Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

Railway Signal Testing System on Account of Differential Evolution Approach

Minggui Huang, Yanhua Wang*
Liuzhou Railway Vocational Technical College, Liuzhou, Guangxi, China
*Corresponding Author.

Abstract:

Railway signal is a system whole composed of several railway components. At present, the test results of traditional simulation testing tools are usually characterized by poor versatility and low test inefficiency. The purpose of this paper is to improve the performance of railway signal testing system. The research method is to use differential evolution approach to improve the railway signal testing system. The innovation of the improved scheme proposed in this paper is to add the processing module of differential evolution approach to the traditional test system, which improves the test performance of the system fundamentally. Through the differential evolution approach processing of the collected railway signals, the clarity and accuracy of railway signals are improved, so as to enhance the acquisition of railway signals by the test system and fundamentally improve the test accuracy. This article studies the railway signal test system based on differential evolution approach, expounds the basic principle of railway signal test system and related content, analyzes the improvements of innovations, which add to the traditional system of differential evolution approach and improves railway signal test accuracy. The innovation of this scheme is conducive to the fundamental improvement of the railway signal testing system. The railway signal test system based on differential evolution approach has excellent results in the railway signal test.

Keywords*: Differential evolution approach, Railway signal, Signal test, System test.*

I. INTRODUCTION

Under the background of national railway speed increasing, railway signal has become the main signal. The safety of railway operation has been mentioned to an unprecedented height. It is a prerequisite for safe running that the railway signal equipment can receive the signal of frequency shifting track circuit accurately, so the railway signal equipment must be checked more accurately before leaving the warehouse. The design of railway signal test system based on differential evolution algorithm innovates and improves the traditional system, which greatly improves the test accuracy of railway signal and thus improves the test efficiency of railway signal efficiently. Many scholars at home and abroad have studied the railway signal. KiedrowskiPiotrKiedrowski. Piotr puts forward that a kind of filter has been used to separate the solution of the power supply circuit. Long-distance data transmission between the sign controller and the LED railway sign is carried out using PLC modems of the same frequency, so separation is required. This paper introduces the structure of the network and a set of equipment to realize this special wired sensor

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

network [1]. Cavuto A proposes that laser ultrasonic testing (LUT) is a nondestructive testing technology with good application prospects, but it has not been applied in practice due to some practical difficulties. The possibility of measuring the entire wheelset by bypassing the wheel keys will greatly reduce inspection time, but has not been proven. In fact, the attenuation of the signal along the path complicates the interpretation of the generated wave. It is intended to demonstrate how to combine simulation data with experimental data to optimize test settings to obtain clearly interpreted output data [2]. Nuryasin M F proposes that non-indicator light plays an important role in train signals. In order to keep the signal light standard, it must be maintained. This study designes wireless sensor networks (WSN) to capture signal parameters for monitoring, analysis, and storage. According to the Regulations of the Indonesian Ministry of Transport on railway signal lights, parameters obtained include light, voltage, temperature and the intensity of nearby signal lights [3]. The innovations of railway signal test scheme based on differential evolution algorithm proposed in this paper is that a more advanced differential evolution algorithm is used as the processing module of railway signal, and the above three researchers mainly for railway signals test is improved on medium, such as the first scholar of filter been used to separate the photoelectric signal of the power supply circuit, the second scholar's laser ultrasonic detection technology, the third scholar's non-indicator test method. The design of railway signal test system based on differential evolution algorithm is more advanced. Different from the improvement of railway signal medium by the above three scholars, the railway signal is processed by differential evolution algorithm fundamentally so as to improve the acquisition power of the test system.

The purpose of this study is to improve the test performance of railway signals, and the research method is to use differential evolution algorithm to process railway signals, so as to improve the signal test accuracy. The data prove that the railway signal test system design based on differential evolution algorithm, fundamentally, carrys out the railway signal differential evolution algorithm processing, processing and extraction of railway signals more precise, so as to improve the test performance of railway signal test system. Therefore, using differential evolution algorithm to test and design railway signal system is conducive to the technical progress of railway signal testing field, thus greatly improving the safety of railway field and improving the safety of railway transportation.

II. DESIGN AND EXPLORATION OF RAILWAY SIGNAL TEST SYSTEM ON ACCOUNT OF DIFFERENTIAL EVOLUTION ALGORITHM

2.1 Differential Evolution Algorithm

Differential evolution refers to the formation of the initial population, and then the initial population mutation, crossover and selection processing, and finally the algorithm results coming out [4-5]. Its overall structure is similar to that of genetic algorithm. The main difference with genetic algorithm is mutation operation. The mutation operation of differential evolution is based on the difference vector of chromosomes, and other operations are similar to genetic algorithm.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

2.2 Principle and Basic Flow of the Algorithm

The basic principle of the algorithm is as follows: firstly, the difference vector between the parent individuals is used to obtain the mutant individuals; The second step in the first step is to cross the two and get the cross result; The third step is to select the crossover results and form the next generation. The algorithm includes three core operations, mutation, crossover and selection, and follows the general flow of evolutionary algorithms [6-7]. The initialization process and operators are analyzed as follows:

(1) Generation of initial population

(2) Mutation operation

(3) Cross operation

(4) Select operation

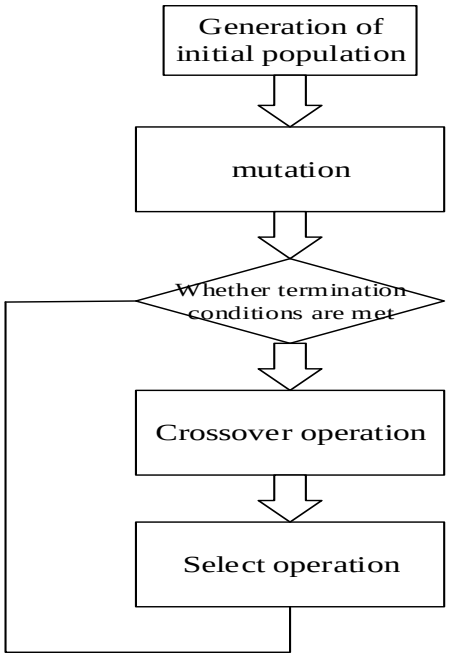

Fig 1: flow chart of basic differential evolution algorithm

All the operation procedures of the algorithm are carried out according to the above four steps, namely the generation of initial population [8-9]. The first step of differential evolution algorithm is to generate the initial population. Mutation operation, the initial population of individual mutation operation; crossover operation, mutation results crossover operation; selection operation, the collection of preferential selection, and finally getting the next generation after the algorithm processing. The basic flow chart is shown in Fig 1.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

2.3 Railway Signal Test System Design Based on Differential Evolution Algorithm

The detection range of railway signal testing system is divided into upper computer and lower computer [10-11]. The upper computer is generally used to collect the station map, record the display information and forward the railway control analog signal. The lower part of the machine is the analog signal equipment board card and the main control plate [12-13]. Structure analysis is as follows:

2.3.1 Design of the main control board

Design of main control board. The main control board card is composed of STM32F407 system and connected interfaces, which are generally used to connect the upper computer and simulate railway signals. The main control board receives the signal from the upper computer and parses it. After the analysis is successful, the signal is sent out. The specific way is to use the serial control bus to send information to each extended signal device. At the same time, each extended signal device collects the state information and transmits it back according to the loop. The signal is encapsulated in communication frame format and uploaded [14-15].

2.3.2 Analog signal machine board design

Board card design of signal machine. The railway signal is simulated and debugged so that the railway signal can achieve the best debugging effect. The railway signal is constantly adjusted so that the analog signal ADAPTS to each part of the circuit. At the same time, the analog signal unit circuit, circuit state detection and circuit wire break are designed [16-17].

2.3.3 Simulate the board card design of point machine

Analog switch machine board card design. The circuit signal of analog switch board also needs constant debugging until the best debugging effect is achieved. At the same time, the motor impedance unit, point machine contact unit and circuit circuit unit and circuit state detection are designed. Aiming at the key position of switch machine board card design, it meets the same three-phase impedance and when current limit reaching a certain condition, the energy consumption of analog resistance is set.

III. EXPLORE THE EFFECT OF RAILWAY SIGNAL TEST SYSTEM ON ACCOUNT OF DIFFERENTIAL EVOLUTION ALGORITHM

(1) Generation of initial population: The algorithm randomly generates N individuals to form the initial population:

$$x_{i,j,0} = l_j + rand() * (u_j - l_j), j = 1,2,...D, i = 1,2,...N \quad (1)$$

Where, $x_{i,j,0}$ represents the initial population with dimension J under the 0 evolution algebra, rand ()

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

represents the random number evenly distributed in the interval [0,1], u_j and l_j represents the last and next values of individual variables in the j-dimension respectively.

(2) Mutation operation: in each generation, the differential evolution algorithm randomly selects three chromosome vectors from the current population $X_{r_1,G}$, $X_{r_2,G}$ and $X_{r_3,G}$. $r_1, r_2, r_3 \in [1, N]$ is calculated as follows, variation vector formula:

$$V_{i,G} = X_{r_1,G} + F*(X_{r_2,G} - X_{r_3,G}) \tag{2}$$

F is the variation factor between values [0, 2], and its function is mainly used to scale the difference vector so as to control the search step.

(3) Crossover operation: The formula involved is as follows:

$$u_{i,G} = \begin{cases} v_{i,G}^{j}, if\ r \geq cr \quad or\ j = rand \\ x_{i,G}^{j} \end{cases} \tag{3}$$

Where, cr is the crossover probability, which is generally valued in the interval [0,1], and rand is the random number evenly distributed between [1, D], which is used to ensure that at least one one-dimensional component of the test individual $u_{i,G}$ is inherited from the mutant individual $v_{i,G}^{j}$, so as to avoid the same as the parent vector $x_{i,G}^{j}$,(4) selection operation:

$$X_{i,G+1} = \begin{cases} U_{i,G}^{j}, if\ f(U_{i,G}) \leq f(X_{i,G}) \\ x_{i,G}^{j} \end{cases} \tag{4}$$

Railway signal test system based on differential evolution algorithm is designed based on the railway signal after the samples for the processing of the above four steps, namely railway signal generating of initial population, the initial population variation samples, cross, the selection operation. It is concluded that the final results are checked for conformity.

Then the railway signal testing system including upper computer and lower computer signal detection, respectively divided into three steps :(1) the main control board card; (2) Analog signal machine board card; (3) Simulate the board card of point machine to test railway signals respectively. Use the above four formulas to test railway signals one by one.

(1) Try to connect the outgoing route and return route of the main control board and the splitter board to connect the two lines. Test operation: assume that the railway area is not used by vehicles, observe when

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

the indoor state GJ is sucked up, now set the railway area,when the indoor state GJ falls. This phenomenon indicates that the function of the main control board card has no problem.

(2) If the connecting line between the signal plate and the splitter board is connected, when the signal light on the analog signal board is on, the indoor GJ is sucked up. This phenomenon indicates that the function of the signal board is normal.

(3)If the interface of the board card of the point machine is connected with the going and returning lines of the dividing board, when the signal light of the analog board card of the point machine is on, DBJ is drawn up, and FBJ is dropped. At this time, reverse operation, if the board signal light is off, abnormal signal light is on, DBJ falls, FBJ is sucked up. This phenomenon shows that the board function of the switch machine has no problem.

IV. INVESTIGATION AND ANALYSIS OF RAILWAY SIGNAL TEST SYSTEM DESIGN ON ACCOUNT OF DIFFERENTIAL EVOLUTION ALGORITHM

Click the interface using VS platform and select MFC and DEV languages to perform test and effect comparison on graphical user interface (GUI), as shown in Table I. Communication Settings and Experience Setting; Universal delay time(s), Special delay time1(s), interlocking, modbus (port name 1), can-communication (port name 2), Collect the extension number (port name 3). Open the software, enter the initialization interface, and manually introduce the Ribbon area. The Ribbon area indicates that various types of railway signal program scripts can independently form functional areas, such as station indication, do not enter command, allow passage and other options. After these functional scripts are generated, click the save button to save all the functional scripts and the saved ones, and then the data will be saved to the database. Before operation, delay setting and communication interface setting are required, TABLE I for details.

TABLE I. Script generation system track signal control interface

DELAY		Communication Settings		Experience setting
Universal delay time(s)	150	interlocking	19	Lab default initial value
Special delay time1(s)	2000	modbus	12,15,20,22	Read from the station database
Special delay time2(s)	3000	CAN-communication		
Special delay time3(s)	5000	Collection extension	04	

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

Fig 2 shows that total number of test scripts in 3 cities (Nanchang, Wuhan, Changsha) in the field of Main control board, Analog signal board card and Simulate switch machine board card. Where, the horizontal coordinate represents the script tests in three items: Main control board, Analog Signal board card and Simulate switch machine. The ordinate indicates the number of tests. Fig 2 shows that the Main control board has been tested 18 times in Nanchang, 28 times in Wuhan and 22 times in Changsha. Analog Signal board cards have been tested 120 times in Nanchang, 123 times in Wuhan and 154 times in Changsha. In terms of Simulate switch machine board card, 256 times were tested in Nanchang, 289 times in Wuhan, and 322 times in Changsha.

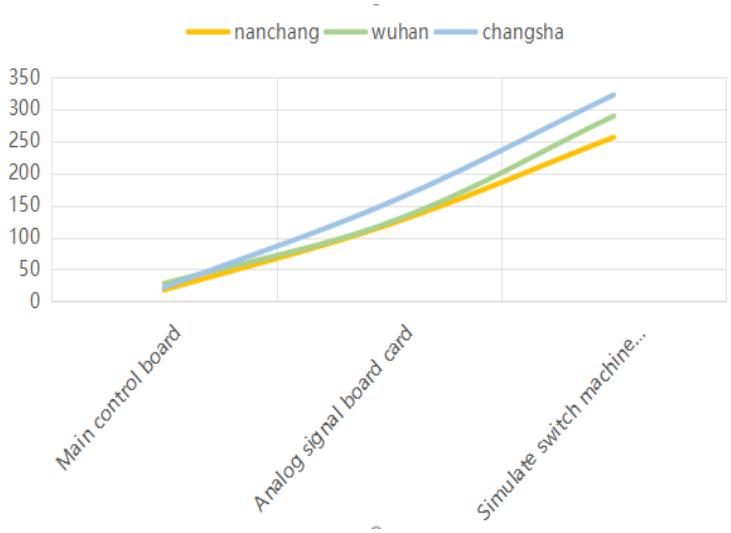

Fig 2: Number of application site and test script tests

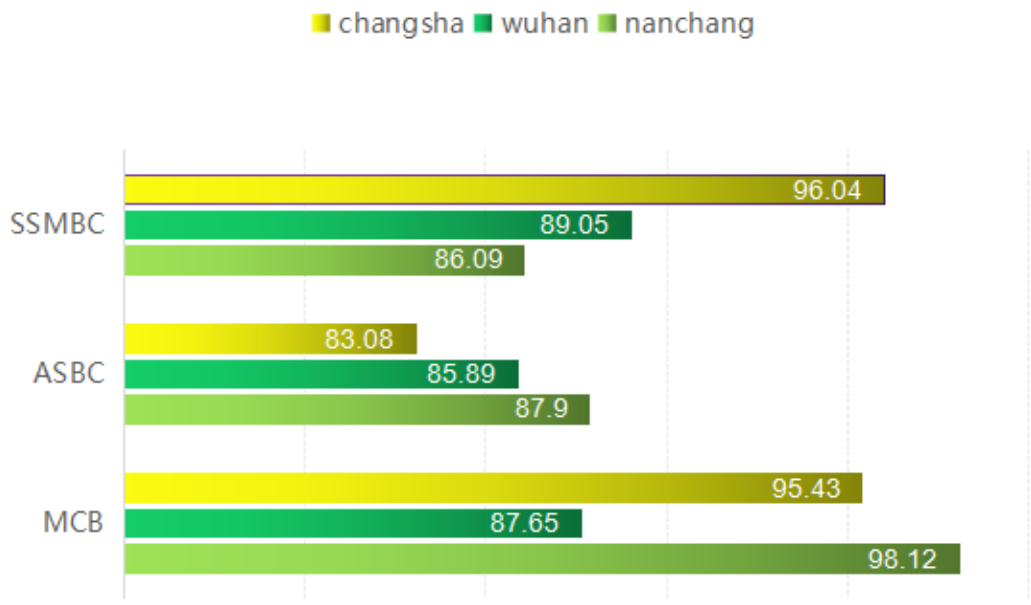

Fig 3: Railway signal test accuracy in 3 cities

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

Fig 3 shows the Main Control board (MCB) and Analog Signal board card (ASBC) and Simulate Switch Machine Board card (SSMBC) in Nanchang, Wuhan and Changsha. Fig 3 shows that the test scores of Main Control board (MCB) in Nanchang, Wuhan and Changsha are 98.12, 87.65 and 95.43 points. The scores of Analog Signal board card (ASBC) in Nanchang, Wuhan and Changsha are 87.9, 85.89 and 83.08. The scores of Simulate Switch Machine Board card (SSMBC) in Nanchang, Wuhan and Changsha are 86.09, 89.05 and 96.04 points. The results show that the railway signal test system based on differential evolution algorithm has achieved more than 80 points of excellence in railway signal test results.

V. CONCLUSIONS

In view of the increasing requirements of equipment testing, the shortcomings and existing disadvantages of the traditional simulation disk are analyzed and summarized, and the general simulation disk is developed and innovated by using computer tools in accordance with the advanced research and development theory, so as to fundamentally solve the defects and deficiencies of the traditional simulation disk, and to improve the performance of the simulation disk. After continuous innovation and research and development of analog disk, the versatility and testing and efficiency of analog disk are improving. At the same time, the volume of the innovative system is smaller and the control box and other components, such as wire tray, cable, etc., are connected, so that it can be more convenient to troubleshoot the line failure of each part. The design of railway signal test system based on differential evolution algorithm improves the test and application of railway signal and promotes the improvement of railway signal test skills.It is conducive to the development and progress of railway technology.

FUND PROJECTS

This work was supported by the Guangxi University Innovation Team and Excellence Scholar Program
.

REFERENCES

[1] KiedrowskiPiotrKiedrowski.Piotr@utp.edu.plSaganowskiŁukaszInstitute of Telecommunications and Computer Science, UTP University of Science and Technology in Bydgoszcz Poland, Al. Prof. S. Kaliskiego 7, 85-796Bydgoszcz, Poland. Method of Assessing the Efficiency of Electrical Power Circuit Separation with the Power Line Communication for Railway Signs Monitoring. Transport and Telecommunication Journal, 2021, 22(4):407-416.

[2] Cavuto A, Martarelli M, Pandarese G, et al. FEM Based design of experiment for train wheelset diagnostics by laser ultrasonics. Ultrasonics, 2021, 113(5):106368-106368.

[3] Nuryasin M F, Wibawa B M, Taufik M. Wireless Sensor Network (WSN) untuk Predictive Maintenance Lampu Sinyal Kereta Api. ELKOMIKA Jurnal Teknik Energi Elektrik Teknik Telekomunikasi & Teknik Elektronika, 2020, 8(2):418-418.

[4] Ghoneim S, Kotb M F, Hasanien H M , et al. Cost Minimizations and Performance Enhancements of Power Systems Using Spherical Prune Differential Evolution Algorithm Including Modal Analysis. Sustainability, 2021, 13(14):8113-8113.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 768-776
Article History: Received: 30 March 2022, Revised: 8 April 2022, Accepted: 15 April 2022, Publication: 30 April 2022

[5] Mutlu M M, Aksoy L C, Alver Y. COVID-19 transmission risk minimization at public transportation stops using Differential Evolution algorithm. European Journal of Transport and Infrastructure Research, 2021, 21(1):53-69.
[6] Setiadi H, Swandaru A, Nugroho T A. Design feedback controller of six pulse three phase rectifier based on differential evolution algorithm. Indonesian Journal of Electrical Engineering and Computer Science, 2021, 22(2):670-670.
[7] Venkatakrishnan GR, Rengaraj R, Sathish K K, et al. Implementation of Modified Differential Evolution Algorithm for Hybrid Renewable Energy System. Journal of the Nigerian Society of Physical Sciences, 2021, 3(3):209-215.
[8] Kien C V, Anh H, Son N N. Adaptive inverse multilayer fuzzy control for uncertain nonlinear system optimizing with differential evolution algorithm. Applied Intelligence, 2021, 51(1):527-548.
[9] Brindha S, Miruna J. A robust and adaptive fuzzy logic based differential evolution algorithm using population diversity tuning for multi-objective optimization. Engineering Applications of Artificial Intelligence, 2021, 102(2):104240-104240.
[10] Chakravarthi M, Chandramohan B. Calibration of Offsets in Time-Interleaved ADCs in an OFDM Receiver Using Differential Evolution Algorithm. Optoelectronics, Instrumentation and Data Processing, 2021, 57(3):287-296.
[11] D Safari, Maheri M R, Maheri A. Optimum Design of Steel Frames Using Different Variants of Differential Evolution Algorithm. Iranian Journal of Science and Technology, Transactions of Civil Engineering, 2021, 45(4):2091-2105.
[12] Dhanalakshmy D M, Akhila M S, Vidhya C R, et al. Improving the search efficiency of differential evolution algorithm by population diversity analysis and adaptation of mutation step sizes. International Journal of Advanced Intelligence Paradigms, 2020, 15(2):119-119.
[13] Elisov N A, Ishkov S A, Khramov A A. Application of differential evolution algorithm in the problem of aeroassisted orbital plane change maneuver. VESTNIK of Samara University Aerospace and Mechanical Engineering, 2020, 18(4):41-41.
[14] Mochizuki H, Nakamura H. Evaluation of an error correction function using correlation characteristics of spread codes in CDMA-based transmission methods. Journal of Physics Conference Series, 2021, 1780(1):012036-012036.
[15] Mikuli M, Mlinari T J. Railway Capacity Enhancement with Modern Signalling Systems – A Literature Review. Promet - Traffic - Traffico, 2021, 33(1):141-152.
[16] Kunisaki A, Fujita H, Nomura T, et al. Lifetime Evaluation Method for Electronic Equipment of Wayside Signalling Systems. Quarterly Report of RTRI, 2021, 62(2):110-117.
[17] Burkov V N, Enaleev A K, Strogonov V I, et al. Models and Management Structure for the Development and Implementation of Innovative Technologies in Railway Transportation. I. Mechanisms of Priority Projects Selection and Resource Allocation. Automation and Remote Control, 2020, 81(7):1316-1329.