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Artificial Fish Swarm Algorithm Based Electric Hybrid Power System

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Abstract: Hybrid vehicles, which refer to vehicles with two power sources, are important for improving the fuel economy, power and reducing pollutant emissions of vehicles. In order to solve the shortcomings of the existing electric hybrid system research, this paper briefly discusses the development environment and hybrid vehicle parameters of the electric hybrid system based on the artificial fish swarm algorithm, based on the discussion of the type of electric hybrid system and the artificial fish swarm algorithm. And the design of the electric hybrid power system energy control model and the system architecture of the artificial fish swarm algorithm are discussed, and finally the electric hybrid power system built by incorporating the artificial fish swarm algorithm and the improved artificial fish swarm algorithm are experimentally analyzed. The experimental data show that the simulated annealing global artificial fish swarm algorithm consumes less than 3598 energy on average for the electric hybrid power system, which is lower than the artificial fish swarm algorithm and the global artificial fish swarm algorithm. Therefore, it is verified that the simulated annealing global artificial fish swarm algorithm has good control effect on the energy of the electric hybrid power system.

1. Introduction

Hybrid power system design is the basis of hybrid vehicle research and is the key to achieve the goal of vehicle economy. With the gradual popularization of hybrid vehicles, the hybrid power system develops to complex configurations, and the complexity of the number of power sources and energy coupling relationships grows dramatically, which bring great challenges to the hybrid power system design work.

Nowadays, more and more scholars have conducted a lot of research in the construction of electric hybrid power system through various techniques and system tools, and some research results have been achieved through practical research. Mab A proposed a single-axis gas-electric

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parallel hybrid power system scheme for ships in order to improve the energy efficiency of ship power system and the poor performance of natural gas engine under low load conditions with poor dynamic characteristics and high fuel consumption. And simulation experiments are conducted to calculate the system battery efficiency based on the full cycle of ship cycle sailing. And the actual system energy saving rate is calculated by the weighting method. The experimental results show that the average system energy saving rate is greater than 20% at different loads [1].Meyer developed the energy control of a series hybrid vehicle (hev) including a launch (SSS) system. The goal was to optimize the drivetrain between energy sources and to reduce fuel consumption. Thus, a proof of optimality for maintaining the charging operation of a tandem hybrid vehicle is obtained. Based on this, a new hysteretic power threshold control method is proposed that combines the control information obtained from the derived set of electromagnetic optimal solutions. For different HEV rules and different control cycles, the system can fully optimize the overall control performance [2].Tworek B designed a novel hybrid energy storage system for electric vehicles in order to improve the long range of electric vehicles and to ensure the minimization of the cost function. For its energy storage system, a control algorithm based on supercapacitor SOC for dynamic power limitation rule control of lithium-ion batteries is proposed. Meanwhile, the magnetic integration technique is introduced in the EV converter. Thus, the power quality of the hybrid energy storage system is optimized [3]. Although there is a wealth of existing research on the construction of electric hybrid power systems, there are limitations in the research on the construction of electric hybrid power systems based on artificial fish swarm algorithms.

The good or bad energy control of hybrid vehicle system directly affects the whole vehicle performance of hybrid vehicles, but there is no very ideal formulation. Therefore, this paper proposes to apply the artificial fish swarm algorithm to the system energy control model for the parallel hybrid system energy control. In this paper, the following parts of research are carried out: complete parallel hybrid system parameters matching and system environment configuration analysis; establish parallel hybrid system functional structure; establish artificial fish swarm algorithm electric hybrid system energy control model. And through the artificial fish swarm algorithm and improved algorithm for electric hybrid power system energy consumption for experimental comparison and analysis, and concluded that the simulated annealing global artificial fish swarm algorithm has the lowest energy consumption.

2. Electric Hybrid Power System Based on Artificial Fish Swarm Algorithm

2.1. Types of Electric Hybrid Power System

(1) Tandem hybrid power system

It is generally divided into engine, engine (ISG), power battery and drive motor components [4]. The electrical energy is transmitted directly to the battery management system (EMS) through the generator controller, and the energy is either transferred to the drive system to convert into electricity to drive the vehicle, or to the energy in the power battery [5]. When the power battery power is sufficient, the generator can stop working and reduce the power battery output [6].

(2) Parallel hybrid system

In this system, the power source engine and electric motor are linked to the drive system through the mechanical structure, so that the engine and electric motor can either drive the car separately or together [7]. The system has fewer energy conversions and high energy utilization, which makes the fuel economy of parallel hybrid system better than that of series hybrid system [8].

(2) Hybrid hybrid system

The output power of the power source engine in the hybrid system is partly converted into electrical energy by a generator, and partly used to drive the vehicle [9]. The electrical energy

converted by the generator is directly supplied to the electric motor to drive the car or to charge the power battery, and the electric motor is mechanically connected to the drive system [10].

2.2. Artificial Fish Swarm Algorithm

(1) Foraging behavior

The foraging behavior of artificial fish is that fish use their visual senses to investigate the food information in the current environment and then move towards the place with more food information, and the previously mentioned visual concept can be applied in this behavior [11].

Assume that the current state of the xth artificial fish is not $G=\left[N_{1x},N_{2x},...,G_{7x},c_{1x},c_{2x},...c_{7x}\right]$, and first select a random state $G_y=\left[N_{1y},G_{2y},G_{7y},c_{1y},c_{2y},...c_{7y}\right]$ in its visible range.

$$G_y=G_x+Visual\cdot Rand \tag{1}$$

The energy of the system is minimal, so if $Y_y<Y_x$, state G_y is better than G_x, the artificial fish takes a step forward in the direction of state G_y:

$$G_x^{n+1}=G_x^n+\frac{G_y-G_x^n}{\left\|G_y-G_x^n\right\|}\cdot Step\cdot Rand \tag{2}$$

On the contrary, if $Y_y\geq Y_x$ then reselect state G_y, and again determine whether the above conditions are satisfied, if after several attempts still not satisfied, then the artificial fish randomly forward:

$$G_x^{n+1}=G_x^n+step\cdot Rand \tag{3}$$

(2) Grouping behavior

In nature, the fish second of the fortunate swimmers to move the whole group over the algorithm process and in the improvement will naturally concentrate on living in groups, which is also a basic survival habit of humans to maintain the survival of the population and to prevent external damage [12].

(3) Tail-chasing behavior

When some individual fish in a school find food, the nearby fish will gradually move closer to them, so that the whole school can find food, and this kind of distributed cooperation reflects the intelligence of the school [13].

(4) Random behavior

When fish do not find food in their own search area, they will swim randomly and go to a larger area to search for search food [14].

3. Investigation of Electric Hybrid Power System Based on Artificial Fish Swarm Algorithm

3.1. Hybrid Vehicle Parameters

In this paper, we take an SUV fuel manual transmission model in the enterprise as the prototype, keep the original vehicle body parameters and eliminate the transmission system of this vehicle [15]. By equipping the hybrid seven-speed automatic transmission device, the plug-in hybrid parallel drive mode is developed twice, and the power and torque matching calculation is carried out according to the performance index, so as to determine the parameters of the motor, engine and

battery pack as well as the selection type [16]. In this paper, the transmission efficiency is 0.8, and the vehicle design parameters are shown in Table 1 [17].

Table 1. Overall vehicle parameters

Parameters of the project	The parameter value
Curb weight	1765
Full quality	2120
Windward area	2.7
The wind resistance coefficient	0.53
Custom of rolling resistance	0016
Transmission efficiency	0.8

3.2. System Experimental Environment

The experimental environment for the artificial fish swarm algorithm-based electric hybrid system established in this paper contains a server cluster of five servers as server-side machines. This includes the configuration of virtualization on the physical servers, the construction of the big data service cluster, the configuration of the database, the machine and computing framework, and the system service interface and other systems [18]. The main hardware and software configurations of the servers are shown in Table 2:

Table 2. hardware and software configuration parameters

The serial number	Hardware	Software
1	CPU:InterCore2Duo2.4G	The operating system:WindowsServerXP
1	Memory:DDR42133MHz,12GB	The database:SQLServer2019
2	Network:1000M wireless network	WEB:IIS6.0,NetFramework2.02
3	1000 g hard disk	Spark1.5.1
4	5 machine	Python3.5

4. Research on The Application of Electric Hybrid Power System Based on Artificial Fish Swarm Algorithm

4.1. Design of Electric Hybrid Power System Based on Artificial Fish Swarm Algorithm

(1) The energy control process of electric hybrid power system based on artificial fish swarm algorithm

In this paper, the system energy control is designed by collecting the signals of acceleration, brake pedal, gear speed ratio, etc., converting them into demand torque after calculation, and then importing them into the artificial fish swarm algorithm program according to the derived optimized objective function (equivalent instantaneous fuel consumption function, ECMS) and other constraints, and using this to calculate the control signals such as engine torque and secondary component torque that minimize the value of the objective function, and the energy control flow chart is shown in Figure 1.

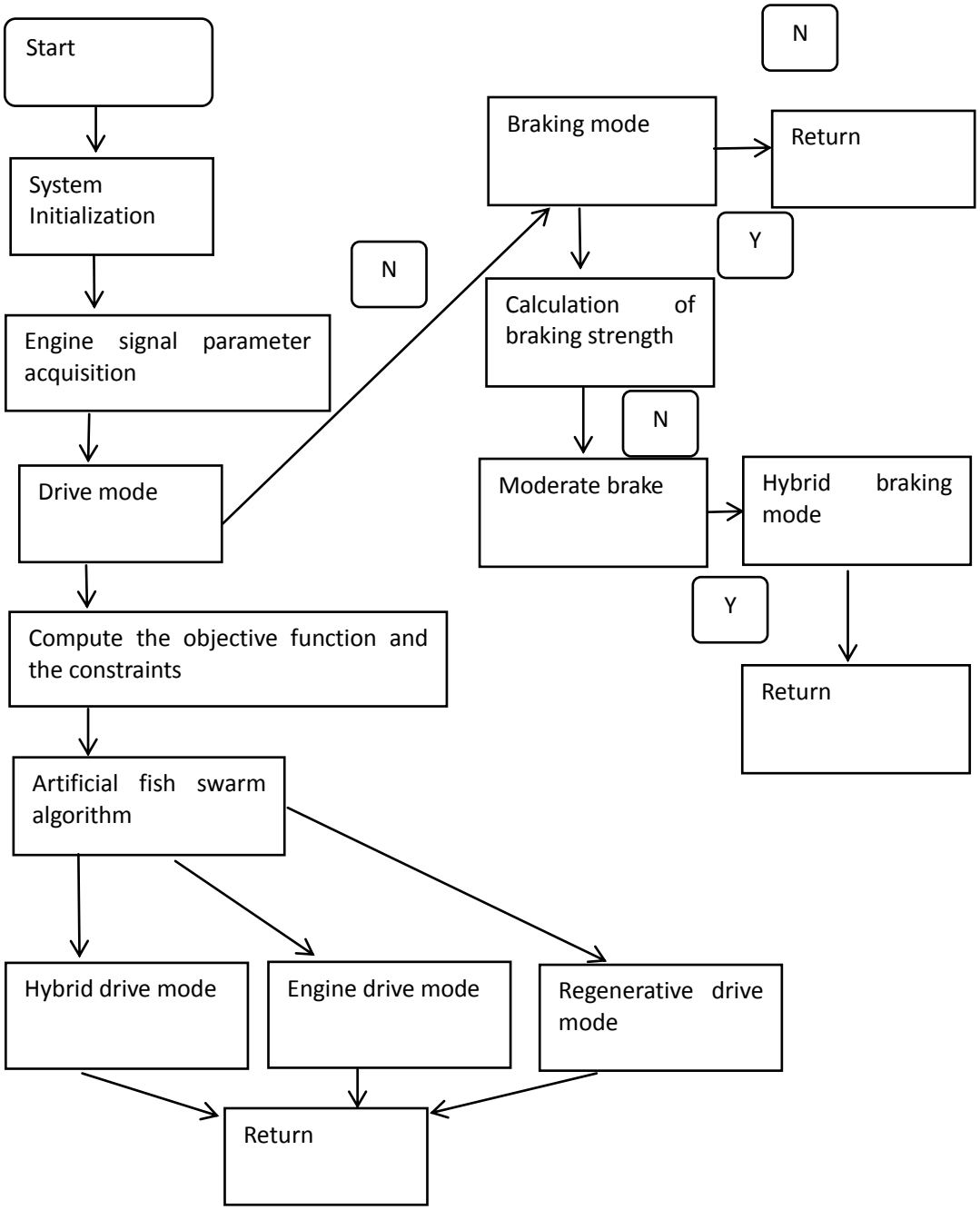

Figure 1. Energy control flow chart

(3) Architecture design of electric hybrid system based on artificial fish swarm algorithm

1) Data layer provides data service support for the system, in this system, including two types of data: system energy control data and drive system optimization data, the database that is the system data after optimization through the artificial fish swarm algorithm.

2) The business logic layer is used to realize all the business logic management involved in the system energy control and drive system, including system user rights management, system instantaneous and global energy optimization settings and the algorithm model of artificial fish swarm, etc. These business logics are realized through specific business logic classes.

3) The control layer is used to realize the control between the business logic and the interface.

On the basis of the data provided by the data layer, all the associations between the control layers are completed, and the logic displayed by the business data to the system is realized through the control layer, and the control of the business logic is displayed through the data. That is, for the realization and manipulation of the control of the system logic.

4) Representation layer function is to run the system function, through the designed functions to carry out the corresponding operation, including the operation interface, in the system optimization, data query and maintenance, through the operation in the main interface, all the main operation functions of the system in the right part to complete, the left part of the system function menu area.

4.2. Application of Electric Hybrid System Based on Artificial Fish Swarm Algorithm

In this paper, based on the previously established energy control model of the electric hybrid system and the establishment of the electric hybrid system, we apply the artificial fish swarm and its improved algorithm to simulate and verify the system energy control. Firstly, the block diagram of the system energy control principle is given, and the whole electric hybrid system is designed according to the block diagram. Then the artificial fish swarm algorithm (AFSA) and global artificial fish swarm algorithm (GAFSA) and simulated annealing global artificial fish swarm algorithm (SAGAFSA) are used to analyze the energy consumption of the system respectively.

Table 3. Energy consumption data

Algorithm	AFSA	GAFSA	SAGAFSA
100	2490	2319	2180
200	3876	3109	3089
300	4320	4102	4009
400	5619	5243	5114

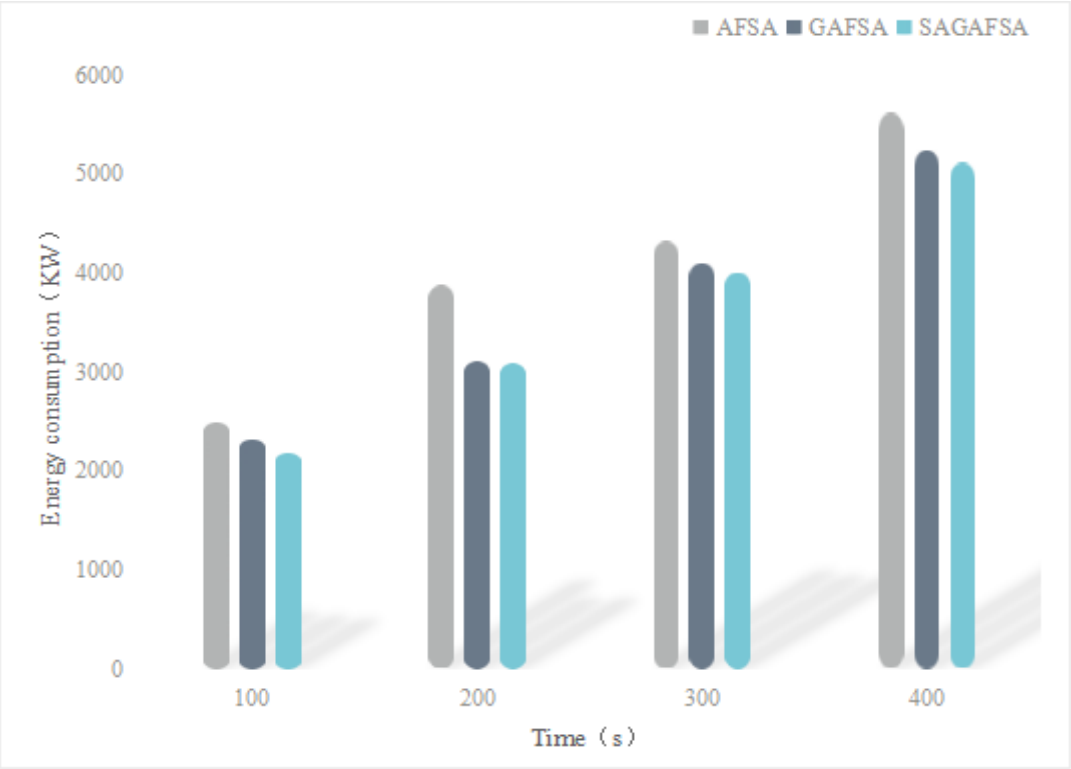

Figure 2. Comparison of results

Figure 2 shows the energy consumption curves when the three algorithms are applied to solve the energy control model based on the control system, from the figure, we can see that the energy fluctuation of the basic AFSA algorithm is larger than the other two algorithms, and the energy consumption is also higher than the other two algorithms. The energy consumption of the GAFSA and SAGAFSA algorithms is always lower than that of the AFSA algorithm, and the energy variation decreases slowly as time stabilizes. From the perspective of energy consumption, SAGAFSA algorithm is more energy efficient than AFSA algorithm and GAFSA algorithm.

5. Conclusion

In this paper, an energy control model and system based on the artificial fish swarm algorithm (AFSA) for electric hybrid powertrain is established, which can be directly applied to real vehicles and ensure a better economic performance of electric hybrid powertrain. The experimental data show that the artificial fish swarm algorithm (AFSA) has the lowest energy consumption compared with the global artificial fish swarm algorithm (GAFSA) and the simulated annealing global artificial fish swarm algorithm (SAGAFSA) method, and is infinitely close to the optimal fuel consumption, The optimization purpose is achieved, which meets the design requirements of this paper, but there are still engine torque oscillation and arithmetic problems to be improved, which is the next development direction.

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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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