



## A survey of meta-heuristic methods for optimization problems

Mehdi Fazli<sup>1\*</sup> and Somayyeh Faraji Amoogin<sup>2</sup>

1,2. Department of Mathematics, Ardabil Branch, Islamic Azad University, Ardabil, Iran

### Article Info

#### Article History:

Received 2023/10/6  
Revised 2023/10/18  
Accepted 2023/10/29

#### Keywords:

Operations research, Meta-heuristic, Hybridization, Memetic algorithm

\*Corresponding Author's Email  
Address: mehdi.fazli.s@gmail.com

### Abstract

In this article, we will examine the problems related to routing and positioning with real variables and examine the related questions. These engineering, inventory and optimization decisions are made in a multi-layered supply chain system, including suppliers, warehouses and different buyers. We are looking for new ways to manage location and routing efficiently and effectively. In order to increase efficiency and achieve optimal results, exploratory and meta-heuristic methods have been used. In meta-heuristic techniques, a combination technique is usually used to increase performance. Therefore, this review article examines meta-heuristic methods and analysis of location problems using different quantities. It also examines the advantages and disadvantages of each method to optimally solve these problems in order to introduce practical and efficient methods.

### 1. Introduction

One of the practical and important issues in the field of optimization is the relationship between the set of facilities, possible warehouses and the set of applicants. The purpose of LRP is to provide better services to applicants and consider various facilities (planning routes and storage locations and cost limits). In these issues, the goal is to minimize the total cost of setting up warehouses, facilities, and turnover to serve each and every applicant. Facing such a problem, location and routing should be considered together and simultaneously, because neglecting any of the components in the location of facilities obviously increases the total cost of the distribution system and sometimes leads to a solution. unfavorable results (Salhi & Rand, 1989). From the perspective of complete supply chain management in the optimization discussion, location and routing seem to act as components of serious concern in real applications. As an urban application, the positioning of regional blood banks

to serve patients Or and Pierskalla (1979), or establishing journal mail delivery systems

Jacobsen and Madsen (1980), or publishing goods parcels philanthropic-care network distribution dynasty Perl and Daskin (1985); Wasner and Zäpfel (2004)), to recitation a few, handle location and routing problems together Obviously, this problem-solving procedure will be challenging for logistics managers and decision-makers.

- In general, despite the effective application of the mechanisms and techniques of the meta-heuristic approach inspired by the real world for the problem of location allocation, according to scientific information, a general and systematic study in terms of antecedents and backgrounds has not been done in this regard. Therefore, in this study, we aim to review the existing real-world inspired algorithms for the specific problem of

location allocation and routing, evaluate the differences of the mentioned techniques, and draw serious competitions and important issues about the mentioned problem that can be addressed in a wider field. In general, the contents and main concepts of this article can help in the following areas:

- Providing insights and implementations of location issue optimization techniques.
- To highlight the importance of using various methods of advanced meta-heuristic optimization, and the many advantages and disadvantages that they provide to deal with the challenges encountered in the location allocation problem.
- Determining relevant new and open issues and clues and ways to solve existing issues.
- In this paper, Section 2 provides an analysis and review of related work. Section 3 presents research terminology and preparation and implementation mechanisms. Section 4 discusses the review of selected meta-heuristic methods for different LRP problems. Section 5 presents the same new issues. Finally, Section 6 concludes the paper.

Table 1 shows the jointly used abbreviation in the article.

**Table 1.** Abbreviation table

Abbreviation	Definition	Abbreviation	Definition
<b>LRP</b>	Location Routing Problem	GA	Genetic algorithm
<b>HM</b>	Hybrid meta-heuristic	MA	Memetic algorithm
<b>ACO</b>	Ant colony optimization	PSO	Particle swarm optimization
<b>HA</b>	Hybrid Algorithm	HEA	Hybrid evolutionary algorithm
<b>COA</b>	Cuckoo optimization algorithm	TS	Tabu search
<b>FA</b>	Firefly algorithm	SA	Simulated annealing
<b>SDO</b>	Saturation degree-based ordering	HGS	Hybrid Genetic simulated annealing
<b>MFFA</b>	Memetic firefly algorithm	ACS	Ant colony system
<b>APSO</b>	Particle swarm optimization		

## 2.Related work

Some diverse studies have been conducted in the field of LRP. In this section, we review the literature for location routing conditions or how to use meta-heuristic algorithms in LRP and their strengths and weaknesses. This review was also conducted on articles from 2002 to 2022. A study of location routing problem is presented by Drexler and Schneider (2015) due to cost minimization.

One of the significant studies of the location-routing problems has been provided out by Prodhon and Prins (2014). The LRP process integrates two major types of objectives. According to the existing and potential warehouses with variable costs, this transport fleet and the set of applicants have special demands. Classical LRP problems such as opening a subset of warehouses, assigning applicants to them, and specifying vehicle routes are used to minimize total costs such as specific storage costs and fixed transportation costs. They are also used throughout the project to minimize total costs. Since the last comprehensive scrutiny on LRP published by Nagy and Salhi (2007), The number of published articles devoted to this particular topic is rapidly increasing, and there is a need to analyze and review comprehensive new research works. This survey article analyzes the recent literature (68 articles) on standard LRPs and new additions such as access to multiple distributions and costs.

Vallada, Ruiz, and Minella (2008) Presented a review and extensive evaluation of heuristics and met heuristics for the m-machine stream shop scheduling problem aiming at minimizing general tardiness. He implemented 40 various heuristics and met heuristics and examined their performance using the same criterion of instances. Their paper has presented an extensive and comprehensive review of heuristic and met heuristic procedures for the permutation flow department store scheduling problem aiming at minimizing the total tardiness. They have encrypted and tested 40 different algorithms to test their method performance under the same conditions. In addition, a benchmark is provided to evaluate all steps under a common dataset of 540 problems and a maximum of 350 related jobs and 50 new device.

Despite the important conditions of heuristic techniques fulfilled in the topic of localization, a global and systematic review of the discussion about their classification has not been presented so far. In addition, future challenges and the critical role of meta-heuristic techniques in a location problem are not well presented. In general, the reviewed articles have several reasonable categories as follows:

- ❖ The articles selection process has not been identified well.
- ❖ Some authentic and written researches have not been scrutinized.
- ❖ Future operations and open issues are not well stated.
- ❖ The categorization of the approaches studied has not been properly described.
- ❖ The strengths and weaknesses of the reviewed articles are well highlighted.
- ❖ In many studies, few papers have been reviewed.

### **3. Systematic literature review**

The purpose of a review research is to provide a general and comprehensive summary of the literature related to the research domains related to the problem (Aznoli & Navimipour, 2017). Inspired by the field of medicine (Kitchenham, 2004), SLR, as a research procedure, provides a repeated procedure in which supplying sufficient details for being regurgitated by other researchers is carried out in (Charband & Navimipour, 2016; Cook et al., 1997; Kupiainen, Mäntylä, & Itkonen, 2015; Navimipour & Charband, 2016). A thorough search of the literature for relevant spread studies is the first step in conducting a principled review (Navimipour & Charband, 2016; Soltani & Navimipour, 2016). This has been supported by foregone studies suggesting that this procedure for literature review can lead to limited systematic errors, reduced chance factors, and enhanced validity of data analyses (Aznoli & Navimipour, 2016, 2017; Navimipour & Charband, 2016).

### **4. Review meta-heuristic algorithms in location problem**

In this part of the article, we examine selected meta-heuristic methods and techniques from the wide range of studies in the optimization problem and especially location. Considering the role of the selection method in Section 3, we present various techniques in the groups of Particle Swarm

Optimization (PSO), Ant Colony Optimization (ACO), Genetic Algorithm (GA) and Firefly Optimization (FA), Tabu Search (TS), We introduce and analyze the simulated annealing technique and the combined algorithm (HA) method. Qualitative measures for the location problem include runtime, comparison, real programs, competition, future development, algorithm improvement, parameter constraints, solution space reduction, and success.

#### **4.1 Ant colony optimization method**

Ant Colony Optimization is a collaborative intelligence-based search algorithm inspired by the behavior of real ants. First, it was practical and applied to solve the traveling salesman problem (TSP), and then it was effectively used to solve a large number of diverse problems such as routing in telecommunication networks, quadratic assignment problem (QAP), and graph coloring. This process is largely based on the idea of indirect communication among worker ant colonies. They go their way by borrowing Fermon. This pheromone pathway helps them find the shortest path between food sources and their nest. In the following, this process led to the formation of the mentioned method.

##### **4.1.1 A summary of the selected process**

A meta-heuristic approach, ACO, has suggested by S. Liu et al. (2017). In the proposed method, selection of pheromone models is an important priority. It is natural to choose pheromone models having fewer constraints; this algorithm can be used especially for the passenger seller problem in which the first order pheromone is widely recognizable. In the tests used, the algorithms using the second model are capable of general searching and have better population diversity. In fact, there is a qualitative difference between these two techniques. As a conclusion, they believe that different pheromone models can be used for problems on small and large scales, while the need to develop this method is extremely sensible.

An effective method has been developed by L. Yang et al (2013). to solve the facility location optimization problem with assumed single resource capacity (SSCFLP). This approach has been studied in three comparative studies of less than two different data size requirements, which can support the use of multiple computers to construct MAS. It also enhances the efficiency of smart computing. In numerical problems, data analysis based on practical examples showed that when multi-agent parallel calculations are performed on several systems, we reach intelligent calculations. In addition, the speed of the data

network transmission process increases the computational efficiency of the multi-agent distribution method. The calculations and reproducibility of this method are high despite the favorable efficiency.

#### 4.1.2. Some points of the ACO method that have been reviewed

Paper	Advantage	Disadvantage
S. Liu et al. (2017)	<ul style="list-style-type: none"> <li>Improve the existing solution</li> <li>Application in practical matters</li> <li>Providing promising solutions</li> </ul>	<ul style="list-style-type: none"> <li>Development of the method in the future</li> <li>Failure to check the same control parameters</li> </ul>
L. Yang et al. (2013)	<ul style="list-style-type: none"> <li>High computing efficiency</li> <li>Apply most restrictions</li> <li>Logical calculation time</li> <li>Cost Estimation</li> </ul>	<ul style="list-style-type: none"> <li>Many repetitions</li> <li>not always able to find the optimal solutions</li> </ul>

Table 2 shows major advantages and disadvantages of ACO method for each research.

**Table 2.** Major advantages and disadvantages of ACO method

#### 4.2 Firefly algorithm (FA) optimization method

In this method and the corresponding algorithm, all fireflies are considered the same, regardless of the gender of the opposite fireflies, and they are attracted only based on the energy level of people. The firefly technique is produced based on the ideal guidance of the flashing characteristics of the firefly. In total, the following three rules can be used in the implementation of these features of the proposed method.

- All fireflies are born unisex, meaning a firefly can attract other things regardless of its gender.
- Their appeal is due to their brightness, that is, for both flashlights, the light travels less and decreases with increasing distance. If no one is brighter than a firefly, it moves randomly.
- The energy intensity of a firefly is influenced by its function and purpose and is optimized.

##### 4.2.1 A summary of the selected process

A nature-inspired optimization method called firefly technique (FA) was proposed by Rao and Kumar (2014) to solve the multi-objective problem, which has multiple objectives based on a multi-criteria objective function. which tries to reduce the total power loss to a minimum, and tries to minimize the total voltage deviations. The total

cost is equal to the fuel cost of producing and loading the branch and the optimal flow tries to reduce this cost. The results of this study show that the installation of SVC can increase the stability of the entire system voltage to a sufficient extent. In addition, the comparison between their proposed technique and a specific optimization method called genetic method showed that FA is an easy-to-use, robust and powerful optimization technique. In addition, the integration of SVC into the separate IEEE 14 and IEEE 30 system can reduce the total active power loss and improve the system performance. However, this method involves many iterations which can lead to longer execution time and is also designed for a specific problem.

Prima and Arymurthy (2019) considered the school transportation situation as a school location-allocation optimization problem. And with the help of optimization methods and algorithms based on nature, they tried to reduce the total distance walked by students to a favorable level and according to this process, they formulated the problem. This particular problem is assumed and modeled as a p-median problem, in which a meta-heuristic approach can be used. In this study, the firefly technique with 2D firefly representation is used to solve the location-assignment problem of the first school in South Jakarta. Therefore, gradual randomness reduction may improve the quality of the solution. Another improvement in the convergence of this technique is to change the parameter slowly, as the optimality is achieved and it can be useful for further research. In addition, as a relatively simple proposal, the firefly technique can be used to solve optimization in research on multi-objective and multi-component operations. However, for large scales, the method needs further development.

Suleiman et al. (2012) used the firefly technique to allocate the location and useful size of distributed generation (DG) in a convenient electricity distribution system. As already mentioned, FA is a meta-innovative technique related to the flashing behavior of fireflies. This behavior of the creatures is applied as a signal system in attracting other neighboring worms as the main target of the problem. In their paper, a new technique based on firefly movement in crowd is implemented to solve the problem of allocation and useful size of DG. Also, the efficiency and effectiveness of FA are discussed with some practical examples. The results show that the combination of DG in a distribution system can reduce the energy loss of the entire line and, as a result, significantly improve the system voltage characteristics. Also, compared

to the performance of GA, the performance of FA is acceptable, in which GA also performs well in solving the optimal allocation problem. In this method, a distribution system with several DGs without DGs or with one DG and two DGs in the system was tested. The FA function is suitable for solving the problem of optimal location and size in the distribution system. In addition, adding DG to the distribution system can improve system performance, reduce total line losses, and improve load characteristics. However, the design of this method is not suitable for large-scale problems.

**4.2.2. Some points of the FA method have been reviewed**

Table 3 shows major advantages and disadvantages of FA method for each research.

**Table3.** Major advantages and disadvantages of FA method

Paper	Advantage	Disadvantage
Rao and Kumar (2014)	<ul style="list-style-type: none"> <li>• Increase total power</li> <li>• High optimization power</li> <li>• Comparability</li> </ul>	<ul style="list-style-type: none"> <li>• Many repetitions</li> <li>• Operating limit like time</li> <li>•</li> </ul>
Prima and Arymurthy (2019)	<ul style="list-style-type: none"> <li>• better results on medium scale</li> <li>• Comparability with other methods</li> <li>• Search space intensification</li> <li>• Increasing the performance of algorithms</li> </ul>	<ul style="list-style-type: none"> <li>• Need to develop algorithm</li> <li>• Unsuitable for real problems</li> </ul>
Sulaiman et al. (2012)	<ul style="list-style-type: none"> <li>• Improved voltage profile</li> <li>• Reduce line losses</li> <li>• Measuring distributed production</li> <li>• Optimal allocation of DG</li> </ul>	<ul style="list-style-type: none"> <li>• Need for future development</li> <li>• Suitable for small scale issues</li> </ul>

**4.3 Genetic Algorithm (GA) optimization method**

In operational research and mathematics and computer science, the genetic algorithm and method is a meta-heuristic inspired by natural sciences that is used to select the next generation of people and is one of the evolutionary approaches. Genetic techniques are mainly used to generate high-efficiency solutions for optimization and search examples based on natural relationships. The main advantage of the genetic technique is the ability of this process to facilitate different subsets

to evolve in different directions by applying other constraints. In examining different problems, it is proven that GA techniques improve the search process and can provide almost accurate and optimal solutions for different problems.

**4.3.1 A summary of the selected process**

Crossland et al. (2014) provided a useful tool for planning and solving heuristics using a simulated system for the problem in question. They use a genetic technique to investigate and solve the problem of electrical storage and measurement of energy storage in LV electrical systems. This particular method is used to check the configuration, storage topology and solve the electrical problem to solve the voltage increase problems as a result of increasing the efficiency of the PV system. Due to the electric absorption by PV, distributed storage is a good alternative to create and maintain the LV system. In addition, it is shown that a single-phase electrical configuration inside the main enclosure can solve the flow problem using a two-phase or three-phase model in the neighborhood. Therefore, this research provides a useful optimization tool for electrical positioning system in distributed LV networks. Single-phase storage at the applicant's site offers solutions that should be evaluated in terms of lower energy and three-phase storage at the main entrance. Home storage can benefit applicants by saving energy and reducing consumer bills due to the energy tariff structure. This generates more revenue to offset system costs. In addition, due to some limitations and attention to a specific case, this method needs to be developed.

Hiassat et al. (2017) used a mathematical model for location routing for perishable goods. In this problem model, the number and location of the warehouse of products throughout the year, the inventory of each seller and the shipping route are evaluated by all the variables of the problem. Their proposed model considers location allocation management decisions in a known inventory routing problem. Simultaneous consideration of these criteria and integration of strategic, tactical and operational management decisions will bring more useful results for the product supply chain. Considering that the model developed here is a hard problem and cannot find practical solutions in

a timely manner without providing a specific technique, they use a genetic technique to solve the problem efficiently and effectively. The obtained results prove that this particular model is more affordable than similar models. Possible formats include using several

different commodities, using different storage time windows for products and commodities (depending on time of year or temperature, etc.), and calculating carbon emissions, which the authors and scientists are working on. The genetic technique here effectively solves large and small samples. The solution of this model has been done using meta-heuristic method. Success is the result of the fact that the exact method does not solve many cases in a reasonable amount of time. To optimize the performance of this method, various parameters of the technique have been studied and tested. Despite the use of stochastic models and parameter constraints, the proposed method calculates the best solutions among similar methods.

Rybičková et al. (2016) stated and implemented a location routing problem. Where it was difficult to solve for NP-hard problems, they used meta-heuristics. This problem is used in supply chain optimization projects and distribution systems. The goal of solving the problem is routing, locating multiple warehouses, along with shipping routes, so that we reach a low amount in terms of costs. In the proposed problem of this research, a genetic method is presented to solve a routing problem. Individual representatives are designed with genetic problem operators to interpolate and solve both location and routing regions. Different parameters are presented using genetic technique to prove their effect on the results and acceptable performance of the proposed algorithm. The problem presented by them consists of optimal location of multiple warehouses along with optimal route distribution. The proposed algorithm continuously obtains better answers from the results of two similar genetic algorithms. In the experiment, several interesting dependences of the parameters on the results were found. Despite the dependence on parameters and the large volume of calculations, the proposed method can provide an optimal solution and reduce costs.

#### 4.3.2. Some points of the GA method that have been reviewed

Table 4 shows major advantages and disadvantages of GA method for each research.

**Table4.** Major advantages and disadvantages of GA method

Paper	Advantage	Disadvantage
Crossland et al. (2014)	<ul style="list-style-type: none"> <li>• Acceptable alternative in the real world</li> <li>• Real-world cost reduction</li> <li>• The best solution for random samples</li> </ul>	<ul style="list-style-type: none"> <li>• The need for real planning</li> <li>• Having some limitations</li> <li>• Improve the algorithm in the future</li> </ul>
Hiassat et al. (2017)	<ul style="list-style-type: none"> <li>• Comparability</li> <li>• Application in practical matters</li> <li>• Provide the best solution to similar methods</li> </ul>	<ul style="list-style-type: none"> <li>• Use random models</li> <li>• Parameter Limit</li> </ul>
Rybičková et al. (2016)	<ul style="list-style-type: none"> <li>• Minimizing the total cost of the system</li> <li>• Provide the optimal solution</li> <li>• Less computing time</li> <li>• reduction in costs</li> <li>• High sensitivity of the algorithm</li> </ul>	<ul style="list-style-type: none"> <li>• Dependence on parameters</li> <li>• Lot of calculations</li> </ul>

#### 4.4 Simulated Annealing (SA) method

The simulated annealing technique is used for problems in which many variables are used and we want to obtain a general optimum. In 1981, this method was used by researchers to find optimal solutions for problems. This process is often used when a discrete search space is considered. For problems in which finding an approximate global optimum is more important than finding a local optimum in a particular framework, simulated annealing may replace other similar techniques.

##### 4.4.1 A summary of the selected process

Küçükoğlu et al. (2019) considered the process of uniform charging of electric vehicles at special stations for electric vehicles. They also considered that; Different technologies for batteries used in certain public stations lead to different battery charging times. Therefore, in this case study, the system (ETSPTW) is extended by considering the electrical operation in the applicant locations with different charge values. In this study, private and public electric stations for the system (ETSPTW) are modeled by applying other constraints. In

In addition to the developed version of ETSPTW, this paper also applies a new simulation technique (SA) to effectively and efficiently solve the ETSPTW-MCR problem. This algorithm uses efficient search methods based on system constraints (TSPTW), which uses a specific advanced solution acceptance process and planning for alternative solutions. However, the main purpose of this comparison is to show that the approach can be applied while respecting the quality of the solution.

Ghorbani and Jokar (2016) stated and formulated multi-stage and multi-product routing problems. There is a lot of competition in this field to solve the problem. For this paper, the simulated annealing method is implemented and a comprehensive numerical problem of multi-product routing is presented, which is investigated by the above method. In addition, the proposed method is solved and compared with the annealing technique in large and small samples. The results show that the proposed method and its algorithm in competition with (IC-SA algorithm) are better than other well-known algorithms in terms of time and CPU solution quality. In addition, the answers and solutions obtained using the IC-SA algorithm technique and the SA algorithm are evaluated in several small and large cases. The results obtained from the numerical examples show that: the IC-SA algorithm method performs significantly better than similar algorithms in terms of the quality of the obtained solution and the convergence of the solutions. However, trying to find a better and more effective algorithm is considered as a topic of future research. For example, a combination of simulated annealing technique (SA) and particle optimization technique (PSO) can be useful in comparison with IC-SA method. However, due to the high volume of calculations, the proposed method should be developed.

**4.4.2. Some points of the SA method that have been reviewed**

Table 5 shows major advantages and disadvantages of SA method for each research.

**Table5.** Major advantages and disadvantages of SA method

Paper	Advantage	Disadvantage
Küçükoğlu et al. (2019)	<ul style="list-style-type: none"> <li>• solving routing problem simultaneously</li> <li>• Compatibility with other algorithms</li> </ul>	<ul style="list-style-type: none"> <li>• Long computing time</li> <li>• Many repetitions</li> </ul>
Ghorbani and Jokar (2016)	<ul style="list-style-type: none"> <li>• Convergent</li> <li>• Comparison with similar methods</li> <li>• high efficiency</li> </ul>	<ul style="list-style-type: none"> <li>• Many repetitions</li> <li>• Computation time</li> </ul>

**4.5 tabu search (TS) method**

The root of the word taboo is taken from the Tongan language. Tonga natives and local people used them to represent things that could not be used because they were sacred. Forbidden search is a special technique that can be used to solve large and combinatorial optimization problems. In line with this method, in the absence of an improved move, worse moves can be accepted (such as when the search gets stuck at a local optimum). In addition, prohibitions (henceforth called taboos) are imposed to prevent previously visited solutions from returning. The implementation of Tabu search is a memory-based process. If you have visited a potential solution or violated a rule for a short period of time, you declare it "taboo" so that it will not be used again in the technique in question.

**4.5.1 A summary of the selected process**

Li et al. (2018) studied several objectives of LRP and compared it with several multi-objective meta-heuristic and heuristic approaches. In their problem, they have to place some plants and products in different environments to meet the demands of some applicants with the main goals of the project. This type of planning is formulated in management decisions to replace real data in the system. To solve this problem in a decision-making system, the metasearch technique based on tabu (TS) and its limitations were used. Using an adaptive memory method, MOAMP tries to adapt the tabu search method to the optimal setup structure of a multi-objective problem in the transportation network. Therefore, it takes an initial population of specified data (the first step of the technique) and uses it to obtain an optimal approximation of the rest using a neighborhood search process. This meta-heuristic approach addresses a real practical problem and provides information from two fire departments and an animal waste disposal plant in Andalusia, which obtains a broad approximation of the efficient set of problems. Future work includes trying to apply

this pattern to non-neighboring points in larger areas. However, some new aspects of the metacognitive process, such as interactive mode and fuzzy information, will be used to provide sufficient information to the actual decision maker in the process. This method is suitable for small problems. In addition, solutions to larger problems must be formulated. In addition, the calculation time is not comparable with other methods.

Lai et al. (2016) investigated a heterogeneous time domain blocking problem for multiple objectives, where the parallax of different travel options is considered based on scales such as time, cost, distance, and number of trips. They expressed this problem as a complex numerical linear programming model in formula form, and proposed a tabu search exploration to efficiently solve the computational challenges of a parallel problem. In this case, numerical tests show that their proposed meta-algorithm is effective. Also, in the discussion of vehicle routing management, the main use of logistics and distribution systems has been. Responses indicate that there are significant savings in shipping costs by using an alternate route, especially when items are delivered to applicants within a limited time frame. This is because multiple structures use solutions using specific multiple arcs. For example, a special arc with higher travel costs but shorter travel time can be added to the vehicle route, which may reduce the need to dispatch an additional vehicle. Also, the large amount of calculation of this method increases its execution time.

Silvestrin and Ritt (2017) offered a variety of vehicle routing problem processing vehicles with different parts to get the best deal. Meta-heuristic methods are used to solve MCVRP problems. Inspired by signs (ITS), they search the location and provide the best solution. Accordingly, they find a solution by local search and then reach a local taboo by finding a taboo. Furthermore, they continue to search for the optimal value until they reach the stopping criteria. The need for different parts often occurs in practical applications. They have shown that ITS works well in VRP. In the existing methods, average quality and timing are applied in most cases. However, the methods may have general principles for different types of VRP. However, additional time did not significantly improve outcomes, whereas ITS improved significantly over time. The results of ITS surveys also show that the amount of various restrictions is relatively limited. This approach works for small problems, while it does not work well for large problems, so it needs to be developed for larger problems.

Polak and Boryczka (2019) presented a combination of location and vehicle decisions, which are known as NP-hard problems and require long computations and sufficient time. Due to the complexity of the problem, the discovery strategies simultaneously solved the routing problem and the routing decision. This two-dimensional architecture speeds up the search space, so that optimal solutions can be generated without excessive computation. An extensive study in this field shows that the performance of the TS algorithm is significantly improved over an active LRP problem. This method provides satisfactory answers to various problems and searches. However, in order to expand it, minor modifications should be made so that it can be effective for larger issues as well.

**4.5.2. Some points of the TS method that have been reviewed**

Table 6 shows major advantages and disadvantages of TS method for each research.

**Table6.** Major advantages and disadvantages of TS method

**4.6 Particle Swarm Optimization (PSO) method**

Paper	Advantage	Disadvantage
Li et al. (2018)	<ul style="list-style-type: none"> <li>• Optimality more universal</li> <li>• Good computing time</li> <li>• Improve the performance of previous methods</li> </ul>	<ul style="list-style-type: none"> <li>• Run on small scales</li> <li>• improving algorithm in the future</li> <li>• no iterations</li> <li>• no runtime</li> </ul>
Lai et al. (2016)	<ul style="list-style-type: none"> <li>• System cost savings</li> <li>• Using the alternative path</li> <li>• Competing with other methods</li> <li>• Search space intensification</li> </ul>	<ul style="list-style-type: none"> <li>• Lot of calculations</li> <li>• Time of calculation</li> <li>• Approximation Method</li> </ul>
Silvestrin and Ritt (2017)	<ul style="list-style-type: none"> <li>• Competing with similar methods</li> <li>• Comparability</li> <li>• better results on medium scale</li> </ul>	<ul style="list-style-type: none"> <li>• Improve the method in the future</li> <li>• Lot of calculations</li> </ul>
Polak and Boryczka (2019)	<ul style="list-style-type: none"> <li>• Solving the two problems at the same time</li> <li>• Less computing</li> <li>• Low computing time</li> </ul>	<ul style="list-style-type: none"> <li>• Parameter Limit</li> <li>• Using Non-Optional Variables</li> <li>• Failure to adapt to real problems</li> </ul>



In various sciences, the particle swarm optimization technique is an operational computational method that is optimized by repeatedly trying to refine a solution in observation with response measurement criteria. Consider this problem with a number of initial solutions, the particles considered as responses, and the movement of these particles into the search space. Researchers solve the problem by using simple mathematical formulas to move the particle in speed and position. At each step, the particles are directed to their known location as well as to known positions in the search space, which are updated when the system demands. This process is expected to lead to the best answer.

#### **4.6.1 A summary of the selected process**

Yu Peng et al. (2019) tested and presented a localization model with random parameters and artificial intelligence techniques. In their model, the location of fuzzy random possibility based on value at risk (VaR-FRFLM) is produced, in this model, both cost components and requests are assumed to be fuzzy random values, and the capacity of each possibility is fixed, and the value of the objective function is assumed to be continuous. A hybridization of the improved particle swarm optimization (MPSO) process is proposed to solve the VaR-FRFLM problem. In this developed technique, an approximation algorithm is used to calculate the stochastic fuzzy VaR target. The numerical results obtained show that the combination of MPSO performs better than when PSO and the corresponding regularized algorithm are used independently, but they only solve VaR-FRFLM. The capacity in the new model is not fixed, but it is assumed that the decision will be made. This action leads to the implementation of the model based on the running work, the proposed MPSO developed method and algorithm can be extended to other 0-1 integration optimization with VaR criterion. In addition, a VaR-based fuzzy stochastic temporal model may be far from a multi-objective model considering the expected profit as another objective. In general, the use of fuzzy variables is a growing result. Although there are optimization problems in random models, the effective efficiency of this method is acceptable.

Yang Peng and Chen (2009) presented a routing problem in the distribution network system and logistics operation, which mathematical example is presented in this research. Since finding the optimal solution for this example is a hard (non-polynomial) problem, they separate the main

problem into several subproblems, for example one of the location allocation problems and the other of the car routing problem. Checks are done with the existing model and are applied with a penalty. The two-dimensional research is concerned with: (1) developing a model and method for multi-product routing and (2) combining the PSO method with another optimization algorithm to solve a more complex location problem than the routing problem. There are two problems at the same time and a suitable solution to the problem. However, this method suffers from parameter limitations despite providing suitable solutions for the intended problem.

Rabie et al. (2014) applied a particle swarm optimization (PSO) method to optimize large-scale continuous p-median location management decisions in the system. A related PSO technique, previously developed for the continuous P center, is used to optimize the p-mean position. Querying the location p is directed towards finding locations on the plane to minimize the total Euclidean distance from the range up to the set of final demand points. A notable aspect of the current work is that in the main topics, the problem was discussed in most of the cases already discussed in the literature. The obtained results are compared with several similar location problems. The Median-PSO-ED technique and method is used to find suitable solutions for problems with relatively large sizes. The results show the superiority of this technique compared to the results obtained in previous methods. In general, this method has been adapted to a specific problem and has yielded acceptable results, but it is not generalizable to other subjects.

Yu et al. (2014) proposed a location allocation problem for the location of urban parks based on the use of particle optimization (PSO) model. In the SLA model for public park, there are several operators such as competition, community compression and access. This shows that a number of parks have been investigated in this study. In order to find the required parking spaces, SLAs are checked using a very complex capping method. The PSO algorithm can reduce the computations and adjust the set of parks in the expected time. For example, by allocating places for hospital services, agriculture, water saving systems, cinemas and

supermarkets, etc., this method can be used for other services. Compared to other artificial intelligence methods, this model is simpler and more practical and requires fewer parameters to calculate. The parameter of building size, the distance of networks from each other and local laboratory parameters for different places have an effect on the estimation of population density in the optimization method. The results obtained from SLA show that this particular approach is simple and cost-effective, and the system development tool can help local managers decide to do better work in urban planning. But in terms of computational time, this method has some shortcomings.

#### 4.6.2. Some points of the PSO method that have been reviewed

Table 7 shows major advantages and disadvantages of PSO method for each research.

**Table7** Major advantages and disadvantages of PSO method

Paper	Advantage	Disadvantage
Yu Peng et al. (2019)	<ul style="list-style-type: none"> <li>achieve the promising performance</li> <li>Using Fuzzy Variables</li> <li>Better time calculations</li> </ul>	<ul style="list-style-type: none"> <li>Not generalizing the algorithm to integers</li> <li>Random optimization problems</li> <li>Not considering the expected profit</li> </ul>
Yang Peng and Chen (2009)	<ul style="list-style-type: none"> <li>Solving the two problems at the same time</li> <li>Provide practical solutions</li> <li>Improve the performance of the algorithm</li> </ul>	<ul style="list-style-type: none"> <li>Performance Limit</li> </ul>
Rabie et al. (2014)	<ul style="list-style-type: none"> <li>Solving big problems</li> <li>comparing results</li> <li>Finding the best solution</li> </ul>	<ul style="list-style-type: none"> <li>Having some limitations</li> </ul>
Yu et al. (2014)	<ul style="list-style-type: none"> <li>Need less parameters</li> <li>Can be generalized to most urban services in the real world</li> <li>Simpler, more sophisticated than other AI techniques</li> </ul>	<ul style="list-style-type: none"> <li>Computation time</li> </ul>

## 4.7 Hybridization of meta-heuristic techniques

Currently, the hybrid of different techniques and the development of methods is one of the best and most prosperous trends in optimization. The combination of metacognition, such as evolution and optimization algorithms of ants and variable neighborhood search with artificial intelligence techniques and operations research, plays an important role. The resulting hybrid algorithms are usually labeled as meta-heuristic hybridization. The rise in this new research field is due to the fact that the basis of optimization research has changed from an algorithmic perspective to a general perspective. In this short review, we will examine hybrid methods and the use of fuzzy logic.

### 4.7.1 A summary of the selected process

(Zhang et al., 2022) consider the layout optimization problem with the desired complexities of the problem that the flow of materials and goods fluctuates between different parts within a certain range. A developed and mathematical model is used to reach the optimal solution. In order to achieve the overall goal of the project, which is MHC planning, the conditions of the floating material flow matrix are used in the production process. Considering that the new mathematical model introduces many intermediate parameters and variables, they are forced to use a multi-step solution method, and with this method, the time to solve the model is greatly increased. Next, they use a problem-based meta-heuristic optimization technique that develops and combines the advantages of the harmony search technique and the forbidden search technique, which integrates the solution phase of calling the exact solver into a two-step method. The project greatly improves facility layout and problem-solving efficiency. And it makes it possible to solve practical and real examples with this initiative. In their proposed model, the problem is implemented through a computer software, and then the mathematical model and the resulting combined algorithm are implemented together in the MATLAB software space. Finally, their proposed developed algorithm is used to solve practical and real problems that could not be solved by the two-step method before. In general, this method is effective for large and real problems.

(Lv et al., 2022) addressed a new location routing problem (LRP) by developing heuristics and called this form of optimization dual-mode integrated routing and location allocation (DMI) in a commodity supply chain logistics system. Warehouse products in their system meet the needs of online service requesters and retailers together, and customers and retailers follow two different order components. The problem in question includes several components that are presented in a general system. In that, the goods are referred from the manufacturing plant to the distribution centers (DC) in the first phase and from the centers (DC) to the buyers and retailers in the second phase. In this system, the mathematical model is presented along with some valid inequalities to strengthen the formula for the exact technique. They propose a solution for applicants and retailers in the problem of location allocation based on fuzzy correlation for each of the components. Following this process, a developed technique for neighbor point search (FCA) is presented for the planning and routing model. In their proposed method, tests have been performed on some standard samples and the results have been compared with some similar exploratory methods and other precise methods. The results of the examples and the optimization done show the effectiveness and feasibility of the proposed method, especially in solving real scale problems.

(Mokhtarzadeh et al., 2021) investigated the issue of new p-mobile hub allocation with all its components. In a system, hub facilities can be transferred to neighboring hubs for a new period. Implementing mobile hubs can contribute to hub opening and closing costs, especially in an environment where customer demands are rapidly increasing. On the other hand, moving the facilities of a network reduces the lifespan of the hubs and increases the related costs. Life expectancy and depreciation of hub facilities and other costs should be considered and specific restrictions on the movement of hub facilities should be applied. Several processes are in place to minimize the noise pollution, costs, and expense of creating a hub for the public. To optimize this proposed model, several meta-heuristic techniques, namely a non-dominated sorting genetic method (NSGA), multi-objective particle swarm optimization (MPSO), a combination of k-medoids as a well-known clustering method, and a combination of k-medoids and KMOPSO is used. The obtained optimization results show that KNSGA-II has a good performance and is effective compared to other methods.

(Fazli et al., 2021) developed a two-phase hybrid heuristic method for solving the vehicle location problem (FLRP). In their methods, the FLRP model examines the location and routing objective. Upon arrival, they face a set of identical vehicles (each with fixed cost and capacity), a set of offices with limited opening cost, limited capacity, and a set of customers with fixed demand. In this case, they used fuzzy functions and variables to make the answers more realistic. The results and solutions of practical calculations show that the proposed mathematical model can solve other problems such as periodic routing problem (PLRP) and multiple routing problems (MDVRP) and several extensions of CLRP. In other words, adding constraints such as window time and heterogeneous fleets becomes problematic. In general, their proposed method is favorable in terms of calculation time compared to similar methods. With the help of using fuzzy values, it is effectively used in real problems.

(Saffari et al., 2022) developed an integrated logistics method in which the main decisions about storage location, route allocation by vehicle is made simultaneously. The balancing skill of joint decision criteria and total system costs shows that concurrent versions have capacity constraints in sequential problems, but they do not temporarily conflict with each other. Concurrent versions are also more effective non-dominant solutions than sequential versions. This procedure considers both problems at the same time and tries to reduce the cost of the system, so it has a challenging situation in terms of efficiency and timing of checks. They used the RBF-NN model by designing the fuzzy formula of the control parameters of the Whale Algorithm method. GWO, FWOA, WOA, GSA, ChOA, LCA, ES, GA algorithms have been used to use RBF-NN. The FWOA method can well define the boundary between exploitation and exploration phases. Therefore, this model does not get stuck in the local optimizer and proves its ability to find global optimizations to solve really high-dimensional problems. The obtained results show that RBF-WOA, RBF-FWOA, RBF-GWO, and RBF-ChOA methods have the best classification solutions, respectively. Also, the convergence speed of the FWOA method in reaching the optimal solution is better than the other seven used methods.

Babaie-Kafaki et al. (2016) have introduced a new method by hybridizing and increasing the number of iterations of genetic algorithms and gradually increasing the probability of using the neighborhood search method on specific members. They implemented the proposed hybrid technique and compared the performance of their method

with several well-developed meta-heuristic techniques. In this context, they use a special method based on neighborhood search for all investigated points, in this process they apply two new simulated hybridization techniques to the best individual in the population in each iteration. They applied algorithms on the location problem using fuzzy values, these fuzzy values were used to reduce uncertainty and make the problems more realistic. To investigate the effectiveness of the proposed technique, they implemented and solved specific models for the fuzzy terminal location problem. It is assumed that the fuzzy model has the number of terminals and passengers with fuzzy values corresponding to the hypothesis, as well as the fuzzy location with default upper and lower bounds for the number of locations required by the problem. They randomly generated algorithms at different terminal locations with large-scale fuzzy values, where the coefficient of the cost function is considered as a fuzzy value. Although the proposed method has many iterations, it is suitable for large and real problems.

Saif-Eddine et al. (2019) introduced two new hybrid techniques. They solve the optimization problem by combining existing methods and forming a new hybrid method (HGA). Their paper deals with the inventory location allocation and routing problem (ILRP) when making managerial decisions. Considering the constraints and to minimize the cost of the whole supply chain, a mathematical model has been used and this is a hard problem. A new improved genetic algorithm (IGA) is designed and modeled to solve the real-scale problem optimally. In the implemented problems, two samples (30 and 10 applicants) have been planned and solved. To demonstrate the impact of this new approach, the total vehicle capacity (number of vehicles in the parking lot and capacity of each vehicle) on the total cost of the supply chain is considered. In the examples, the obtained results show that the IGA technique performs better than the GA technique in achieving a lower cost, especially for a large number of applicants. Improving the efficiency of the solution and the obtained solutions is mainly achieved at the cost of optimal computing time. Despite the limitations of the parameters, this method is highly efficient and has a good computing time compared to similar methods.

#### 4.7.2. Some points of the HA method that have been reviewed

Table 8 shows major advantages and disadvantages of HA method for each research

**Table8** Major advantages and disadvantages of HA method

Paper	Advantage	Disadvantage
Zhang et al. (2022)	<ul style="list-style-type: none"> <li>Solving the two problems at the same time</li> <li>Provide practical solutions</li> <li>Improve the performance of the algorithm</li> </ul>	<ul style="list-style-type: none"> <li>Having limits on big problems</li> </ul>
Lv et al.(2022)	<ul style="list-style-type: none"> <li>Generate synchronous version</li> <li>Average cost improvement</li> <li>Low computing time</li> <li>Average and proper distance</li> </ul>	<ul style="list-style-type: none"> <li>Applying medium graphs</li> </ul>
Mokhtarzadeh et al. (2021)	<ul style="list-style-type: none"> <li>Improve the quality and time of the CPU</li> <li>Solving the two problems at the same time</li> <li>Application for large samples</li> </ul>	<ul style="list-style-type: none"> <li>Computation time</li> </ul>
Fazli et al. (2021)	<ul style="list-style-type: none"> <li>Low computing</li> <li>Using real values</li> <li>Comparability</li> </ul>	<ul style="list-style-type: none"> <li>Having some limitations</li> </ul>
Saffari et al.(2022)	<ul style="list-style-type: none"> <li>Generate synchronous version</li> <li>Average cost improvement</li> <li>Low computing time</li> <li>Average and proper distance</li> </ul>	<ul style="list-style-type: none"> <li>Applying medium graphs</li> </ul>

Babaie-Kafaki et al. (2016)	<ul style="list-style-type: none"> <li>• Real-world application</li> <li>• Low computing time</li> <li>• It works for great issues</li> </ul>	<ul style="list-style-type: none"> <li>• Repeated algorithms</li> </ul>
Saif-Eddine et al. (2019)	<ul style="list-style-type: none"> <li>• Low computing time</li> <li>• Compare with similar algorithms</li> <li>• Little repeats</li> </ul>	<ul style="list-style-type: none"> <li>• Having some limitations</li> <li>• Using random data in the algorithm</li> </ul>

**5. Open issue**

In this section, we will examine the different methods of the location allocation problem, which have not yet been widely and comprehensively addressed. This can be taken into consideration in Moore's future research and be a research guide. According to the meta-heuristic techniques used, in the location and routing problem, the priorities and criteria mentioned in this article are the number of repetitions, competition, and execution time, while some researches completely ignore these important issues. For example, in research, it is necessary to consider convergence algorithms, appropriate execution time, number of iterations and method improvement. Also, in some related techniques and algorithms, success, competition and comparison are considered, while these issues are not prioritized in some studies. Therefore, meta-heuristic techniques and their algorithms were analyzed in detail. There is no independent technique that addresses all criteria in a given problem. Another important point of future study can be the investigation of solving the location problem with the development of meta-heuristic algorithms. In addition, some meta-heuristic algorithms that are efficient and effective in specific subjects are considered. It will be interesting to examine their methods. When we increase the size of the location problem, it is clear that the number of iterations of the algorithm and the execution time increase. So that these problems do not occur, meta-heuristic methods and algorithms should be redesigned with the aim of eliminating the problems caused by such cases. In addition, the efficiency of meta-heuristic algorithms in solving real location problems is one of the important aspects, including in larger-scale problems. Therefore, the efficiency of the methods and their algorithms for convergent solutions, global optimality, number of successes, etc. are interesting and good criteria for future studies.

In most of the reviewed techniques, many new meta-heuristic algorithms such as particle swarm optimization, artificial fish algorithm, simulated annealing, etc. are used with the aim of increasing the efficiency for this special problem in prominent journals. In addition, some factors such as dependence of algorithms on parameters, starting with infeasible solutions, large scale graph, reduction of solution space and standard deviations were not considered. In addition, in this review article, the application of meta-heuristic algorithms in the location problem is fully discussed. By reviewing the studies, we observed that in hybrid meta-heuristic algorithms, better results are obtained than independent methods. In other words, most scientific criteria are improved by specific hybrid methods. Therefore, some new hybrid approaches are needed in future projects.

**6. Conclusion**

Location allocation and routing problems can have different effects on the economy of the society. Although meta-heuristic algorithms are practical methods for solving location problems, due to the computational time and more iterations, in recent years, the tendency to combine these methods has been suggested to increase their efficiency. Therefore, we propose a hybrid of these methods to solve these types of problems. These methods give the best results and at the same time work best on a set of problems. Again, the calculations show that: meta combination results are better than heuristic and metacognitive combinations. As its creation mechanism for generating new solutions, it allows storing and using relatively large equations of good and varied solutions during the search process. These methods require minimal computing time and are very suitable in line with similar experiments presented in the literature. In general, combined metacognitive methods are very effective tools for finding suitable solutions. Case studies illustrate the approaches needed for social learning research, as long-term process analysis requires sensitivity to social and economic contexts. Therefore, fuzzy data can be used for problem solving in obtaining a dataset of real problems. This issue can also be the subject of future research.

## References

- Amaya, J. E., Porras, C. C., & Leiva, A. J. F. (2015). Memetic and hybrid evolutionary algorithms. In *Springer Handbook of Computational Intelligence* (pp. 1047-1060): Springer.
- Aznoli, F., & Navimipour, N. J. (2016). Deployment Strategies in the Wireless Sensor Networks: Systematic Literature Review, Classification, and Current Trends. *Wireless Personal Communications*, 1-28.
- Aznoli, F., & Navimipour, N. J. (2017). Cloud services recommendation: Reviewing the recent advances and suggesting the future research directions. *Journal of Network and Computer Applications*, 77, 73-86.
- Babaie-Kafaki, S., Ghanbari, R., & Mahdavi-Amiri, N. (2016). Hybridizations of genetic algorithms and neighborhood search metaheuristics for fuzzy bus terminal location problems. *Applied Soft Computing*, 46, 220-229.
- Charband, Y., & Navimipour, N. J. (2016). Online knowledge sharing mechanisms: a systematic review of the state of the art literature and recommendations for future research. *Information Systems Frontiers*, 6(18), 1131-1151.
- Crossland, A., Jones, D., & Wade, N. (2014). Planning the location and rating of distributed energy storage in LV networks using a genetic algorithm with simulated annealing. *International Journal of Electrical Power & Energy Systems*, 59, 103-110.
- Drexler, M., & Schneider, M. (2015). A survey of variants and extensions of the location-routing problem. *European Journal of Operational Research*, 241(2), 283-308.
- Ellis, R., & Petridis, M. (2009). *Research and Development in Intelligent Systems XXVI: Incorporating Applications and Innovations in Intelligent Systems XVII*: Springer Science & Business Media.
- Fazli, M., F.M.Khiabani and B. Daneshian, *Hybrid whale and genetic algorithms with fuzzy values to solve the location problem* mmep, 763-768
- Ghorbani, A., & Jokar, M. R. A. (2016). A hybrid imperialist competitive-simulated annealing algorithm for a multisource multi-product location-routing-inventory problem. *Computers & Industrial Engineering*, 101, 116-127.
- Hiassat, A., Diabat, A., & Rahwan, I. (2017). A genetic algorithm approach for location-inventory-routing problem with perishable products. *Journal of Manufacturing Systems*, 42, 93-103.
- Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University*, 33(2004), 1-26.
- Küçükoğlu, İ., Dewil, R., & Catrysse, D. (2019). Hybrid simulated annealing and tabu search method for the electric travelling salesman problem with time windows and mixed charging rates. *Expert Systems with Applications*, 134, 279-303.
- Kupiainen, E., Mäntylä, M. V., & Itkonen, J. (2015). Using metrics in Agile and Lean Software Development—A systematic literature review of industrial studies. *Information and Software Technology*, 62, 143-163.
- Lai, D. S., Demirag, O. C., & Leung, J. M. (2016). A tabu search heuristic for the heterogeneous vehicle routing problem on a multigraph. *Transportation Research Part E: Logistics and Transportation Review*, 86, 32-52.
- Li, X., Yue, C., Aneja, Y. P., Chen, S., & Cui, Y. (2018). An Iterated Tabu Search Metaheuristic for the Regenerator Location Problem. *Applied Soft Computing*, 70, 182-194.
- Liu, S., Leng, H., & Han, L. (2017). Pheromone Model Selection in Ant Colony Optimization for the Travelling Salesman Problem. *Chinese Journal of Electronics*, 26(2), 223-229.
- Lv, C., Zhang, C., Ren, Y., & Meng, L. (2022). A fuzzy correlation based heuristic for Dual-mode integrated Location routing problem. *Computers & Operations Research*, 146, 105923.
- Mokhtarzadeh, M., Tavakkoli-Moghaddam, R., Triki, C., & Rahimi, Y. (2021). A hybrid of clustering and meta-heuristic algorithms to solve a p-mobile hub location-allocation problem with the depreciation cost of hub facilities. *Engineering Applications of Artificial Intelligence*, 98, 104121.
- Nagy, G., & Salhi, S. (2007). Location-routing: Issues, models and methods. *European Journal of Operational Research*, 177(2), 649-672.
- Navimipour, N. J., & Charband, Y. (2016). Knowledge sharing mechanisms and techniques in project teams: literature review, classification, and current trends. *Computers in Human Behavior*, 62, 730-742.
- Peng, Y., & Chen, Z.-X. (2009). *Two-phase particle swarm optimization for multi-depot location-routing problem*. Paper presented at the New Trends in Information and Service Science, 2009. NISS'09. International Conference on.
- Peng, Y., Cheng, J.-f., & Jiang, R.-x. (2019). Inversion of UEP signatures induced by ships based on PSO method. *Defence Technology*.
- Perl, J., & Daskin, M. S. (1985). A warehouse location-routing problem. *Transportation Research Part B: Methodological*, 19(5), 381-396.
- Polak, I., & Boryczka, M. (2019). Tabu Search in revealing the internal state of RC4+ cipher. *Applied Soft Computing*, 77, 509-519.
- Prima, P., & Arymurthy, A. M. (2019). *Optimization of school location-allocation using Firefly Algorithm*. Paper presented at the Journal of Physics: Conference Series.
- Prodhon, C., & Prins, C. (2014). A survey of recent research on location-routing problems. *European Journal of Operational Research*, 238(1), 1-17.
- Rabie, H. M., El-Khodary, I. A., & Tharwat, A. A. (2014). *Particle Swarm Optimization algorithm for the continuous p-median location problems*. Paper presented at the Computer Engineering Conference (ICENCO), 2014 10th International.
- Rao, B. V., & Kumar, G. N. (2014). Sensitivity analysis based optimal location and tuning of static VAR compensator using firefly algorithm. *Indian Journal of Science and Technology*, 7(8), 1201-1210.

- Rybičková, A., Burketová, A., & Mocková, D. (2016). *Solution to the location-routing problem using a genetic algorithm*. Paper presented at the Smart Cities Symposium Prague (SCSP), 2016.
- Saffari, A., Zahiri, S. H., & Khishe, M. (2022). Fuzzy whale optimisation algorithm: a new hybrid approach for automatic sonar target recognition. *Journal of Experimental & Theoretical Artificial Intelligence*, 1-17.
- Saif-Eddine, A. S., El-Beheiry, M. M., & El-Kharbotly, A. K. (2019). An improved genetic algorithm for optimizing total supply chain cost in inventory location routing problem. *Ain Shams Engineering Journal*, 10(1), 63-76.
- Salhi, S., & Rand, G. K. (1989). The effect of ignoring routes when locating depots. *European journal of operational research*, 39(2), 150-156.
- Silvestrin, P. V., & Ritt, M. (2017). An iterated tabu search for the multi-compartment vehicle routing problem. *Computers & Operations Research*, 81, 192-202.
- Soltani, Z., & Navimipour, N. J. (2016). Customer relationship management mechanisms: A systematic review of the state of the art literature and recommendations for future research. *Computers in Human Behavior*, 61, 667-688.
- Sulaiman, M. H., Mustafa, M. W., Azmi, A., Aliman, O., & Rahim, S. A. (2012). *Optimal allocation and sizing of distributed generation in distribution system via firefly algorithm*. Paper presented at the Power Engineering and Optimization Conference (PEDCO) Melaka, Malaysia, 2012 Ieee International.
- Vallada, E., Ruiz, R., & Minella, G. (2008). Minimising total tardiness in the m-machine flowshop problem: A review and evaluation of heuristics and metaheuristics. *Computers & Operations Research*, 35(4), 1350-1373.
- Wasner, M., & Zäpfel, G. (2004). An integrated multi-depot hub-location vehicle routing model for network planning of parcel service. *International Journal of Production Economics*, 90(3), 403-419.
- Yang, L., Sun, X., & Chi, T. (2013). *An ant colony optimization algorithm and multi-agent system combined method to solve Single Source Capacitated Facility Location Problem*. Paper presented at the Advanced Computational Intelligence (ICACI), 2013 Sixth International Conference on.
- Yu, J., Chen, Y., Wu, J., Liu, R., Xu, H., Yao, D., & Fu, J. (2014). *Particle swarm optimization based spatial location allocation of urban parks—A case study in Baoshan District, Shanghai, China*. Paper presented at the Agro-geoinformatics (Agro-geoinformatics 2014), Third International Conference on.
- Zhang, Z., Gong, J., Liu, J., & Chen, F. (2022). A fast two-stage hybrid meta-heuristic algorithm for robust corridor allocation problem. *Advanced Engineering Informatics*, 53, 101700.