DECIDE PROJECT SESSION

# MOBILE ROBOT PATH PLANNING OPTIMIZATION BY ARTIFICIAL BEE COLONY

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Abstract:

The main goal of this paper is to set a new approach in optimizing the problem of path planning for an autonomous mobile robot in static and dynamic environments. The development of computing and information technology has made life easier for people in many areas. With the increase in computing power, new branches of science have developed, such as artificial intelligence, machine learning, and deep learning. As this is an area that is developing very fast, so has its application in various spheres of society. Currently, robots are considered an important element in society. This is due to the relief of humans by robots in basic and dangerous conditioning. Still, designing an effective navigation strategy for mobile robots and ensuring their securities are the most important issues in autonomous robotics.

Keywords:

Path Planning, Mobile robot, Metaheuristic, ABC.

## INTRODUCTION

One of the areas that are imposing itself due to the growing volume of ground-breaking applications, is the area of mobile robotics. Today, mobile robots are increasingly used in various fields. Mobile robots, especially drones, have found their applications in agriculture, where the use of such devices facilitates field monitoring, all the way to the increasing use in the military industry. The main aspect of mobile robots that must be considered is route/path planning [1]. Route planning involves finding the most optimal route for mobile robots to move without obstructing obstacles, from the starting point to the endpoint. Solving this problem is also the most demanding part of the development of autonomous mobile robots. This complexity arises due to different aspects of the path itself that need to be optimized: distances, travel times, or energy consumed. Various studies suggest that metaheuristic methods can help to solve this problem [2].

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## 2. PROBLEM DEFINITION

The problem of path planning is one of the most researched problems in robotics today. This problem involves finding the most optimal path from the starting point to the endpoint. In this paper, a metaheuristic approach to solving the path planning optimization problem is proposed, specifically, the artificial bee colony (ABC) algorithm was used in this paper [3].

The results show the advantages of the proposed approach. In particular, different quality metrics are used to evaluate the obtained results, demonstrating high performance and high applicability under general conditions. This indicates that the proposed multi-purpose evolutionary algorithm is a good choice for solving route planning problems.

## 3. SWARM INTELLIGENCE

Like most technological innovations, swarm intelligence finds inspiration in nature. The most famous examples from nature that are taken as an example for application in the Intelligence of swarms are birds, bees, and ants. As this field progresses, so has its application in various fields such as medicine, robotics, blockchain, etc.. [4] [5]. There are many examples from nature, from bees in creating complex nests to bees and ants. Today, swarm intelligence techniques are mainly used in optimization processes which is present and necessary from applications in computing, the Internet of Things to medicine and financial systems. In practice, people have always wanted to optimize either to reduce costs or energy consumption or to increase efficiency. Specifically, in swarm intelligence, each swarm member must communicate with other members and thus contribute to collective intelligence. Some of the main principles according to which such systems should work are that members must exchange information with each other, solve real problems and be very effective in learning together. Solving the problem of optimization using intelligence swarms is certainly more efficient than some standard, traditional ways, especially in terms of robustness and decentralization. Some of the algorithms that have proven to be the most effective are Artificial Bee Colony, Ant Colony, PSO, and Firefly Algorithm [6] [7] [8]. Let's say that the Ant Colony is inspired by the phenomenon of ants that find the shortest way from the nest to the food. This phenomenon has been observed by biologists for a long time and they have come to the conclusion that this phenomenon can be explained by the rules according to which ants function in their colony [9]. Namely, none of the units functions separately, all the ants within one colony work at the same time in order for the entire colony to survive.

## 4. METAHEURISTIC

Metaheuristic algorithms are inspired by nature and represent the field of stochastic optimization. Stochastic optimization methods use some degree of randomness and search for optimal or near-optimal solutions. Each metaheuristic algorithm has two main phases: Intensification and Diversification. Diversification is responsible for the global search space, while intensification performs a local search. In metaheuristic algorithms, it is important to find a good balance between intensification and diversification. Two main categories of metaheuristic algorithms are swarm intelligence (SI) and evolutionary algorithms (EA). Swarm intelligence algorithms are motivated by nature's evolved intelligence, where the entire population tends to act in an intelligent, global manner. There are numerous swarm intelligence- based algorithms with different designs, but they all share certain common characteristics. First, the population is randomly generated in the initialization phase. Random generation is used to explore the search space and avoid congestion in the local optimum [10] [11]. The location of each solution changes after each iteration and when the algorithm satisfies the interrupt condition returns the best solution. Updating the position allows the system to develop and approach the global optimum. Metaheuristic approaches based on swarm intelligence have successful applications in various fields such as the design of a revolutionary neural network in deep learning [12], the grouping of images [13], application in computing in task scheduling cloud (user requirements), etc. Each evolutionary algorithm includes the following elements: solution definition, random population initialization, assessment of fitness function, reproduction, selection, strategy substitutions, and termination criteria. In each iteration, new solutions are generated from old solutions called phases reproduction. The reproduction phase uses different operations to create new individuals, such are crossbreeding operations and mutations. Metaheuristic hybridization is a very successful category of metaheuristic studies. It's a hybrid algorithm with parallel or distributed implementation of two or more algorithms, which combines the benefits of different metaheuristic algorithms, using algorithmic ingredients of different optimization methods or a mixture metaheuristic with different artificial methods intelligence. The result of the hybridization technique is a synergistic synthesis of fused algorithms. Some metaheuristic algorithms have fast convergence, while others are slow to converge. Hybrid optimizers are often significantly more powerful in terms of convergence rate and solution quality; they can produce more efficient and higher performance flexibility when dealing with complex problems. A necessary part of the design of a metaheuristic algorithm is creating an optimal balance of global research and local exploitation. Early convergence is a consequence of small diversity; on the other hand, greater diversity allows more careful research, allows research in the field of global search, and avoids jams in local optics. In the process of hybridization, the algorithm becomes more complex so the structure needs to be put together for easy implementation. There are many successful applications of hybridized metaheuristics in different fields. a hybrid metaheuristic is applied to deep learning variations to optimize convolutional architecture neural networks as well as various applications in cloud computing [14].

## 5. ARTIFICIAL BEE COLONY

The Artificial Bee Colony (ABC) algorithm is a swarm-based metaheuristic algorithm inspired by the behavior of honey bees. The algorithm consists of three components: employed and unemployed bees, and food sources. The first two components, employed and unemployed bees, search for the third component, food sources. In ABC, a colony of artificial bees (agents) searches for artificial food sources [15]. To apply ABC, the optimization problem under consideration is first transformed into the problem of finding the best parameter vector that minimizes an objective function. Then, artificial bees randomly discover a population of initial solution vectors and iteratively improve them by applying strategies: They move toward better solutions using a neighborhood search mechanism, while abandoning bad solutions [16]. The distribution of bees is such that the first half of the swarm consists of employed bees, and the other half consists of observer bees. The number of employed bees or observer bees is equals to the number of solutions in the swarm. After all, employed bees complete the search process, they share the information of their food sources with the onlooker bees [17]. An onlooker bee evaluates the information taken from all employed bees and chooses a food source with a probability associated with its nectar amount [18].

This probabilistic selection is described as follows:

$$\rho_i = \frac{fit_j}{\sum_{j=1}^{SN} fit_j}$$

Equation 1 - probabilistic selection

We can divide the process of the ABC algorithm into a few steps or phases. The first phase is the initialization phase. In this phase population of food sources is initialized by scout bees and control parameters are set:

$$.X_{ml} = l_i + rand(0,1) * (u_i - l_i)$$

Equation 2 - Initialization phase

where $l_i$ and $u_i$ are lower and upper bound of the parameter $X_{mi}$. After this, we enter the employed bee phase where agents search for new food sources within the neighborhood of the food source. After employed bee phase, starts onlooker bee phase. Unemployed bees are divided into two groups: onlooker bees and scouts. Employed bees share their food source information with onlooker bees and then onlooker bees choose their food sources depending on this information.

In ABC, an onlooker bee chooses a food source depending on the probability values calculated using the fitness values provided by employed bees. The last phase is the scout bee phase. In this phase, we have two types of bees unemployed bees or scouts and employed bees. If employed bees cannot be improved become scouts and their solutions are abandoned. After that scouts start to search for new solutions.

## 6. SIMULATION SETUP AND RESULTS

The proposed optimization algorithm for mobile robot path planning was implemented using Matlab R2015a. Experiments were performed on the platform with Intel Core i7-10700KF CPU at 3.8GHz, 32GB RAM, Windows 10 Professional OS. Parameters for the proposed methods were set empirically by conducting several pre-tests. Population size for the ABC algorithm was initially set to 10 and the number of Handle Points was 4. The maximum number of iterations was 150. Later population size was changed to 20. The main goal of this algorithm is to find the most optimal route from the starting point to the endpoint. Figureure 1 and Figure. 2 show the results of robot movements with different values for the population. It can be concluded that both values give similar and very good results. The variation in fitness function is shown in Figureures 3 and 4. Although the higher the population size, the larger the number of computations, we may notice the better performance of the fitness function as the population grows.

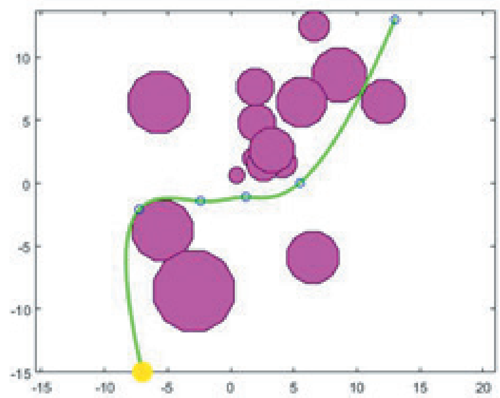


Figure 1, population size nPop = 10

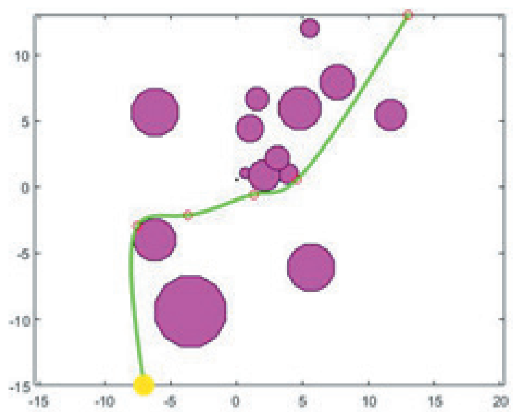


Figure 2, population size nPop = 20

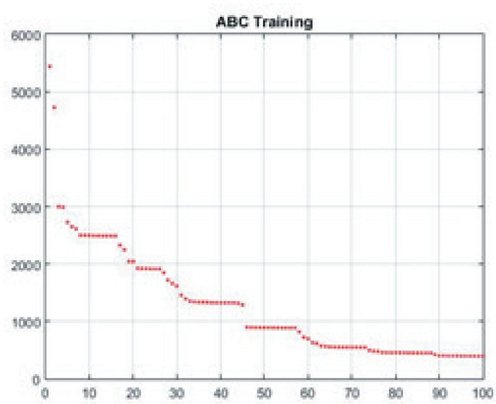


Figure 3, Fitness function nPop = 10

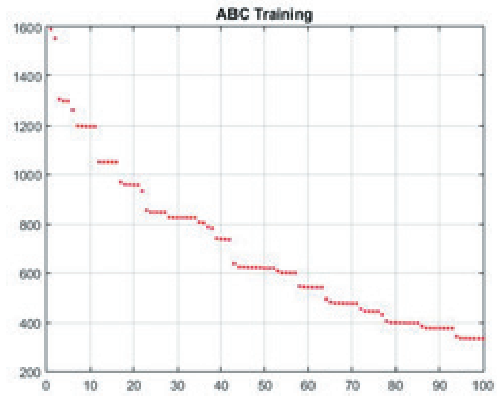


Figure 4, Fitness function nPop = 20

## 7. CONCLUSION AND FUTURE WORK

This paper proposes an approach to the advanced optimization of an increasingly necessary problem of mobile robot path planning. The approach to solving this problem suggests the use of algorithms based on swarm intelligence. This paper proposes to use one of the most popular algorithms lately. Future work will include testing this solution in the real world using real mobile robots. Future work will also include testing other metaheuristic methods to solve this problem and a mutual comparison of the obtained results to find the most optimal solution. Also, as a next step, hybridization of algorithms based on swarm intelligence with the Genetic Algorithm can be introduced to obtain the best and most optimal solutions.

## 8. ACKNOWLEDGEMENT

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