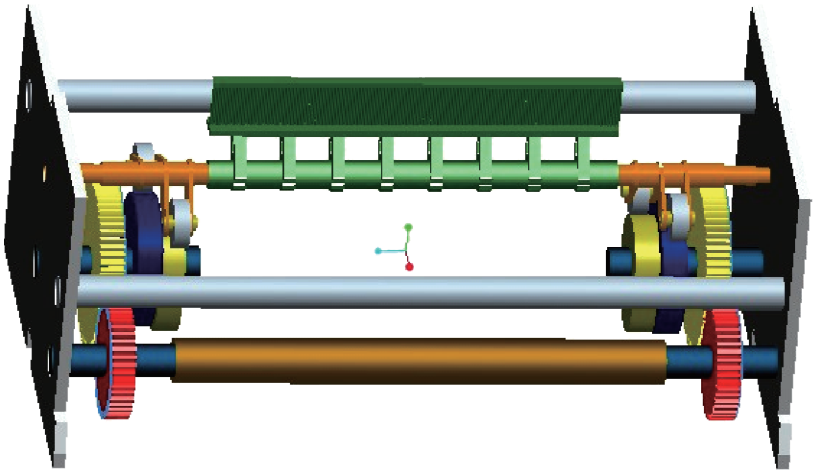

Fig. 1: Parameterized model of beating-up mechanism

2 Improved Particle Swarm Optimization

2.1 Particle Swarm Optimization

Particle Swarm Optimization was proposed in 1995 by Eberhart, an American electrical engineer and Kennedy, an American social psychologist, which was an optimization algorithm to simulate the intelligent behaviors of biotic population [5, 6]. The algorithm stemmed from the simulation study to social systems of birds by Reynolds in 1987, which was also a Complex Adaptive System (CAS). In PSO, the feasible solution of each optimization problem can be imagined as a single particle in a search space. The particle flies in the space with a fixed speed, which decides the direction and distance of its flight. Each particle is offered an adaptive value by optimization function, which is searched by following the current optimized particle in the space. The algorithm generates a set of initial population randomly and finds an optimal solution by a step-by-step iteration. Each particle updates itself by tracing two extremes and finally searches the optimal solution.

Its mathematical description [7] is as follows: supposing the population search space as D-dimension, the number of particles as N; the space location of the particle i is $X_i = (x_{i1}, x_{i2}, \cdots, x_{iD})$, and the optimal location is $P_i = (p_{i1}, p_{i2}, \cdots, p_{iD})$, the flight speed of the particle is V_i=$(v_{i1}, v_{i2}, \cdots, v_{iD})$; the optimal location searched by all the particles in the population by the current time is $P_g = (p_{g1}, p_{g2}, \cdots, p_{gD})$; as to each generation, its D-dimension evolves by the following formula:

$$v_{id}(k+1) = v_{id}(k) + c_1 \times r_1 \times (p_{id} - x_{id}(k)) + c_2 \times r_2 \times (p_{gd} - x_{id}(k)) \quad (1)$$

$$x_{id}(k+1) = x_{id}(k) + v_{id}(k+1) \quad (2)$$

In which, k is the current number of iteration; c_1 and c_2 are learning factor or acceleration factor, nonnegative constant, used to adjust the flight step of the particle; r_1 and r_2 are random