

Application and Analysis of Improved Ant Colony Algorithm in Physical Fitness Test

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Objectives: The ant colony algorithm is an algorithm that the Italian scholar sums up by studying the living habits of the creatures, and algorithm model established by inspiration according to ants finding things in the shortest path. **Methods:** In this paper, through the establishment of algorithm model based on an ant colony algorithm, all kinds of problems in physical fitness test were solved, which makes the physical test more efficient and convenient. **Results:** Through the testing and use of the algorithm model, it is found that the ant colony algorithm established in this paper can meet the requirements, can plan the information of physical fitness test as a whole, **Conclusion:** and help to deal with the problems of physical tests, so it is a good performance algorithm.

Keywords: ant colony algorithm; application analysis; physical fitness test

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With the deepening of computer technology applications, many problems are calculated by using computer algorithms. In particular, at present, colleges and universities continue to expand enrollment, students continue to decline in physical fitness, the importance of physical fitness test is self-evident. As the number of people increases, the difficulty of physical testing is also increasing, if the manual processing alone, these problems have been difficult to solve, so this article uses ant colony algorithm to calculate the operation, reduce the operation difficulty of physical fitness test.¹ However, the current ant colony algorithm has some defects, which should be modified and processed in the process of using, and adapted to the ant colony algorithm suitable for this paper. But this is quite difficult, this paper will conduct a detailed study, to overcome the difficulties, so as to bring the ant colony algorithm into a new world.²

This paper first introduces the model of the ant colony algorithm, introduces the most basic algorithm formula of the ant colony algorithm, then adapts the ant colony algorithm into the

algorithm suitable for this paper, and tests and uses the modified ant colony algorithm, demonstrates the great superiority of this algorithm by means of a controlled experiment.³ The establishment of this algorithm model can reduce the workload of physical tests to make it more reasonable, and can use less time to achieve greater success.⁴ In addition, in this paper, the use of physical fitness test will greatly expand the use of ant colony algorithm, and do what little one can to help. Most importantly, this will provide great help to the future research of ant colony algorithms, which reduces the later study pressure, also make a new step of development of the ant colony algorithm.⁵

The ant colony algorithm was first developed and popularized by Italy scientists in the early 90s of the last century. Once found, it has aroused wide attention from all walks of life, a large number of scholars have carried on research and promotion for it. At present, abroad, ant colony algorithm has become a major calculation method, can be used to solve many problems, and achieved great success.⁶ Although this algorithm invented late, started very high, at this stage, in the highly developed computer technology, ant

colony algorithm is quickly used in various fields. However, due to the reason of too short time, foreign scholars still haven't developed a set of systematic analysis method and solid mathematical foundation.⁷This also limits the development and progress of ant colony algorithm, but scholars are trying to solve these problems.⁸

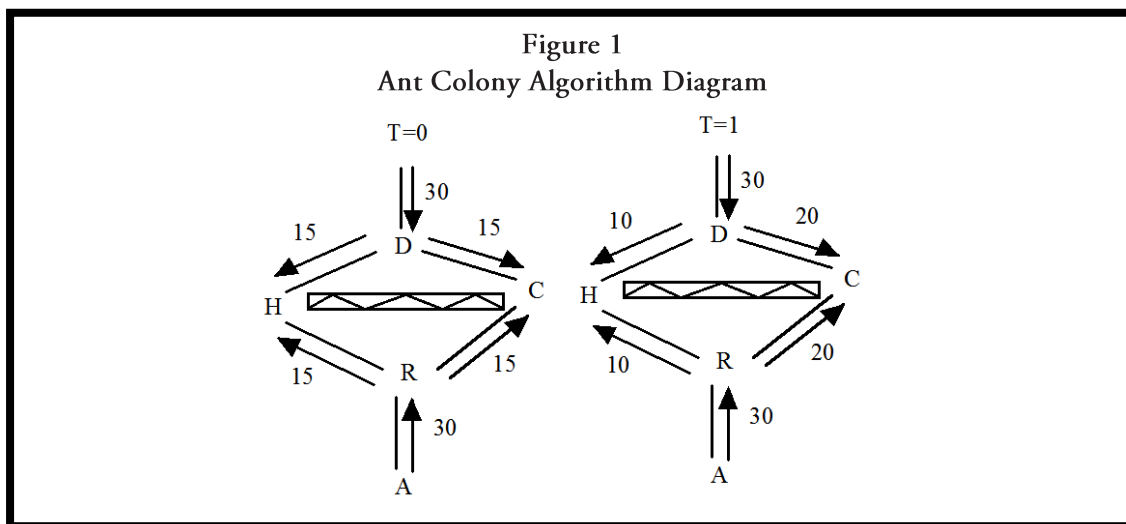
In recent years, domestic and foreign scholars have done a lot of work in the improvement and application of ant colony algorithm. The common purpose is to improve optimization ability of the ant colony algorithm in space complexity under the constraint of reasonable time complexity, so as to improve the global convergence of ant colony algorithm and broaden the application field of ant colony algorithm, so as to improve the global convergence of ant colony algorithm and broaden the application field of ant colony algorithm. Through the joint efforts of various disciplines scientists, the research speed and development speed of ant colony algorithm have risen in a straight line, believing that in the future, it will be as mature as the neural network

algorithm.⁹ The development of domestic ant colony algorithm is basically in line with international practice. In the 1990s, the domestic scholars have been keen about this and began to study and use for a long time. After 20 years of development, at present, the development level is an international first-class level.¹⁰

METHODS

Basic ant colony algorithm model

The ant colony algorithm is an algorithm research based on bionics proposed by the Italian scholar, which mainly takes ants searching for food as the prototype to design the shortest route and solve the common discrete optimization problem. In the natural ant colony, ants go out to search for food, and ants go through all kinds of routes, ants always find the shortest path. In the process of crawling on the ground, the ants will secrete a kind of information hormone, affecting the nearby ants, and the end result is that ants that choose the shortest path will be more and more. The ant colony algorithm is shown in Figure 1 below.



Ant colony algorithm was originally used to solve travel problems, and then was extended to solve all kinds of problems, the physical test of this problem is a category extended. In this paper, the number of ants in the ant colony is M , $d_{ij}(i, j = 1, 2, \dots, n)$ means the distance between the vertex i, j , that is, the path

length. $B_i(t)$ represents the number of ants at point i at time t . $\tau_{ij}(t)$ represents the amount of residual information left by the ants on route (i, j) at time t . The more the path the ants pass through, the more information, of course, at the initial moment, the residual information is zero. In order to ensure that the residual information on each path is the same at

the beginning, in the course of movement, ants $k(k=1,2,\dots,M)$ move according to the residual information of each road. At time t , the probability of ants moving from i to j is represented by the following formula:

$$p_{ij}^k(t) = \begin{cases} \frac{[\tau_{ij}(t)^\alpha [\eta_{ij}]^\beta]}{\sum [\tau_{ij}(t)^\alpha [\eta_{ij}]^\beta]}, & j \in allowed_k \\ 0, & other \end{cases} \quad (1)$$

The formula of the number of ants M is as follows:

$$M = \sum_{i=1}^n B_i(t) \quad (2)$$

The above formula is explained below. Among them, $allowed_k$ represents the vertex when ant chooses the next route. η_{ij} represents the expected value of the ant from the vertex i to the next vertex j . The expected value is constantly changing as an ant's path length. The size of η_{ij} comparing with 0 determines the next step of the ants, if it is greater than zero, then it shifts to neighborhood j according to the probability p , if less than zero, then the ant walking route becomes a search state, search radius is r . α , β represent the information and heuristic factor that ant accumulated in the course of the campaign. Assuming that the retention factor of the information hormone is $\rho(0 \leq \rho \leq 1)$, it reflects the persistence of the information hormone strength; and $1-\rho$ represents the degree of extinction of the

information hormone. After the Δt period, the ants complete a cycle, the refresh formula of information hormone quantity on each arc (i, j) is:

$$\tau_{ij}(t + \Delta t) = \rho \tau_{ij} + \Delta \tau_{ij} \cdot \Delta t \quad (3)$$

Among them, $\rho \in (0,1)$ is the evaporation factor because the information left on the path will gradually fade over time, and the parameter ρ represents the degree of attenuation of the amount of information $\tau_{ij}(t)$ over time. The information increment $\Delta \tau_{ij}(t)$ can be expressed as:

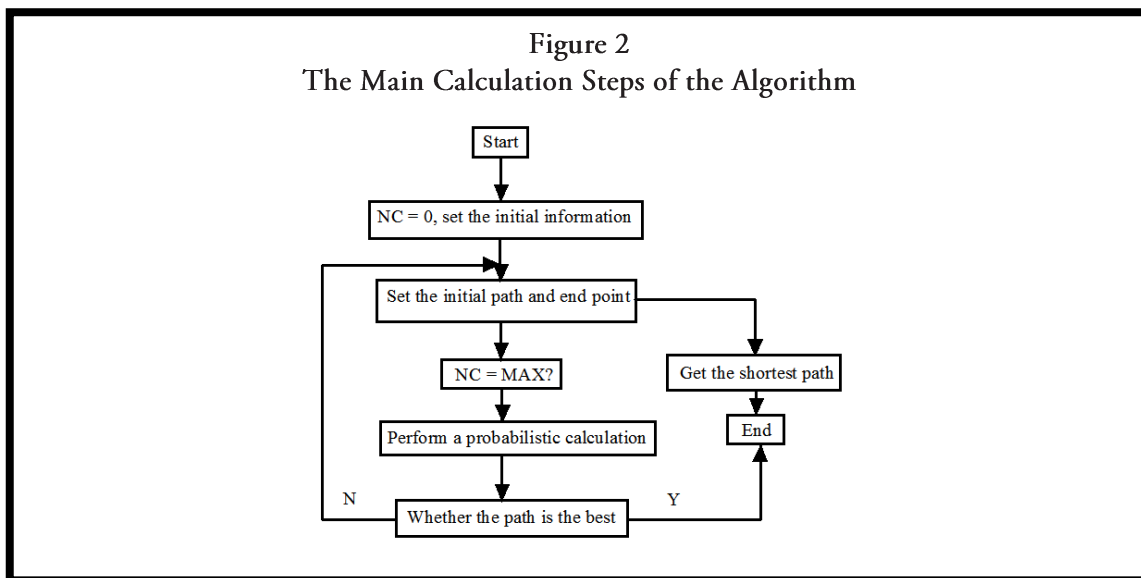
$$\Delta \tau_{ij}(\Delta t) = \sum_{k=1}^m \Delta \tau_{ij}^k \quad (4)$$

$$\Delta \tau_{ij}^k = \begin{cases} \frac{R}{L_k}, & \text{if the } k \text{ ant goes through the arc}(i, j) \\ 0, & otherwise \end{cases} \quad (5)$$

The R is a constant in the formula, and L_k denotes the path length of the first k ant in this cycle, the calculation formula is:

$$L_k = \sum_{(i,j) \in tabu_k} d_{ij} \quad (6)$$

The above is the basic step of the ant colony algorithm. Through the calculation of this step, the optimal results can be calculated and the results needed in this paper can be calculated. The main calculation steps of the algorithm are shown in Figure 2.



According to the above algorithm, this paper firstly carried out the initial information collection, set the initial number of ants and the size of each index, and then set the initial point, the final point and the path for all ants, calculated the probability that the ant chooses the route and then counted the shortest path and then checked whether it is the shortest. If the shortest algorithm ends, the algorithm ends, and if there is no expected goal of this article, the probability of choosing the route of the ant colony is further calculated until the shortest path is selected. This algorithm was first proposed to solve the traveling salesman problem. However, with the continuous development of computing technology, this algorithm is not optimal solution to solve the traveling salesman problem, but it provides new ideas for solving other problems, and is in good condition and use. This article is very appropriate for the use of physical fitness test. The following

is a brief introduction to the selection of parameters in the formula.

Parameter selection and attribute of basic ant colony algorithm

The calculation of $\Delta\tau_{ij}^k$ is the key link for the realization of random search and fast convergence of the basic ant colony algorithm. M. Dorigo has given three different implementation methods, corresponding to three different models, which called ant-cycle system, ant-density system and ant-quantity system model. The difference between them is the difference in the expression of $\Delta\tau_{ij}^k$. This article sets M to 20. $\alpha=1, \beta=2, \rho=0.1, Q=100$, this paper carried out five experiments and took the average value, and the experimental results are shown in Table 1 below.

Table 1
Comparison of the Results Of Different Model Algorithms

Number of experiments	ant-cycle systemmodel	ant-density system model	ant-quantity system model
1	27.33	32.5	25.63
2	32.06	27.7	26.04
3	27.01	27.3	25.54
4	33.07	27.0	25.87
5	27.35	29.0	26.39
Average length	28.82	28.84	25.96
Optimal length	26.53	27.01	24.88

It is not difficult to see from the above table that the main reason for the difference between the calculation results of the three models is the difference of feedback information. For the ant-cycle system model, the optimal result is related to the type of feedback information, and the other two used local information.

Pheromones are volatile. This feature is also determined according to the nature of the ants.

The evaporation rate of volatile elements will bring very different changes to the results. Therefore, this article should be based on experiments to determine the impact of volatile matter. This article is still using the ant-cycle system model for testing. This paper set $M = 30$, $Q = 100$, $\alpha = 1$, $\beta = 1$, $\rho \in \{0.3, 0.5, 0.7, 0.9\}$. The test results are shown in Table 2 below.

Table 2
Comparison of Pheromone Test Results

Pheromone Residual Coefficient	average value	Optimal path length	Worst path is long	Optimal minimum difference	Number of iterations
0.3	430.92	426.53	434.26	7.73	24
0.5	430.65	424.94	432.20	7.26	32
0.7	428.53	424.69	431.31	6.62	46
0.9	431.05	428.63	436.01	7.38	120

Through the above calculation results, it is not difficult to find that the rate of pheromone

volatilization has a great influence on the convergence times of the algorithm when the number of ants is consistent. The larger the volatilization coefficient is, the larger the number of cycles and the lower the convergence. The slower the volatilization rate is, the better the calculation of the optimal solution is. Therefore, a suitable volatility should be chosen for the calculation, too little will lead to inaccurate calculation results, too high will lead to too long calculation cycle. Through the above experiment and the overall situation, this paper makes a reasonable evaluation of the convergence rate. This paper concludes that the volatility is best between 0.5 and 0.7, which can ensure that the calculation of this paper is correct, but also to ensure that the calculation cycle is not very long.

There is a very important element that is a heuristic factor in ant colony algorithm, the pheromone heuristic factor α and expectation value heuristic factor β . The pheromone heuristic factor represents the importance of searching for residual information during ant colony movement, while the expected heuristic factor represents the importance of the heuristic information, and the two heuristic factors have great impact on the calculation results. The bigger the α , the ant is more likely to take the old road, the smaller the search. The bigger the β , the greater the probability of selecting the local shortest, and this paper still uses ant-cycle system model for test, and set $M=30$, $Q=100$, $\alpha=1$, $\beta=1$, $\rho \in \{0.3,0.5,0.7,0.9\}$. The test results are shown in Table 3 below.

Table 3
Heuristic Factor Test Results Comparison Table

Inspiration factor α	Inspiration factor β	average value	Optimal path length	Worst path length	Number of iterations
1	1	431.05	425.26	436.40	33
2	1	449.76	434.89	469.22	34
1	0.5	472.23	446.29	482.23	50
1	2	425.44	423.90	427.17	36
10	5	425.87	424.02	426.74	12
10	10	425.66	424.00	426.72	12

From the above test results, it can be found that the shortest path and the number of iterations are different for different values of heuristic factors. Through the above experimental results, this paper can be analyzed that the value of α optimal is 1, the value for β optimal in 2-5 is appropriate. The above results find an optimal range for the calculation and set of parameters of ant colony algorithm. In the test process, according to the above data, this paper can choose and use the value of the various parameters. Before each calculation,

there is no need to sort out and calculate, this paper only needs to choose the appropriate parameter values from the upper table according to the information.

RESULTS

After the design of the ant colony algorithm is completed, it is necessary to test the feasibility and the superiority of the algorithm, so as to check whether the ant colony algorithm in this paper satisfies the use requirement of this paper and

whether the algorithm has absolute superiority compared with other algorithms. This paper has done a few sets of rigorous comparative tests, through the detailed analysis and research of the test results, to examine the flaws and advantages of the algorithm, so that it can be better improved in this article.

In order to test the performance of the algorithm used in this paper, his paper has carried out some simulation experiments on the computer. In all experiments, the parameters are set as follows: $q_0 = 0.9, \beta = 2, \rho = \alpha = 0.1, m = 10, \tau_0 = (n \cdot L_m)^{-1}$, and L_m represents the length of the journey generated by the nearest neighbor of the mountain, n represents the number of nodes, the computer simulation runs 30 times, the local weight $w = 0.6$,

and the external weight $(1-w) = 0.4$. In addition, the author compares the average length of the ACOMAC and Dorig'ACS proposed in this section with four benchmark questions Ei151, Ei176, Kroa100, and D198. Table 4 shows the comparison of the results of the ACOMAC algorithm and Dorigo's ACS algorithm in solving different physical test problems. Fig. 3 is the comparison of the evolutionary times of ACOMAC algorithm and Dorigo's ACS algorithm in solving Kroa100 problem (node number =100, running times 30 times). The results show that the ACOMAC algorithm was improved obviously than the performance of ACS in solving TSP problems, which can find the global optimal or solution that is close to the global optimal.

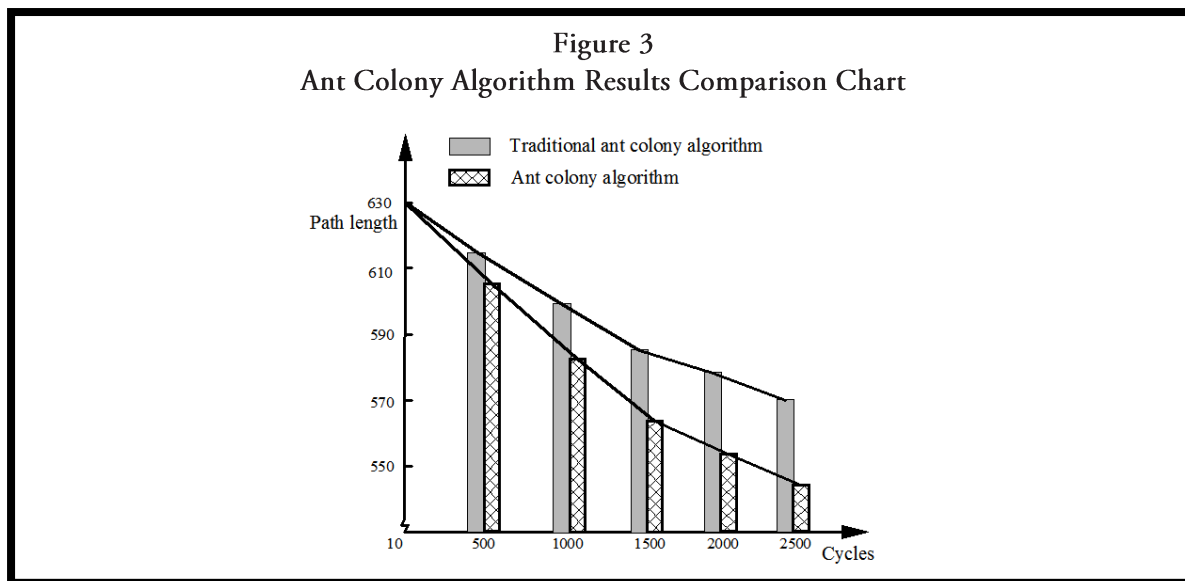
Table 4
Comparison of ACOMAC algorithm and Dorigo's ACS algorithm in solving different physical test problems

Problem	ACS	ACOMAC
Ei151	433.9472	430.6884
Ei176	559.7041	554.3948
Kroa100	21559.183	20972.896
D198	16820.6	15955.6

Through the above table, it can be seen that the ant colony algorithm used in this paper has a good computing power when dealing with various physical test problems. It is an excellent calculation method and can pick out the shortest path in many paths, and has a great advantage compared to other algorithms, and can get the good experience in the physical test. The above experiments show that the algorithm used in this paper can meet the use requirements of this stylistic test, but its advantages need further testing in this paper.

This paper carried out a comparative test on the algorithm model and the traditional model ant colony algorithm. In this paper, the length of the average

path was counted at five nodes of 500/1000/1500/2000/2500. However, this paper also made a macroscopic detection of the overall path length. The final test results are shown in Figure 3.



Through the summary of the experimental data above, it is found that the shortest path calculated by the algorithm used in this paper has been shorter than the traditional algorithm, especially, with the increase of the cycle number, the gap between the shortest path calculated by algorithm used in this paper and the shortest path calculated by traditional algorithm is getting bigger and bigger. When the number of cycles reaches 2500, the maximum difference value of the path reaches 20, which also shows the great advantage and superiority of the improved algorithm. In addition, in the computation time experiment, this paper also made a huge advantage. The modified ant colony algorithm in this paper not only has a short computation time, but also gets shorter path under the same cycle number, which is a kind of algorithm with excellent performance.

Through the testing and use of this algorithm, a lot of conclusions are drawn. The modified algorithm not only has short computing time, but also has high accuracy, and the better results can be obtained at the same time. In this paper, physical testing is widely used, which can reduce the number of queues, and can increase efficiency, can enable more people to participate in physical fitness test in limited time. In particular, the algorithm can play a huge advantage in the physical fitness test in colleges and universities. Although this algorithm has made great achievements, there is

still room for improvement. The next step is to improve the accuracy of heuristic factors α , β . This paper will find a more reasonable and accurate heuristic factor, so that the accuracy of the algorithm can be greatly improved, so that the results of this paper can be more accurate.

CONCLUSION

With the continuous development of computer technology and people's understanding of the importance of computer modeling algorithm, in this paper, the research of algorithm is more and more thorough. The ant colony algorithm was put forward in this background. The ant colony algorithm was originally used as an algorithm to solve the traveling salesman problem, and later evolved into algorithm for various fields. Now, researchers have begun to study the application of algorithm in the physical test. The ant colony algorithm designed in this paper has a great advantage. The ant colony algorithm used in this paper has a good computational power when dealing with various physical test problems. It is an excellent calculation method and can pick out the shortest path in many paths. The comparative test on the algorithm model and the traditional model ant colony algorithm was carried out. In this paper, the length of the average path was counted at five nodes of 500/1000/1500/2000/2500. When the number of

cycles reaches 2500, the maximum difference value of the path reaches 20. These tests show that the modified ant colony algorithm has great advantages and good usability. However, in the study, there are also some shortcomings of the algorithm. This paper will make up the defects of the algorithm in the subsequent research, and apply ant colony algorithm in physical fitness test to the extreme, expand the scope of ant colony algorithm, and make a contribution to the study of later generations.

Human Subjects Approval Statement

This paper did not include human subjects.

Conflict of Interest Disclosure Statement

The authors have no conflict of interest to disclosure.

References

1. Zheng W, Hu N. Automated Test Sequence Optimization Based on the Maze Algorithm and Ant Colony Algorithm. *International Journal of Computers Communications & Control*. 2015; 10(4):593.
2. Tian J, Gao M, Ge G. Wireless sensor network node optimal coverage based on improved genetic algorithm and binary ant colony algorithm. *Eurasip Journal on Wireless Communications & Networking*. 2016;2016(1):104.
3. Saidi-Mehrabad M, Dehnavi-Arani S, Evazabadian F, et al. An Ant Colony Algorithm (ACA) for solving the new integrated model of job shop scheduling and conflict-free routing of AGVs. *Computers & Industrial Engineering*. 2015; 86(C):2-13.
4. Diwekar U M, Gebreslassie B H. Efficient Ant Colony Optimization (EACO) Algorithm for Deterministic Optimization. *International Journal of Swarm Intelligence & Evolutionary Computation*. 2016; 05(1).
5. Chávez J J S, Escobar J W, Echeverri M G. A multi-objective Pareto ant colony algorithm for the Multi-Depot Vehicle Routing problem with Backhauls. *International Journal of Industrial Engineering Computations*. 2016; 7(1):35-48.
6. Sapin E, Keedwell E, Frayling T. An Ant Colony Optimization and Tabu List Approach to the Detection of Gene-Gene Interactions in Genome-Wide Association Studies [Research Frontier]. *Computational Intelligence Magazine*. 2015; 10(4):54-65.
7. Zhang X, Yuan D. A niche ant colony algorithm for parameter identification of space fractional order diffusion equation. *Jaeng International Journal of Applied*
8. Zhang X M, Song W, Feng W. Improved ant colony algorithm for parameter estimation on the BISQ model. *Inverse Problems in Science & Engineering*. 2015; 23(6):997-1010.
9. Kwarciak K, Radom M, Formanowicz P. A multilevel ant colony optimization algorithm for classical and isothermic DNA sequencing by hybridization with multiplicity information available. *Computational Biology & Chemistry*. 2016; 61:109-120.
10. Pessoa C M, Ranzan C, Trierweiler L F, et al. Development of Ant Colony Optimization (ACO) Algorithms Based on Statistical Analysis and Hypothesis Testing for Variable Selection. *Ifac Papersonline*. 2015; 48(8):900-905.