Personalised Dormitory Roommate Matching System Based on Multiple Swarm Genetic Algorithms

Lingyu Zhang , Lili Wang[*], Yiyang Dai, Qisheng Chen, Jinxuan Shen and Hao Lin

School of Computer Science and Technology, Harbin University of Science and Technology, Harbin, China

wanglili@hrbust.edu.cn

Keywords: Roommate Matching System, Multiple Swarm Genetic Algorithm, Vue, Golang

Abstract: In order to allocate suitable dorm rooms for students more effectively and improve the matching degree of interests, living habits and future plans between roommates, this paper designs a personalised dorm room roommate matching system based on multiple swarm genetic algorithms. The system uses Vue framework to build the front-end, which is responsible for user interaction and information collection; the back-end uses Golang language to process the data and call the dormitory allocation procedure; the database uses SQLite to store the data; and the dormitory allocation procedure is based on multiple cluster genetic algorithms written in Python. Student information is collected through a front-end questionnaire, and the user can manually set the weight of each preference. The system will automatically iterate the optimal roommate assignment programme and return the results to the front-end.

1. Introduction

Dormitories in colleges and universities serve multiple roles beyond just providing a place to rest. They are spaces for learning, socializing, and self-expression, directly impacting students' academic performance and mental well-being. With the expansion of higher education in China, the increasing student population and improvements in socio-economic factors and technology have highlighted the significant role of dormitories in student education.

Currently, dormitory management is facing multiple challenges and changes. Conflicts within student dormitories stem from multiple sources, including personality differences, living habits, work schedules, interests, family backgrounds, and other factors [1]. By domestic and international studies have shown that dormitory peer effects [2] have a wide range of impacts on the quality of life of college students, including shaping their outlook on life, values, promoting learning motivation, and playing an important role in the development of their psychological health. Currently, a variety of intelligent algorithms have been proposed for resource allocation problems such as dormitory assignment, including greedy algorithm [3], backtracking method [4], K-means algorithm [5] and k-modes clustering algorithm [6]. These methods have common problems such as locally optimal solutions, low algorithmic efficiency, insufficiently comprehensive objective functions, difficulty in adjusting parameters, and restricted search space.

In this paper, a personalized dormitory roommate matching system based on multiple swarm genetic algorithm [7] is designed to address the above problems. Multi-population genetic algorithm has a strong global search ability, can find the optimal solution or near-optimal solution in the complex solution space, and is not easy to fall into the local optimum. The system adopts homogenized dormitory allocation according to the characteristics of different students, aiming to achieve more reasonable roommate allocation through genetic algorithms, improve the degree of matching between members in the dormitory, and promote solidarity and mutual assistance and common development.

2. System Analysis

2.1. Demand Analysis

The system has two types of users: administrators and students. The administrator manages user information, designs questionnaire types and posts completion announcements. Students log into the system to fill out the questionnaire and then wait for the results. The administrator collects the questionnaires and clicks on the "Assign" button, and the system uses genetic algorithms to assign students to dormitories. The allocation result is sent to the students and they can check the roommate information and questionnaire options. If they are satisfied, they can confirm the allocation result; if they are not satisfied, they can request a second allocation and confirm it again after the second allocation., as shown in Figure 1 of the system example.

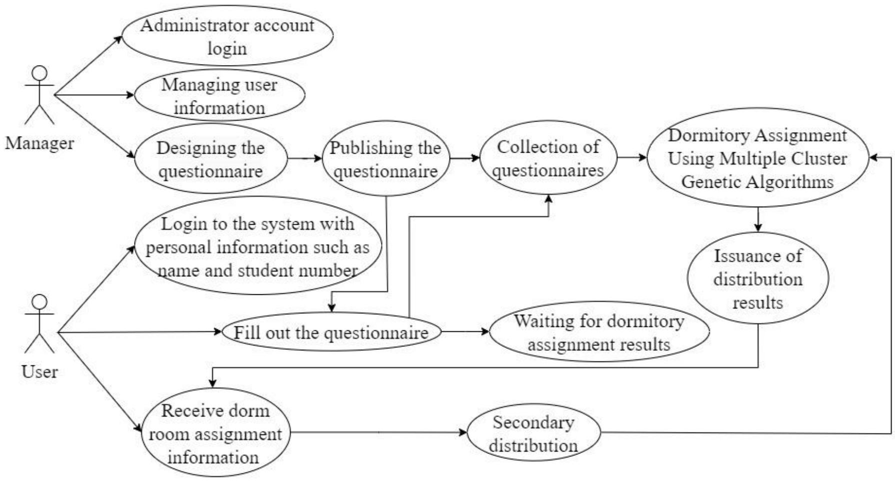


Figure 1: Use case diagram of system.

2.2. System Framework

This system integrates Vue framework, Golang language (using Gin framework for front-end and back-end communication and Gorm framework for database management), SQLite database and Python language to achieve personalized dormitory assignment based on multi-population genetic algorithm. The front-end is responsible for user interaction and information collection, collecting students' preferences in the form of questionnaires and passing the data to the back-end for processing. The back-end uses Go language to interact with SQLite database for storing student information and allocation results. Multiple Swarm Genetic Algorithm program written in Python receives the student information and preference data passed to the backend for roommate assignment and returns the optimal solution to the backend. The system architecture is shown in Figure 2.

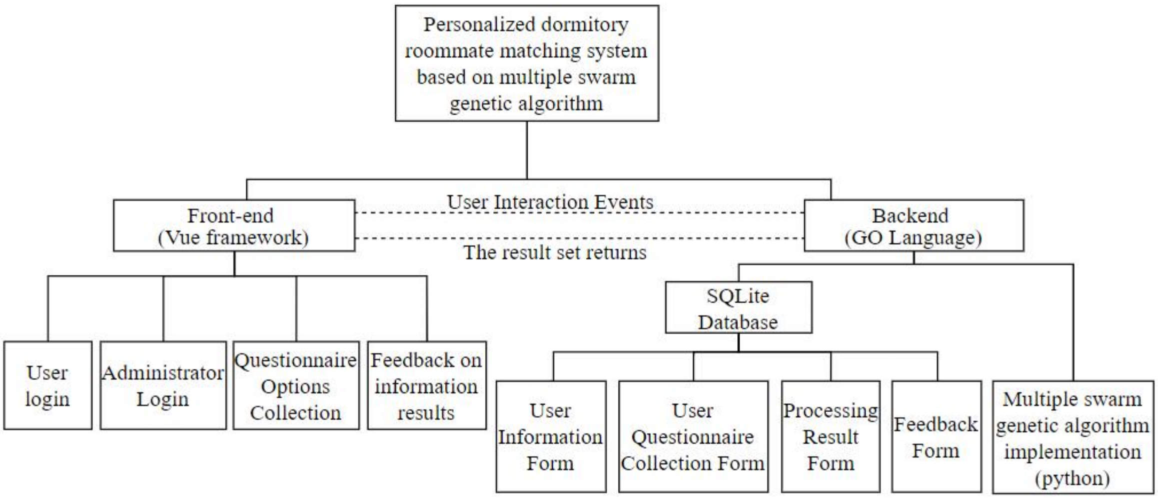


Figure 2: System architecture diagram.

3. Data Acquisition and Processing

3.1. Questionnaire Design

The system collects data through a questionnaire survey before the start of the school year, which includes students' personal information, life behaviors, personal hygiene, hobbies and interests, and consumption tendencies. Personal information includes basic information such as name, gender, major, age, place of origin and ethnicity, taking into account factors such as same-gender grouping and major grouping. The living habits section covers sleeping time, waking time, willingness to synchronize work and rest time, and study or entertainment preferences in the dormitory, aiming to improve comfort and study environment. The personal hygiene section includes dorm room tidiness requirements, cleaning cycles, and bathing cycles, focusing on reducing conflicts and ensuring tidiness and hygiene. The Spending Preferences section examines monthly living expenses, major spending, willingness to go out and share spending with roommates to ensure compatibility among roommates. The hobbies section addresses students' interests and whether they wish to share them with their roommates, and the system matches roommates with similar interests to facilitate communication. Other categories include shared space issues such as smoking, drinking, snoring, and sleep quality to effectively address potential conflicts.

3.2. Database Design

To facilitate maintenance, SQLite, which is easy to maintain, was chosen as the data storage solution. The data tables include login table, basic user information table, user habits table, allocation results table and information feedback table. The entity-relationship (E-R) diagram of the database is shown in Figure 3.

4. MPGA Multiple Population Genetic Algorithm

Genetic algorithms (GA) use the gene crossover mutation mechanism to simulate the biological inheritance and evolutionary process, and carry out iterative probabilistic optimization search for specific objectives. However, the stochastic operation of genetic algorithms will exclude the optimal individuals of the parent generation from the population with a certain probability [8], and is prone to fall into local optimal solutions. Dormitory allocation involves the needs and preferences

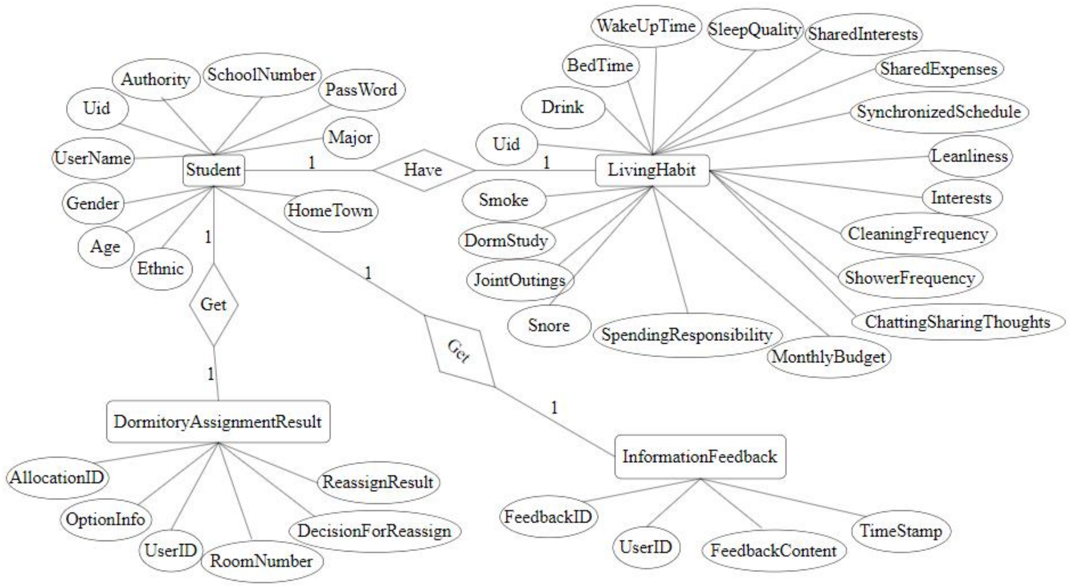


Figure 3: E-R diagram.

of multiple student groups, and GA needs to perform a large number of iterative searches to converge to the optimal solution, and the convergence speed is slow. To address the above problems, this system introduces multiple population genetic algorithm (MPGA). MPGA divides the search space into subspaces and uses small populations with different parameters for parallel exploration. The immigration mechanism [9] promotes population connectivity by replacing the least adapted individuals with the most adapted individuals from other populations. The best individuals in each population are retained to form an elite population, which helps to assess convergence. Meanwhile, independent genetic operations allow some sub-populations to focus on local search while others focus on global exploration of optimal solutions.The flowchart of the MPEG algorithm is shown in Figure 4.

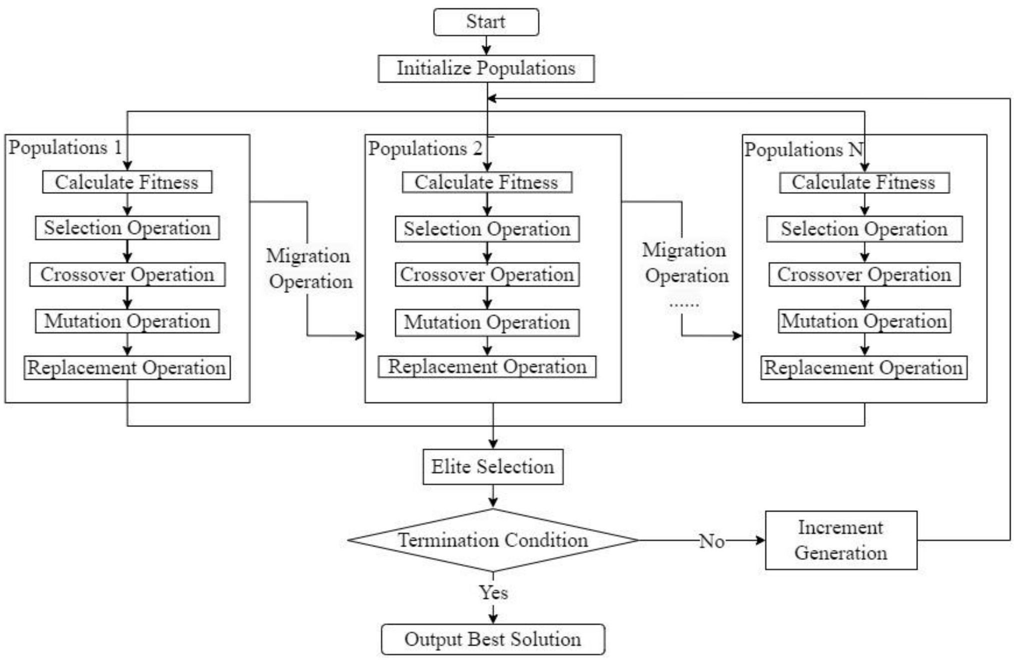


Figure 4: MPEG Algorithm Flowchart.

4.1. Design of the Fitness Function

In MPGA, fitness functions are used to assess the fitness of an individual and guide selection, crossover, and mutation during evolution.

$$f(A)=\frac{\sum_{R\in A}\sum_{x,y\in R\wedge x\neq y}\frac{1}{|R|\times(|R|-1)}\sum_{i}\frac{w(i)}{(x_i-y_i)^2+1}}{\sum_{R\in A}|R|} \tag{1}$$

Where: A denotes a legitimate global bedding scheme constructed from a single DNA individual (i.e., arrangement I); R denotes the set of students in a particular dormitory; x and y represent two different students in the dormitory; x_i or y_i denotes the degree of the student's preference for issue i; and w is a weighting function used to modulate the degree to which each issue influences bedding.

4.2. Variational Operator Design

This systematic variation operator uses random exchange variation, where for an individual in an alignment (i.e., a DNA sequence), a new individual is generated by randomly selecting two different positions and exchanging the elements at these two positions.

$$I=[x_1,x_2,\ldots,x_N] \tag{2}$$

Where: I is the individual in the arrangement; N is the length of the arrangement; x_i is the element in the i th position of the arrangement. The mutation operation is as follows:

$$I'=swap(I,j,k) \tag{3}$$

Where: $swap(I,j,k)$ denotes the exchange of elements at position j and position k in individual I.

4.3. Intersection Operator Design

The crossover operator in this system uses single-point crossover to maintain individual integrity and ensure that the offspring are still valid dormitory allocation schemes to avoid generating invalid solutions. Suppose there exist two parent individuals P_1 and P_2, representing two different dormitory room allocation schemes. These individuals can be considered as DNA sequences consisting of students, where each position i represents a student:

$$P_1=[x_1,x_2,\ldots,x_i,\ldots,x_n] \tag{4}$$

$$P_2=[y_1,y_2,\ldots,y_i,\ldots,y_n] \tag{5}$$

Where: n is the number of individuals in the subpopulation.

A crossover point C (at position k) is randomly chosen. The crossover position of the two parent individuals is determined. The two parent individuals are split into two parts and then exchange their tails to form new offspring individuals, Q_1 and Q_2:

$$Q_1=[x_1,x_2,\ldots,x_k,y_{k+1},y_{k+2},\ldots,y_n] \tag{6}$$

$$Q_2=[y_1,y_2,\ldots,y_k,x_{k+1},x_{k+2},\ldots,x_n] \tag{7}$$

4.4. Immigration Arithmetic Design

The immigration operator is used to facilitate the exchange of information and migration of individuals between different populations, and is usually triggered periodically at a certain frequency during the evolution of MPGAs. When the immigration operator is triggered, it selects a certain number of individuals to be migrated from one or more populations to another. The migration operator design process is as follows:

(1) Initial subpopulations:

$$R_i = \{I_1, I_2, \ldots, I_n\} \tag{8}$$

Where: n is the number of individuals in the subpopulation.

(2) Migration selection, where k individuals are randomly selected based on the migration rate mr:

$$k = \lfloor n \cdot mr \rfloor \tag{9}$$

Where: $\lfloor x \rfloor$ denotes rounding down to the nearest integer for x.

(3) The set of immigrants, let $M_i \subseteq R_i$ be the set of immigrants chosen from R_i:

$$|M_i| = k \tag{10}$$

(4) Immigration exchange: select another subpopulation R_j, remove k individuals from R_j to form M_j, and then add M_i to R_j.

(5) Renewal of stocks:

$$P_j^{new} = (P_j \setminus M_j) \cup M_i \tag{11}$$

Where: $\setminus$ denotes the set difference operation and $\cup$ denotes the set concatenation operation.

5. Functional Module

The user login module adopts the form of account password assigned by default, and the specific format of the assignment is set by the school according to the management of student information. The system will query the identity information in the database when logging in, and if it is an administrator, it will automatically jump to the administrator page.

The system interface includes separate modules for student users and administrators. The student interface displays the system name, sidebar and main content area. The administrator interface includes functions such as questionnaire design, announcement posting, user management, process permission assignment, and feedback collection.

The questionnaire module collects user preferences through a variety of question formats such as fill-in-the-blank, single choice and multiple choice. After submitting the questionnaire, users can view roommate assignments and profiles. If they are not satisfied, they can confirm the assignment or request a secondary assignment. Each student is given an opportunity for a secondary assignment with the aim of increasing satisfaction with the room assignment.

6. System Test

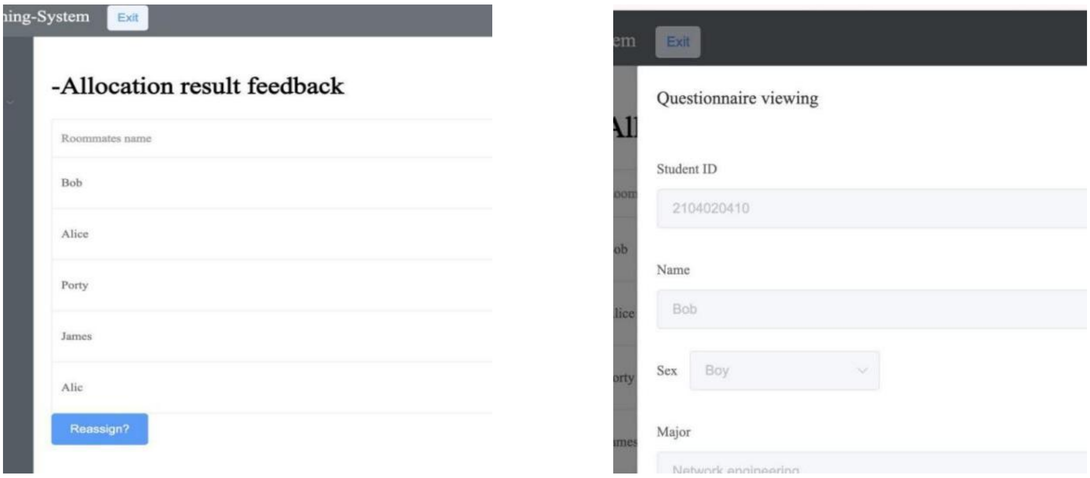
6.1. Questionnaire Completion

In the questionnaire interface, the user can view and fill in the questionnaire as shown in Figure 5. After collecting the questionnaires the system will utilize multiple swarm genetic algorithms for dormitory assignment.

6.2. Dormitory Allocation Result Inquiry and Feedback

After the first dorm assignment, the user will be notified of the results, including information about the assigned roommate and the questionnaire they filled out, as shown in Figure 6. If they are not satisfied, they can click "Re-assign" to request a new assignment. After confirming the dormitory assignment, users can rate their satisfaction and submit feedback to the system.

Figure 5: Questionnaire filling interface.

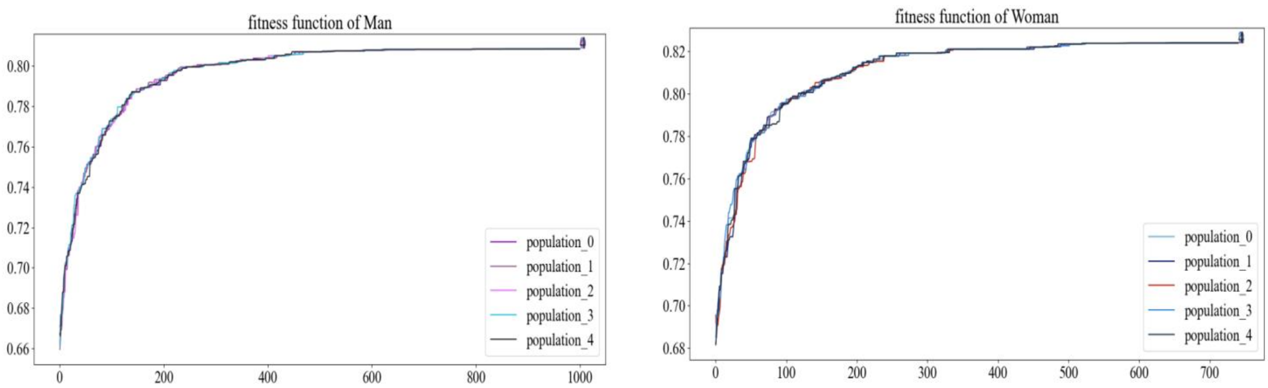


(a) Allocation result feedback (b) Questionaire reviewing

Figure 6: Allocation results interface.

6.3. Dormitory Allocation Result Inquiry and Feedback

The system was optimized using multiple swarm genetic algorithms for boys' and girls' dormitory assignments and their fitness functions were evaluated as shown in Figure 7. The results show that the girls' fitness function tends to converge after 700 iterations, while the boys' fitness function converges after 1000 iterations. The fitness values for both reached about 0.82, indicating that most students were satisfied with the current allocation scheme.



(a) Fitness function of Male (b) Fitness function of Female

Figure 7: Adaptation assessment for male and female students..

7. Conclusions

This research system is built with Vue framework, Golang language, and SQLite database, and MPGA Multiple Swarm Genetic Algorithm is used to realize the roommate assignment function. The administrator is responsible for user information management and questionnaire design, and the students fill out the questionnaire and wait for the allocation result. The customized questionnaire collects the data of new students' personal information, living habits, consumption tendency and interests to achieve the accurate matching of roommates and optimization of dormitory allocation. The user login module adopts the default allocation method, which simplifies the login process and improves the ease of use of the system. The student user operation module provides a clear interface and convenient functions to meet the needs of users to fill out questionnaires and browse the system. The questionnaire module is used to collect personalized information and provides data support for roommate matching. The Administrator Operation Module includes functions such as questionnaire design, announcement release and user management, providing comprehensive system management support. The result feedback module allows students to view the roommate assignment results and make secondary assignments, which further enhances the flexibility and user satisfaction of the system. The design and implementation of this system provides an efficient and accurate solution for university dormitory management, with good application prospects and promotion value.

Acknowledgements

This work is sponsored by the Innovation and Entrepreneurship Training Program for College Students in Heilongjiang Province (S202310214021).

References

[1] Gao Miao. (2010). How to Prevent College Dormitory Conflicts and Resolve Disputes. Journal of College Advisor, (02), 19-21. doi:10.13585/j.cnki.gxfdyxk.2010.02.007.

[2] Sacerdote, B. (2001). Peer effects with random assignment: Results for Dartmouth roommates. The Quarterly journal of economics, 116(2), 681-704.

[3] Deng Xihui. (2011). Greedy Algorithm Scheduling System Research. Computer & Telecommunication, (07), 29-30. doi:10.15966/j.cnki.dnydx.2011.07.010.

[4]WANG Wen-fa, MA Yan, & LI Hong-da. (2008). Application and research of backtracking algorithm based on matrix storage in multi-constraint assignment problem. Journal of Southwest Minzu University (Natural Science Edition), (05), 935-939.

[5] SUN Hui-ting & MA Jian. (2019). Research on College Intelligent Dormitory Allocation Based on K-means Algorithm. Computer & Telecommunication, (05), 29-32. doi:10.15966/j.cnki.dnydx.2019.05.008.

[6] Zhang Quan, Xue Shanshan, & Zou Chengdong. (2023). Protection and Development Strategy and Classification of Historical and Cultural Villages in Anhui Based on K-modes Clustering Algorithm. Huazhong Architecture, (01), 23-27. doi:10.13942/j.cnki.hzjz.2023.01.018.

[7] MEI Zhen, GONG Jiacheng, GAO Yichao, WEI Lin, & LI Haifeng. (2024). Integrated optimization of structure and control systems based on a modified adaptive multi-population genetic algorithm. Journal of Central South University: Science and Technology, (02), 799-809.

[8] GAO Hongjian, CHEN Linzhouting, HU Jianxing, SU Xiaodong, WANG Yangsheng, & WANG Wenju. (2024). Research on Self-optimizing Method of Missile Stability Control Parameters Based on Improved Genetic Algorithm. Machinery & Electronics, (04), 22-28.

[9] HAN Yuchen, LYU Weicai, ZHONG Chen, XIAO Xingxing, & LIU Qinghua. (2021). Research on Geomagnetic Indoor Positioning Algorithm Based on MPGA-SVM. Radio Engineering, (11), 1313-1319.