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Optimization application of particle swarm algorithm in civil engineering

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Abstract: In the construction and development of modern society, civil engineering as the basis of promoting the steady development of the industry economy and ensuring the stability of urban residents' lives, with the continuous innovation of social economy and science and technology, is now facing severe challenges and rich opportunities. Particle swarm optimization (PSO), as a simulation of bird predation process, can obtain the optimal solution of searching space, and its application in civil engineering structure optimization and damage detection can help workers find the existing problems faster, and put forward effective solutions. Therefore, on the basis of understanding the development status of modern civil engineering technology, according to particle swarm optimization algorithm and improved scheme, this paper deeply discusses how to apply particle swarm optimization algorithm in the damage detection of civil engineering structures. The final experimental results show that the improved particle swarm optimization algorithm has unique application advantages and plays an important role in civil engineering.

Keywords: Particle swarm optimization; Civil engineering; Building structure; Damage detection; Structure optimization

1. Introduction

Along with the social economy and the steady development of the science and technology, civil engineering as the foundation of the national economic construction in our country, belongs to a basic facilities construction activities, which mainly include water conservancy project, transport facilities, high-rise buildings, such as content, construction quality directly affects all aspects of the development of social economic construction, It plays an important role in promoting the rapid development of national economy and the progress of human civilization. In China's urbanization process gradually speeding up, in order to effectively solve the rapid growth of city population, building land tension and other development contradictions, high-rise buildings are getting attention. Now, there are more than a thousand high-rise buildings more than 100 meters in China, and the number of high-rise buildings also exceeds tens of thousands, which cannot be done without the optimization innovation of civil engineering. In other words, social development cannot be achieved without the promotion of civil engineering. In addition to high-rise building, civil engineering also played an important role in transportation infrastructure, including road traffic is the basis of the development of China's economic development condition, in civil engineering, driven by comprehensive urban railway, the number of Bridges, roads and other infrastructure, more and more, our country has reached basic gridlocked traffic network system, The construction quality of urban transportation facilities is getting higher and higher, which provides a basic guarantee for urban residents to travel safely and effectively controls the probability of safety accidents. At the same time, the structure as the main factors influencing the quality of civil engineering construction, to guarantee the overall quality of engineering design and construction, on the basis of perfecting the structure design is critical, so the current research scholars to wind load and earthquake load is widely used in practical work, civil engineering structure design is to increase the height and flexibility of the steady development. After China enters the information age, civil engineering begins to reform the direction of information. The information development of civil engineering construction technology cannot leave the support of communication technology, network technology and computer technology, especially after the theory of artificial intelligence technology

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is proposed, the structure design of civil engineering in our country presents the characteristics of The Times and intelligence.[1.2.3]

Particle swarm optimization (PSO) was developed and proposed by Kennedy, Eberhart and other scientists in the mid-1990s. It basically refers to the foraging behavior of birds. Researchers in the survey found that the birds often changes direction when flying, their behavior is unpredictable, but overall would remain consistent, has the suitable distance between individual and individual, the reason is that there is a similar biological group social information sharing mechanism, provides a unique advantage group evolution, this also is the basic research contents of particle swarm optimization (pso) algorithm. From the point of view of practical application, this kind of algorithm is easier to understand and implement, and the practical development and application speed is fast. At present, it has been regarded as the topic content of the international Conference on Evolutionary Computing. In addition to the standard particle swarm optimization algorithm, researchers also put forward a variety of hybrid algorithms in practice, such as the expansion of the core particle swarm optimization algorithm, integrated the use of the relative basis learning principle; Some scholars introduced the multi-mother crossover operator in the particle swarm optimization algorithm to improve it. In the process of studying hybrid algorithms, Liu Bo et al. fused particle swarm optimization algorithm and ant colony algorithm together, and proposed swarm intelligent search. From the perspective of practical research and application, this improved way can continue the advantages of standard particle swarm optimization algorithm and solve the original problems at the same time. Nowadays, based on civil engineering construction structure, the use of damage identification technology is proposed to monitor and analyze, focusing on ensuring the safety of the applied structure from the basis. The structural health monitoring system is as shown in Figure 1 below:[4.5]

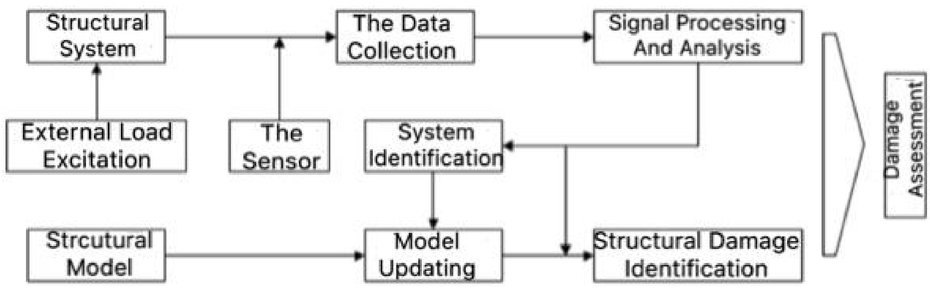

FIG. 1 Structure diagram of building health monitoring system for engineering structures

Therefore, on the basis of understanding the status quo of the development of civil engineering technology in China, according to the basic principle of particle swarm optimization algorithm, this paper focuses on the improvement of particle swarm optimization algorithm as the core of civil engineering structural damage detection and sensor optimization arrangement, to verify the effectiveness of the application algorithm.

2. Method

2.1 Particle Swarm Optimization (PSO)

According to the analysis of the flow chart shown in Figure 2 below, the operation steps of this kind of algorithm involve the following points:[6.7]

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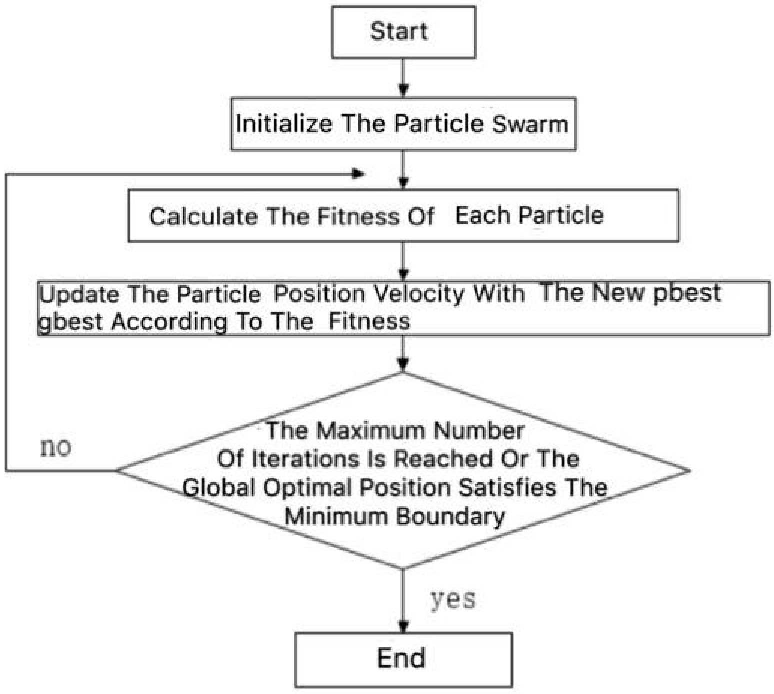

FIG. 2 Flowchart of PSO algorithm

Firstly, the particle swarm containing velocity and random position is initialized.

Second, the fitness function is determined according to different problems, and different fitness functions have different evaluation methods to accurately calculate the value of the fitness function.

Thirdly, the individual historical optimal position was identified. After calculating the fitness function value of the particle, the individual optimal value was determined by comparing and updating.

Fourthly, the global optimal position is mastered, the fitness function value of particles is also obtained, and then the population optimal is updated by comparing the two.

Fifth, the velocity and position of particles in the population are updated according to the formula.

Sixth, loop iteration. If the optimal result is not achieved, the second step of the process is repeated, after several consecutive cycles, until the end condition is met.

2.2 Installing a Sensor

In the health monitoring system of civil engineering building structure studied in this paper, in order to comprehensively identify structural damage, it is necessary to scientifically install sensors before formal work, so as to obtain more basic information of structural damage. According to the accumulated practical experience, the optimal layout of sensors can be divided into two parts, on the one hand, the number of sensors is optimized, and on the other hand, the position of sensors is optimized. In this paper, the improved particle swarm optimization algorithm is used for research and analysis, and the number of selected grid structure is optimized according to the MAC optimization criterion. MATLAB software is used to realize the improved particle swarm optimization program, and the algorithm is applied to the sensor position optimization problem on the basis of obtaining the grid structure model and related information.

Combined with the simulation model of the same family grid structure as shown in Figure 3 below for research and analysis, before optimizing the layout of sensors, the staff should first make clear that the model contains 60 nodes and 174 rods, the plane size of the structure is 3 meters ×5 meters, and the rod material is Q235 bars:[8.9.10]

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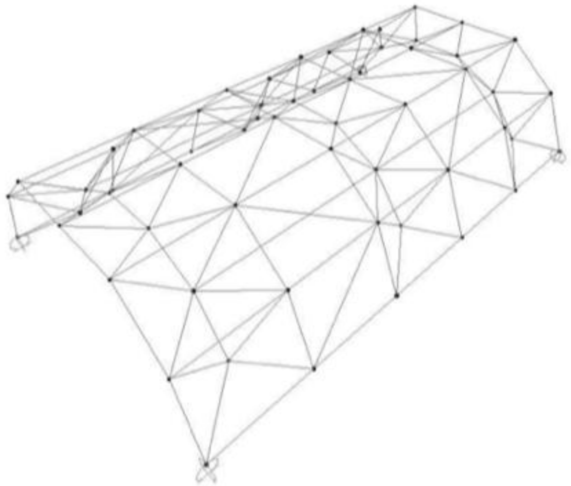

FIG. 3 Simulation model diagram of grid structure

After the fitness function and algorithm parameters are defined, the layout should be optimized according to the process shown in FIG. 4 below:[11.12.13]

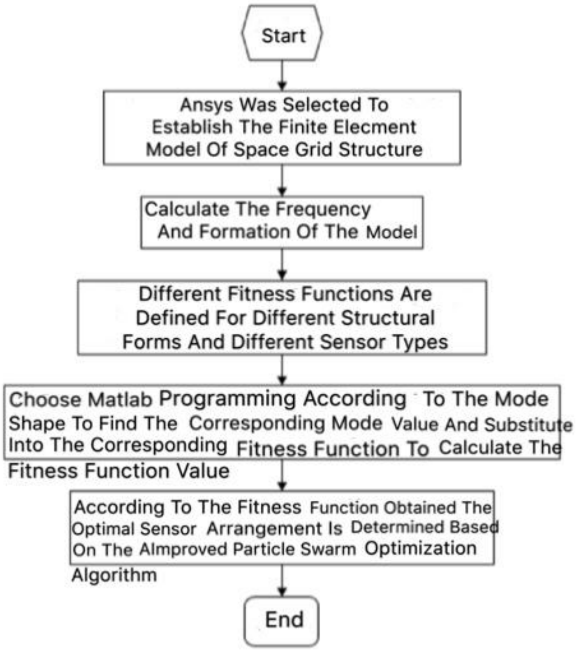

FIG. 4 Flowchart of improved particle swarm optimization algorithm

2.3 Optimizing Applications

Because particle swarm optimization algorithm itself has unique technical advantages, so in the civil engineering construction management optimization application, in line with the new era of the field of construction technology innovation requirements. , for example, some scholars in the study, this paper presents a particle swarm optimization (pso) with inertia weight factor, which is applied to the structural damage detection, to solve constrained optimization problems, can be found that the traditional problems more constrained optimization method, and particle swarm optimization (pso) algorithm is easy to fall into local minimum, so scholars analysis of particle swarm optimization (pso) algorithm is improved. The numerical simulation results of the two-layer steel frame structure show that the improved algorithm has more advantages than the original standard algorithm.

Based on the analysis of the damage identification flow chart shown in Figure 5 below, it can be seen that the following operations should be carried out in this study: first, dynamic test and analysis of the grid model under real damage conditions should be carried out to clarify the

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corresponding modal information; Second, in order to obtain the structural vibration frequency and formation of the foundation model waiting for comparison, dynamic test should be carried out on the foundation model, so as to facilitate subsequent research and analysis. Third, the particle swarm optimization algorithm should be used to optimize the judgment, focusing on improving the existing problems of the model. Each model modification will obtain a "pseudo condition", accurately identify the modal information of this model, and then use the particle swarm optimization algorithm to optimize the design, after the particle swarm optimization algorithm cycle design, can obtain a more real "pseudo condition". In this state, the stiffness reduction coefficient of each element of the structure can be clarified by continuously modifying the stiffness. From the perspective of overall operation, the improved particle swarm optimization (PSO) algorithm should be used in the damage identification of civil engineering structures to ensure that the modal information of the modified structure is consistent with the damage condition, and then the basic idea of model modification is cited.[13.14.15]

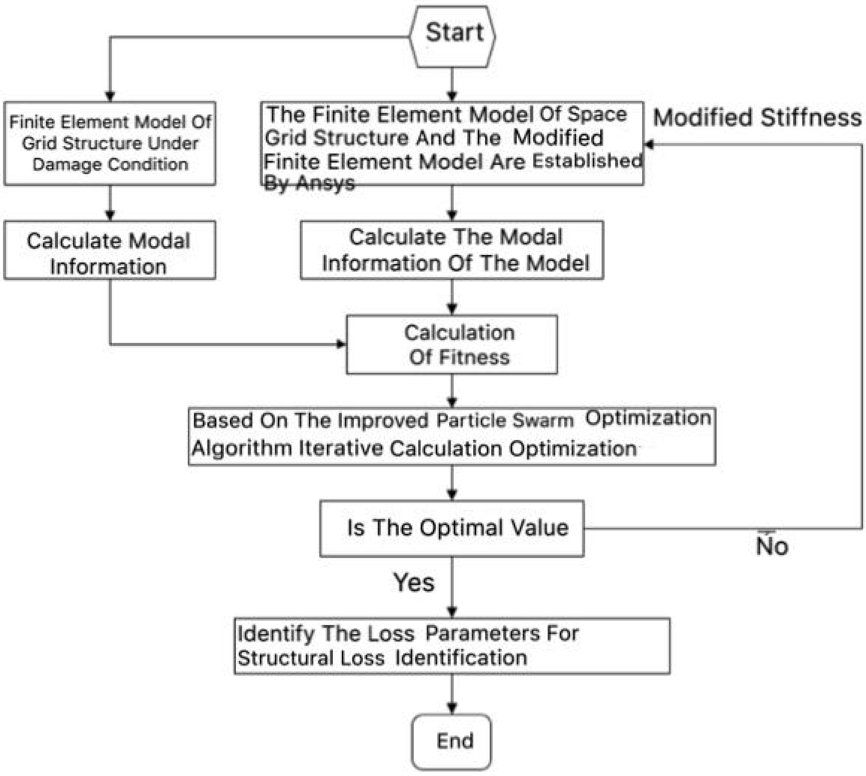

FIG. 5 Flow chart of damage identification

In this paper, the damage identification model with particle swarm optimization (PSO) as the core is studied, and the program of PSO is written. Before practical work, the corresponding parameter design and fitness function file should be modified, and the program results should be adjusted scientifically by ANSYS software to find the optimal value in iterative calculation.

3. Result analysis

From the point of view of identification of single damage, three working conditions are set up in this research experiment: Firstly, the first kind of winding rod -- No. 92 rod is completely damaged, and the node numbers at both ends are 28 and 37; Secondly, the second type of lower chord rod - No. 54 rod is completely damaged, and the node numbers at both ends are 23 and 27; Finally, the THIRD type OF upper and lower chord - rod 121, with joint numbers 45 and 47 at both ends, was completely damaged. The dimension of the particle swarm optimization algorithm is set as 174, and the population size is set as 100 when the population size is appropriately increased. The final damage identification results of different working conditions are shown in Table 1, Table 2 and Table 3:

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Table 1 Identification results of the first working condition

Bar code	x	Bar code	x	Bar code	x	Bar code	x	Bar code	x
1	0.0704	21	0.0885	41	0.0165	61	0.0358	81	0.0270
2	0.0386	22	0.0472	42	0.0766	62	0.0285	82	0.0423
3	0.0891	23	0.0340	43	0.0403	63	0.0494	83	0.0399
4	0.0308	24	0.0346	44	0.0597	64	0.0811	84	0.0489
5	0.0423	25	0.0878	45	0.0860	65	0.0347	85	0.0433
6	0.0830	26	0.0412	46	0.0663	66	0.0402	86	0.0440
7	0.0557	27	0.0502	47	0.0742	67	0.0534	87	0.0561
8	0.0672	28	0.0639	48	0.0706	68	0.0741	88	0.0834
9	0.0705	29	0.0424	49	0.0702	69	0.0423	89	0.0856
10	0.0762	30	0.0781	50	0.0629	70	0.0179	90	0.0744
11	0.0903	31	0.0717	51	0.0380	71	0.0091	91	0.0369
12	0.0530	32	0.0437	52	0.0831	72	0.0075	92	00.095
13	0.0887	33	0.0848	53	0.0351	73	0.0644	93	0.0406
14	0.1044	34	0.0300	54	0.0175	74	0.0673	94	0.0883
15	0.0978	35	0.0003	55	0.0940	75	0.0872	95	0.0740
16	0.0039	36	0.0534	56	0.0512	76	0.0571	96	0.0595
17	0.0028	37	0.0551	57	0.0869	77	0.0409	97	0.0608
18	0.0495	38	0.0374	58	0.0559	78	0.0668	98	0.0455
19	0.0819	39	0.0590	59	0.0458	79	0.0479	99	0.0722
20	0.0795	40	0.0292	60	0.0408	80	0.0388	100	0.0622

Table 2 Identification results of the second working condition

Bar code	x	Bar code	x	Bar code	x	Bar code	x	Bar code	x
1	0.0525	21	0.0636	41	0.0634	61	0.0568	81	0.0431
2	0.0681	22	0.0168	42	0.0720	62	0.0529	82	0.0853
3	0.0833	23	0.0368	43	0.0234	63	0.0810	83	0.0299
4	0.0547	24	0.0566	44	0.0618	64	0.0759	84	0.0502
5	0.0050	25	0.0247	45	0.0428	65	0.0300	85	0.0004
6	0.0016	26	0.0729	46	0.0414	66	0.0341	86	0.0585
7	0.0694	27	0.0627	47	0.0168	67	0.0460	87	0.0002
8	0.0589	28	0.0700	48	0.0038	68	0.0296	88	0.0739
9	0.0185	29	0.0696	49	0.0038	69	0.0746	89	0.0502
10	0.0764	30	0.0858	50	0.0494	70	0.0512	90	0.0351
11	0.0589	31	0.0843	51	0.0575	71	0.0399	91	0.0396
12	0.0796	32	0.0559	52	0.0738	72	0.0300	92	0.0475
13	0.0676	33	0.0890	53	0.0521	73	0.0763	93	0.0482
14	0.0601	34	0.0627	54	0.9594	74	0.0761	94	0.0383
15	0.0866	35	0.0308	55	0.0418	75	0.0036	95	0.0754
16	0.0395	36	0.0226	56	0.0746	76	0.0726	96	0.0545
17	0.0619	37	0.0872	57	0.0638	77	0.0326	97	0.0565
18	0.0683	38	0.0637	58	0.0680	78	0.0740	98	0.0365
19	0.0570	39	0.1381	59	0.0905	79	0.0394	99	0.0868
20	0.0733	40	0.0505	60	0.0480	80	0.0316	100	0.0412

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Table 3 Identification results of the third working condition

Bar code	x	Bar code	x	Bar code	x	Bar code	x	Bar code	x
71	0.1252	91	0.0823	111	0.0899	131	0.0400	151	0.0648
72	0.0471	92	0.0281	112	0.0675	132	0.0410	152	0.0428
73	0.0462	93	0.0711	113	0.0658	133	0.0927	153	0.0847
74	0.0342	94	0.0864	114	0.0719	134	0.0664	154	0.0510
75	0.0911	95	0.0312	115	0.0360	135	0.0616	155	0.0561
76	0.0593	96	0.0827	116	0.0587	136	0.0384	156	0.0492
77	0.0604	97	0.0457	117	0.0083	137	0.0971	157	0.0384
78	0.0713	98	0.0705	118	0.0390	138	0.0571	158	0.0497
79	0.0874	99	0.0530	119	0.0484	139	0.0299	159	0.0230
80	0.0676	100	0.0579	120	0.0907	140	0.0569	160	0.0507
81	0.0313	101	0.0661	121	0.9718	141	0.0422	161	0.0811
82	0.0714	102	0.0666	122	0.0481	142	0.0804	162	0.0730
83	0.0345	103	0.0099	123	0.0255	143	0.0727	163	0.0291
84	0.0728	104	0.0415	124	0.0542	144	0.0520	164	0.0089
85	0.0622	105	0.0584	125	0.0584	145	0.0692	165	0.0009
86	0.0320	106	0.0211	126	0.0910	146	0.0052	166	0.0437
81	0.0421	107	0.0645	127	0.0455	147	0.0067	167	0.0359
88	0.0326	108	0.0582	128	0.0366	148	0.0570	168	0.0648
89	0.0385	109	0.0472	129	0.0565	149	0.0742	169	0.0459
90	0.0651	110	0.0353	130	0.0295	150	0.0473	170	0.0721

By comparing the data analysis shown in the above table, it can be seen that the bars with significantly large stiffness reduction coefficient are No. 92, No. 54 and No. 121, and obvious damage is found in the identification process of the three bars. From the point of this paper studies data information, after using the improved particle swarm algorithm of space truss structure damage identification in civil engineering analysis, will damage identification problem into a function optimization problem, but because of the vibration mode and natural frequency as the core of recognition result is not ideal, so the application of both together. The application efficiency of PSO algorithm can be compared by setting multiple damage points for experimental analysis at the same time. Therefore, in the future, researchers should strengthen the research on the optimization application of particle swarm optimization in civil engineering, and pay attention to the proposed more perfect recognition model.

4. Conclusion

To sum up, this paper studies in current situation of the development of civil engineering, on the basis of the integrated use of the optimization analysis of particle swarm optimization (pso) algorithm, this paper mainly discusses the structure of the civil engineering construction damage identification problem, pay attention to exploit more valuable content, help staff faster completion of space truss structure damage detection and optimal placement of the sensor. At the same time, also introduced in damage identification model updating ideas, to amend the model ideas together and the particle swarm algorithm for construction engineering structure damage identification, can achieve expected set technology application, proof performance of particle swarm optimization (pso) algorithm, and can provide more empirical analysis to research scholars thinking, gradually optimizing our country civil engineering technology innovation ability.

Reference

[1] Peng An. Optimization application of Particle swarm optimization algorithm in civil engineering [J]. New Materials · New Decoration, 2021, 3(6):2.

ISSN:2790-1688 DOI: 10.56028/aetr.3.1.275
[2] Xiang Yin, Yi Huang, Kaiqiang Li, et al. Gray dynamic model for corrosion prediction based on Particle Swarm optimization algorithm [J]. Corrosion and Protection, 2020, 41(1):5.

[3] Haitao Li, Borui Wang. Application of BP neural network based on Particle Swarm Optimization Algorithm in seawater quality assessment [J]. Marine Science, 2020, 44(6):6.

[4] Xuanying Meng, Lijun Li. Optimization of lifting point layout in structural hoisting engineering based on APDL parametric modeling [J]. Civil Engineering, 2020, 9(3):10.

[5] Shusong Li. Research on the application of Particle Swarm Optimization Algorithm in optimization problem [J]. Science and Technology Innovation, 2020(32):2.

[6] Fei Xiao, Wenming Dong, Weihong Wang. Joint optimization of coupling algorithm for nitrogen pollutants [J]. Journal of Chongqing University of Technology, 2021, 035(006):P.220-229.

[7] Haifeng Guo,Ning Liao, Cuiling Zhang. Improved Particle Swarm Optimization Based on Multiple Strategies and Its Application in E-commerce Multi-level Logistics [J]. Nature Science, Jinggangshan University, 2020, 41(1):48-53.

[8] Yu Han, Zhipeng Sun, Rui Huang, et al. Optimization water distribution model of irrigated area based on backtracking search algorithm [J]. Engineering Science and Technology, 2020, 52(1):9.

[9] Xu Meng, Lianbo Zhu, Zhenqun Shi. Research on Production scheduling optimization of prefabricated Components based on Particle Swarm Optimization Algorithm [J]. Value Engineering, 2020, 39(3):4.

[10] Juntao Kang, Kai Liu, Yazhou Zhang. Linear optimization of steel truss Arch Bridge Structure based on probabilistic Jumping Particle Swarm Optimization [J]. Chinese and Foreign Highways, 2020, 40(5):6.

[11] Xiaoning Shen, Hongli Pan, Qingzhou Chen, et al. Application of Particle Swarm Optimization Algorithm with heuristic Information in Low Carbon TSP [J]. Computer Engineering and Science, 2022, 44(06):1114-1125.

[12] Jiangping Huang, Xiaojing Zhong. Application of multi-objective Particle Swarm Optimization algorithm in Subway speed curve optimization [J]. Railway Standard Design, 2022(009):066.

[13] Ran Cai, Yuhang Zhang, Linke Wang, et al. Application of Adaptive Particle Swarm Optimization in Cable Force Optimization [J]. Journal of Highway and Transportation Science and Technology, 2022(001):039.

[14] Qian Feng, Qing Li, Yaozu Wang, et al. Application of Constrained multi-objective Particle Swarm optimization in Sinter ore blending optimization [J]. Control Theory and Applications, 2022, 39(5):10.

[15] Xiaoshu Gao, Tong Cao, Zong Zhang. Application of Particle Swarm Optimization in Stamping Forming Optimization of Magnesium Alloy 3C Product Cover [J]. Forging Equipment & Manufacturing Technology, 2022, 57(4):4.