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Electromechanical Integration Construction of Automobile Inspection Equipment Based on Particle Swarm Optimization

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Abstract: Based on particle swarm optimization (PSO), this paper studies the mechatronics design method of automobile inspection equipment. Firstly, the basic theoretical knowledge of CANSYB and its operation principle are introduced. Secondly, the PSO algorithm is analyzed, improved and verified for applicability, and the effective parameters are selected as test variables and combined with the objective function to build a complete system structure model. Finally, the real-time dynamic performance of the vehicle monitoring equipment under the simulated experimental environment is realized on the Matlab platform using MATLAB software, so as to obtain the required data. The test results show that the improved PSO algorithm can effectively save the material cost, and the stator copper consumption of small three-phase asynchronous motor can be saved by 8% on average; the silicon steel consumption is saved by 3% on average. At the same time, the improved PSO algorithm not only reduces the number of iterations in the optimization process, but also has a strong distributed ability. At the same time, the random search nature of the PSO algorithm makes the function not easy to fall into local optimization, so as to ensure that the best optimization effect can be achieved.

1. Introduction

With the rapid growth of social economy, car ownership is also increasing, which has brought a series of problems, such as traffic congestion, frequent traffic accidents, etc. In order to alleviate the increasingly serious road traffic pressure and protect the life safety of drivers, it has become one of the topics that need to be solved urgently to consider how to improve the drivers and passengers to better ride the equipment to reduce the probability of accidents. As the most widely used and widely used functional device, the sensor is also the most researched electromechanical device, which plays a very important role in optimizing vehicle performance [1-2].

Many scholars have carried out relevant research on vehicle inspection equipment. Foreign

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experts and scholars have mainly studied the moving objects, and they found that when there are multiple moving objects, they can search the same location through different kinds of particles in the same place. American scholars put forward a multi parameter identification method that has good separation performance, anti fatigue and robust characteristics, and less interference ability, and can be used in combination with other equipment (such as radar system) without affecting the effect of motion control, that is, dynamic random process characteristics with strong repeatability, high accuracy and stability [3-4]. Domestic scholars have done a lot of research on vehicle detection equipment. In order to solve the problem of mutual influence between sensors, some scholars have proposed many Doppler effect analysis technologies with strong practicability, high effective and reliable performance, strong ability to adapt to various complex environments and low cost. Some scholars have studied the electromechanical system of vehicle detection equipment using PSO algorithm and designed an auto disturbance rejection strategy with good robustness [5-6]. Therefore, based on PSO algorithm, this paper studies the mechatronics of automobile detection equipment.

In automobile inspection, there are many defects due to traditional manual operation, such as high failure rate and low efficiency. In order to solve these problems and improve the diagnostic speed and accuracy. In this paper, an aircraft assembly system algorithm based on machine vision is proposed to carry out real-time automatic tracking, identification and positioning function test experimental research on vehicles, and it is verified that the method can effectively meet the requirements of electromechanical performance indicators of vehicle detection equipment, and has good adaptability, which can provide some technical support for its growth in the future.

2. Discussion on Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

2.1. Vehicle Testing Equipment

With the continuous improvement of computer processing capacity and the rapid growth of relevant theoretical research fields such as artificial intelligence algorithms, the vehicle detection equipment is mainly composed of sensors and actuators, among which the executive components include the engine speed signal acquisition module, ECU, master control unit (STC12C4S7) and peripheral circuit boards, which are one of the most important core parts of the device operation [7-8]. The vehicle detection equipment refers to the system for real-time monitoring of vehicle driving status, which consists of three parts: hardware, software and application management system. The former is vehicle mounted device (or instrument), and the latter is hardware, which can identify and judge certain targets, and realize automatic control and regulation functions of the system through certain technical methods on the basis of analysis. On board equipment is called worktable, control platform, measuring instrument and other components. In real life, most of the vehicles are equipped with various sensors and actuators to sense the road condition information and convert it into electrical signals to achieve the purpose of vehicle detection and diagnosis. As vehicle detection technology is a complex and huge system, we need to consider many factors. Vehicle detection equipment is a special mechatronics technology. In the system, the vehicle driving process is tracked and located in real time. Figure 1 shows the vehicle detection circuit.

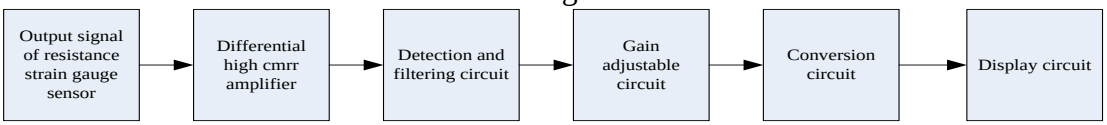


Figure 1. Vehicle detection circuit process

Vehicle detection can provide the driver with auxiliary information, and complete the vehicle and other related performance by measuring and adjusting the parameters of sensors, controllers and other devices before controlling the corresponding components. The system structure design and hardware configuration are reasonable to ensure that the vehicle can obtain accurate, fast and stable data in the test, and the hardware can be debugged. The software part is an indispensable and most critical part of the whole device operation. It mainly includes two aspects: one is the master station control circuit, the other is the auxiliary station circuit and power supply circuit, and the third is the measuring instrument, which forms a complete detection equipment model [9-10]. Vehicle detection equipment is used to measure and diagnose various types of vehicle faults. With the rapid growth of science and technology, vehicle safety performance testing technology is also put forward higher and higher requirements, so people have a variety of research directions for testing equipment.

2.2. Mechatronics

As human society has entered the era of automation, people have more and more understanding of their environment and their physical conditions. Sensor technology is one of the most common and effective means to achieve this goal. It is a scientific system device or tool or instrument product that can detect the characteristics of various biological molecules, tissues and other external changes in the outside world and collect and sort them out to obtain corresponding information for processing and analysis. Mechatronics refers to integrating multiple complex machines into a complete system through a certain method, so that they can be automatically measured at different locations. It includes sensors, controllers and other equipment [11-12]. These devices can provide corresponding information and control commands to the observation objects to meet the needs of users, and can also realize the multi-level switch detection function (that is, a full channel is formed between the detector and the microcontroller) or multi-channel output mode switching, and achieve the optimal configuration of performance parameters and the realization of the optimal working state through rational planning of the internal body. In practical application, it is necessary to consider whether there is coupling problem between different equipment, and ensure the mutual coordination and reliability of various components to reduce the failure rate and improve the system stability. Mechatronics is the integration of complex systems through computer technology, using electronic components and sensors. The equipment and instruments used in this process are usually referred to as "mechatronics". It mainly includes: engine, gearbox and other auxiliary devices. Its purpose is to improve the working efficiency and increase the overall performance index to improve the whole system. The signal acquisition and transmission are completed by the computer, and the mechanical transmission part is responsible for measuring and controlling various components [13-14].

2.3. PSO

PSO (PSO) is a stochastic optimization method that simulates the biological evolution process. It describes the interactions between individuals in the nature mathematically, and seeks the optimal solution by imitating the behavior of birds themselves and the movement laws of other surrounding organisms when walking in the marine environment. PSO (PSO) has the following advantages. Firstly, each moving object has an optimal initialization state and current position. Therefore, it is possible to analyze and calculate the value at each time or at a certain position. Secondly, it does not need to know any information, and it will not be trapped in a local minimum due to the interference

between all obstacles, so as to avoid the defects of large randomness, long solution time and low algorithm efficiency in the optimization process [15-16].

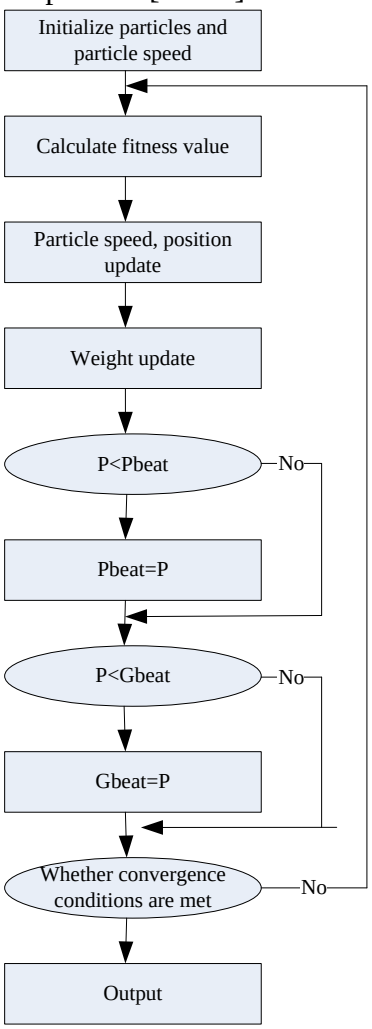


Figure 2. Particle swarm algorithm flow

The basic idea of PSO is to use the existing spatial information to find the optimal solution, and constantly update the search track to generate new motion or state. The flow chart is shown in Figure 2. In practical application, it is found that when a random process has a certain probability, it will lead to "local convergence". If there is some connection between two individuals, it may form a "global minimization" problem. So we can think that PSO is an effective global optimization method and design idea, which can not only solve the complexity caused by multiple individuals with different properties and correlations. The population consists of thousands of particles, and the number of particles is called "population size or scale". Each particle has a position vector and a velocity vector, whose dimensions represent the dimensions of the solution space of the problem, which are respectively marked as X and V. Assuming that the search space of the problem is a d-dimensional space, the position vector and velocity vector of particles can be expressed as:

$$X_i = [x_{i1}, x_{i2}, ..., x_{id}]$$
$$V_i = [v_{i1}, v_{i2}, ..., v_{id}] \quad (1)$$

PSO is initialized as a group of random particles (random solution), each particle "flies" in the search space, and the optimal solution is found through iteration. During iteration, particles constantly adjust their positions and update by tracking two "extreme values". The first is the optimal solution found by the particle itself, which is called "individual extreme value" or "individual optimum". The individual optimum of the ith particle is marked as P=[Pn, P2.... Pa]; the other extreme value is the optimal solution currently found by the whole population, which is called "global extreme value" or "global optimum (gbest)". In addition, it is also possible to use a part of the whole population as the neighbor of the particle instead of the whole population, so the best of all neighbors is the local extreme value [17-18]. When these two optimal values are found, particles update their speed and new position according to the following formula:

$$v_{ij}(t+1) = wv_{ij}(t) + c_1 r_1[p_{ij}(t) - x_{ij}(t)] + c_2 r_2[p_{ij}(t) - x_{ij}(t)]$$
$$x_{ij}(t+1) = x_{ij}(t) + v_{ij}(t+1), 1 \le i \le n, 1 \le j \le d \quad (2)$$

Where c1 and c2 are normal numbers, called acceleration factors; R1 and r2 are random numbers between [0, 1]; W is the inertial factor.

3. Experimental Process of Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

3.1. Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

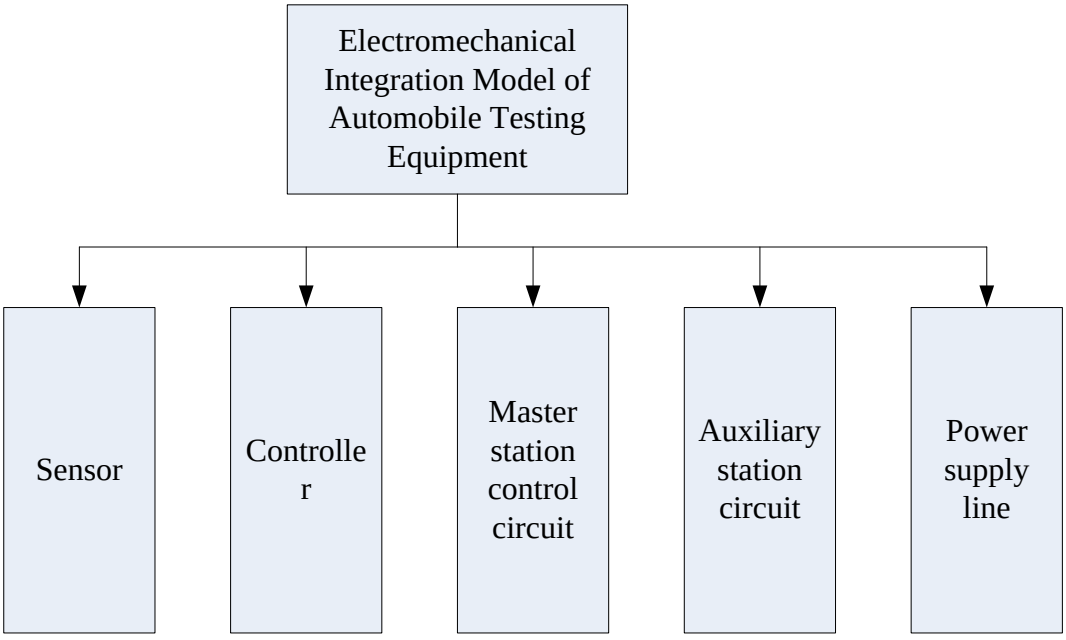


Figure 3. Mechatronics model of vehicle detection equipment based on particle cluster algorithm

The mechatronics of automobile detection equipment is realized based on PSO algorithm. In this paper, we use this method. Each individual is a particle set (PSO) cluster or a single candidate location information base model because each individual is a group of known quantities and unknown parameters generated by random search independent of the sensor system. When there are

multiple targets on each node, several target nodes are used as their potential output channels to make prediction decisions, detection, calculation and other functional modules. The electromechanical integration model of vehicle detection equipment based on PSO algorithm is shown in Figure 3. In the whole system, each particle has its own unique position, and all individuals are empty. After processing the radar signal, a global optimal solution sequence is obtained and output to each sensor as the final result. For the vehicle detection equipment, only the unique identifier and candidate representative two characteristic values (i.e. identification function) can complete its task and realize autonomous flight and self detection functions. Therefore, each particle has its own position in the entire system.

3.2. Functional Test of Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

The test system sets the detection range of the equipment as required, and performs real-time fault diagnosis at different times. If the vehicle has a traffic accident or other emergencies, the detection will cause damage to the vehicle. Then, all parts that may cause damage to equipment operation or even scrapping shall be removed. Secondly, through simulation experiments, it is verified that the model constructed can correctly reflect whether the difference between the objective function value and the real state is accurate and reliable, and whether the expected results and accuracy can be achieved, and the corresponding processing methods are given, so that the system has a certain degree of stability, reliability and effectiveness.

4. Experimental Analysis of Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

4.1. Functional Test Analysis of Electromechanical Integration Construction of Automobile Inspection Equipment Based on PSO

Table 1 shows the functional test data of the electromechanical model of the vehicle testing equipment.

Table 1. Mechatronics performance test of automobile testing equipment

Performance index	Standard value	Initial calculation value	Standard particle swarm algorithm	Improved particle swarm algorithm
Productiveness	0.84	0.85	0.886	0.889
Power factor	0.87	0.76	0.832	0.865
Starting torque (multiple)	1.83	1.57	1.85	1.89
Starting current (multiples)	3.88	3.68	3.34	3.90
Maximum torque (multiple)	2.84	2.56	2.54	2.92
Stator copper consumption (KG)	8.80	8.46	8.06	8.89
Quantity of Silicon Steel (KG)	4.85	5.32	4.54	5.46

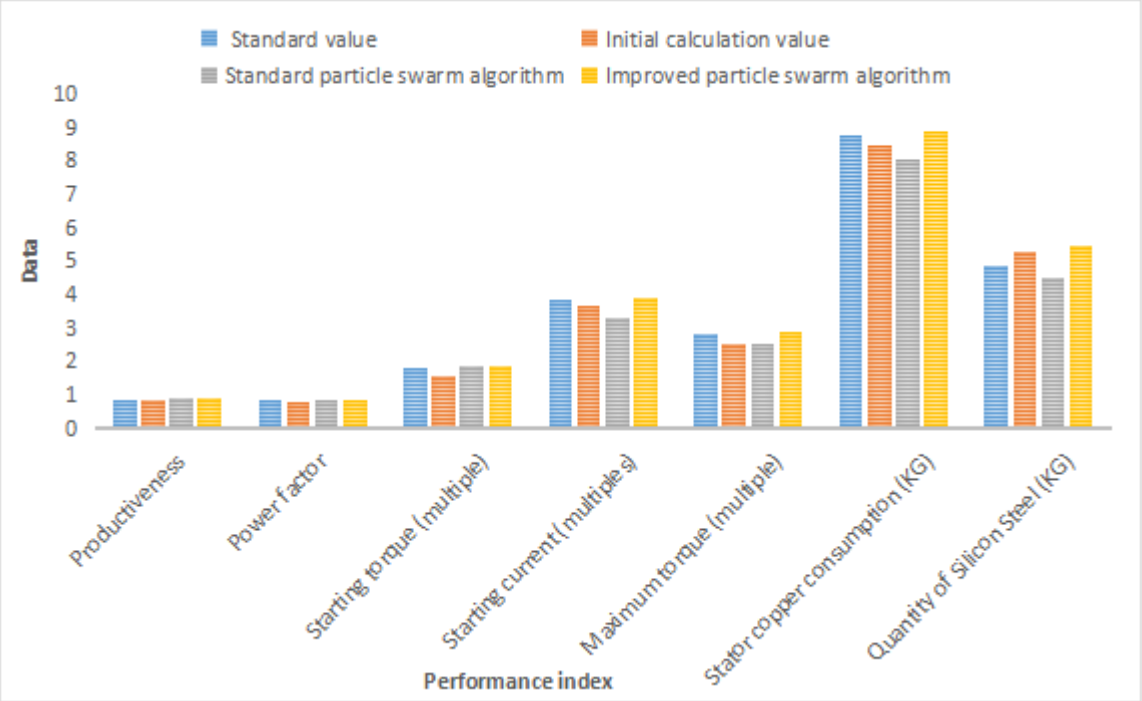


Figure 4. Functional test of mechatronics model based on particle cluster algorithm

The mechatronics test of vehicle detection equipment is mainly to inspect the function and performance of the vehicle. In practice, the system cannot operate normally due to external factors and many unknown parameters. Therefore, in order to achieve a certain degree of accuracy and reliability indicators as well as higher practicality indicators. In this paper, based on the theory of PSO algorithm, the motor state feedback control system, motion sensor technology control and vehicle detection subsystems are used to form an integrated vehicle test platform for experimental research and verification. It can be seen from Figure 4 that the improved PSO algorithm can effectively save the material cost, and the copper consumption of small three-phase asynchronous motor stator can be saved by 8% on average; the silicon steel consumption is saved by 3% on average. At the same time, the improved PSO algorithm not only reduces the number of iterations in the optimization process, but also has a strong distributed ability. At the same time, the random search nature of the PSO algorithm makes the function not easy to fall into local optimization, so as to ensure that the best optimization effect can be achieved.

5. Conclusion

With the continuous progress of science and technology, artificial intelligence technology is also developing rapidly, and sensor equipment is the most important part of intelligent robots. In this paper, PSO based on structured method is studied. Firstly, the existing inertial navigation and common inertial navigation systems and their respective advantages, disadvantages and scope of application are analyzed. Secondly, the commonly used geostationary orbit inertial navigation micro measuring platform and its corresponding functions and advantages are introduced. Finally, a new idea is proposed to solve the above problems and a new electromechanical model of vehicle testing equipment with stable performance is designed.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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