PAPER • OPEN ACCESS

A Survey for Vehicle Routing Problems and Its Derivatives

To cite this article: Ming Han and Yabin Wang 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **452** 042024

View the article online for updates and enhancements.

A Survey for Vehicle Routing Problems and Its Derivatives

Ming Han[a], Yabin Wang[*]

The Army of Engineering University of PLA, Shi Jiazhuang, China

*Corresponding author e-mail: wangyabin@163.com,[a]2858759673@qq.com

Abstract. Based on the research of recent papers on routing optimization, this paper classifies routing problem into traditional vehicle routing problem and its derivatives, such as CVRP (Capacity Vehicle Routing Problem), HVRP (Heterogeneous Vehicle Routing Problem), MDVRP (Multi-warehouse Vehicle Routing Problem, VRPTW (Vehicle Routing Problem with Time Window). Optimization problem, MDVRPTW (multi-depot vehicle routing problem with time windows), MDHVRPTW (multi-depot heterogeneous vehicle routing problem with time windows). The characteristics of the above problems are summarized and analyzed, and the innovative solution methods are proposed. Finally, the further research trends and hot spots of the path optimization problem are prospected.

1. Introduction

The number of high-quality papers can reflect the research strength of the corresponding field from the side. Based on Lv Cheng's statistical analysis of the literature collected by SCI and SSCI during the four years from 2012 to 2016, it can be seen that more and more countries have paid attention to the study of logistics issues in the past year. As shown in Figure 1, in recent years, a great deal of logistics has sprung up in the world. The top five hot topics in logistics research are green logistics, urban logistics, emergency logistics, transportation and logistics scheduling, as shown in Figure 2. It is noteworthy that transportation as a traditional logistics problem is still among the hot issues in recent years, and its growth rate ranks first among the above hot issues, such as table 1 [1].
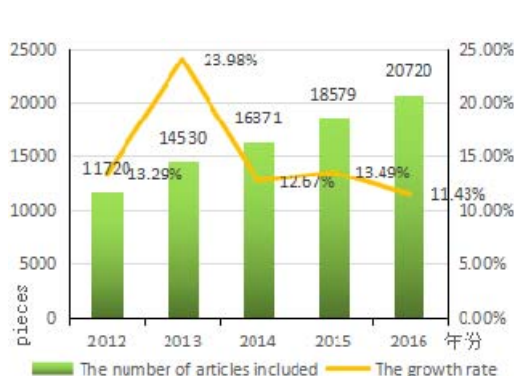

Figure 1. The number of papers and its growth rates collected by SCI and SSCI in logistics field between 2012 and 2016 in the world.
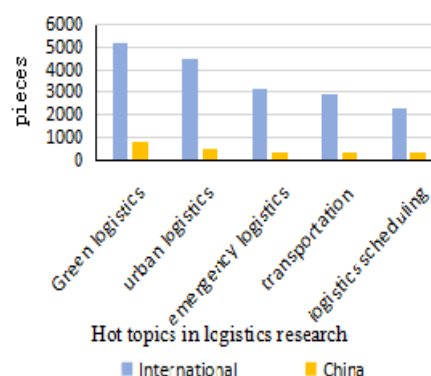
Figure 2. Hot Issues whose papers in the field of logistics were ranked the top 5 by SCI and SSCI from 2012 to 2016.

Table 1. Statistics on the number of papers and annual average growth rates of SCI and SSCI in the research field of logistics hotspots.

Year	International					Domestic				
	GL	UL	EL	T	LS	GL	UL	LS	T	EL
2012	681	586	422	374	346	112	149	56	41	41
2013	911	789	514	493	396	130	125	51	54	45
2014	1047	891	642	585	457	162	79	76	58	51
2015	1217	1074	760	642	520	193	78	67	68	78
2016	1340	1134	849	791	563	240	53	102	107	91
Annual growth rate%	18.44%	17.94%	19.10%	20.59%	12.94%	20.99%	-22.77%	16.17%	27.10%	22.06%

Note: GL-green logistics, UL-urban logistics, EL-emergency logistics, T-transportation, LS-logistics scheduling

The reason is the application of advanced information technology (such as Internet of Things, cloud technology, big data, etc.), the refinement of spare parts demand standards, the high efficiency of logistics management mode, the diversification of transportation modes, etc., which have impacted the traditional mechanical extensive The mode of transportation has spawned the emergence of transportation optimization results that are closer to practical problems and requirements, especially with regard to path optimization.

2. Vehicle Routing Problems and Its Derivatives

There are mainly basic vehicle routing problems VRP and its variants in solving vehicle routing optimization problems, such as the capacity vehicle routing problem (CVRP), the heterogeneous vehicle routing problem (HVRP) and the multi-warehouse vehicle routing problem (MDVRP). Vehicle window problem for time windows (VRPTW), and MDHVRPTW. But only a limited number of papers describe this variant.

2.1. Vehicle Routing Problem (VRP)

VRP is a promotion of Traveling Salesman Problem (TSP) and Packing Problem (BPP) and is the most basic vehicle routing problem. The solution methods can be roughly divided into three types: precise method, heuristic method and meta heuristic algorithm. The approximation algorithm (heuristic algorithm and meta heuristic algorithm) is more effective in solving the problem, such as tabu search algorithm. Ant colony algorithm, particle swarm algorithm, etc. Although as a traditional path problem, a lot of research results have been produced recently, mainly focusing on model improvement, algorithm improvement and method innovation. For example, Agustín et al. completed the original VRP model by considering the constraints of picking and delivery constraints [2]. Florian and Kenneth developed a data mining-based approach and used heuristics to solve VRP problems [3]. Darat et al. proposed a self-organized differential evolution mapping algorithm (MESOMDE_G-Q-DVRP-FD) based on multi-factor evolution to solve the VRP problem considering hybrid picking [4]. Pan Wenwen et al. added the consideration of the recovery value of oil casing in the traditional VRP mathematical model, and proposed to solve the above problem by using the differential evolution algorithm of the small mirror technology [5].

2.2. Capacitated Vehicle Routing Problem (CVRP)

All Capacity Vehicle Routing Problem CVRP refers to the limitation of vehicle capacity for basic VRP issues. That is, multiple vehicles are dispatched from a single warehouse, and the total demand of each route does not exceed the vehicle capacity, so that the total cost of service delivery is minimal.

There are many algorithms for solving this optimization problem. For example, Teymourian uses the intelligent water droplet algorithm IWD, the improved cuckoo search ACS, the local search hybrid algorithm LSHA and the hybrid meta heuristic algorithm POHA to control the balance betwenn diversity and intensity of the search process. Its research shows that ACS has good convergence, LSHA can be improved according to the traditional rhododendron CS, and can use the optimal solution of CVRP problem in ACS after the IIWD convergence, as shown in the following figure3, 4. Bouzid et al. proposed a Lagrangian relaxation method called Lagrangian splitting for CVRP [7]. Hosseinabadi uses the gravity simulation local search algorithm to solve CVRP, which helps to obtain high quality solutions in reduced runtime [8]. Mahmuda Akhtar et al. proposed an improved backtracking search algorithm (BSA) to solve the CVRP problem of garbage collection [9]. For large-scale CVRP problems, Kır proposed a meta-heuristic algorithm based on tabu search and adaptive large neighborhood search [10]. Cooray and Rupasinghe proposed a machine learning based parameter adjustment genetic algorithm to solve the green logistics CVRP problem [11]
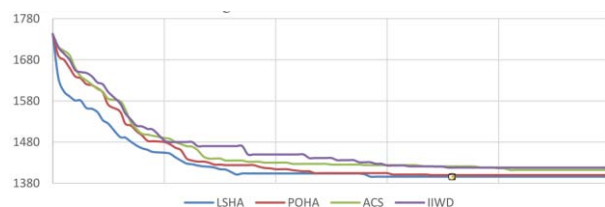

Figure 3. The convergence curve of all algorithms for Christofide's PR10.
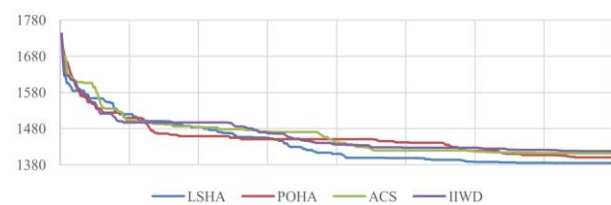

Figure 4. The convergence curve of all algorithms for Golden's PR05.

2.3. Heterogeneous Vehicle Routing Problem (HVRP)

To make up for the traditional VRP problem, only consider the limitations of the same type of vehicle transportation. It is more practical to consider the use of different capacity vehicles for spare parts supply in path optimization. Gan et al. proposed a method for solving heterogeneous fixed fleet vehicle routing problems (HFFVRP) based on structural redesign of bacterial foraging optimization (SRBFO) [12]. The tabu search heuristic algorithm proposed by David et al. can effectively solve the HVRP problem [13]. Vincent et al. developed a simulated annealing heuristic algorithm using a restart strategy (SAYRS) and used the Cauchy function to determine the acceptance probability of a worse solution (SAO-RSCF), effectively solving the hybrid vehicle path problem [14]. Simona Mancini studied the path optimization problem for hybrid (electrical and conventional fuel) vehicles, practicing a simplified version of the HVRP problem, the Green Vehicle Routing Problem (GVRP) [15].

2.4. Multi-Depot Vehicle Routing Problem (MDVRP)

For the classic VRP problem, the path of all vehicles can only start from a warehouse. Laporte Laporte considered the MDVRP problem when the vehicle departed from multiple warehouses. Montoya Torres classified the algorithms for solving this problem in terms of precision, heuristics, and metaheuristics [16]. Many scholars have studied the application of genetic algorithms and improved genetic algorithms in MDVRP problems, such as the review of Karakatic and Podgorele [17], Luo Yaobo et al. Applying adaptive hybrid genetic algorithm to the solution of MDVRP problem in returnable mode [18]], Bae and Moon developed a routing construction heuristic algorithm and genetic algorithm for this problem [19], and Zhang Lifeng and other semi-parallel operators improved genetic algorithm to effectively solve the multi-warehouse path optimization problem of wartime equipment distribution [20] . There are also many scholars who have made improvements to the ant colony algorithm for solving MDVRP, such as Zibaei [21] and ya [22]. Luo Yan and He Lili proposed a tabu search algorithm to solve the logistics problem of multiple transceiver nodes [23]. In response to the multi-resource MDVRP problem, Dai Xi and others have innovatively developed a human-computer interactive solution method based on two-stage heuristic algorithm [24]. Calvet proposed a hybrid approach that combines statistical learning techniques with a metaheuristic framework to

predict the tasks of individual warehouses based on customer needs [25]. Oliveira proposed a co-evolution algorithm to decompose the problem, each sub-problem becomes a single warehouse VRP and evolves independently in its domain space [26]. Iman considered the branch pricing method to solve this problem [27].

In addition, Jairo et al. reviewed the relevant literature on MDVRP from 1988 to 2014 and explored several variants of traditional MDVRP issues: considering time windows, batch delivery, heterogeneous fleets, scheduled delivery, and picking. And delivery, etc. MDVRP [28].

2.5. Vehicle Routing Problem with Time Window (VRPTW)
The Vehicle Path Problem with Time Window (VRPTW) is a well-known combinatorial optimization problem often encountered in many industrial applications. It was originally proposed by Solomon and Desorios in 1987. The time window is divided into soft time windows (customers end spare parts that exceed the upper limit of the time window, but impose certain penalties on the delivery side) and hard time windows (customers have strict requirements on the time window and do not accept spare parts that exceed the time window). VRPTW is a hot issue in path optimization research in recent years. With the unremitting efforts of scholars at home and abroad, research results on such problems have emerged.

2.5.1. Improvement of algorithm. Toth and Vigo [29], Kumar, and Paneerselvam [30] have classified the methods for solving VRPTW. In particular, in recent years, a large number of domestic and foreign scholars have been actively pursuing the improvement and practical research on the heuristic algorithms of natural biota, which have caused a series of achievements to spring up. Fan Wenbing and Feng Wen used the hill-climbing algorithm to improve the genetic algorithm, which effectively improved the speed of VRPTW [31]. Deng Ye developed a multi-type ant system (MTAS) algorithm based on the multi-ant colony algorithm of local search process (ACS) and the minimum ant system (MMAS) algorithm [32]. Ge Bin et al. designed a dynamic hybrid ant colony optimization algorithm (DHACO) based on fusion strategy and cloud association rules to make up for the limitations of the traditional ACO algorithm [33]. Eneko proposed an evolutionary discrete bat algorithm (EDBA) for solving VRPTW problems by randomly inserting multiple heuristic operators [34]. The particle tabu search (GTS) algorithm designed by Michael not only can significantly improve the computational efficiency of the VRPTW problem, but also gives a complete Pareto foreword [35]. Yang et al. proposed that the chaotic particle swarm optimization algorithm improves the speed, robustness and speed of the solution of the VRPTW problem [36]. Pinar Kirci uses tabu search and neural networks and implements VRPTW on Google Maps [37]. The following algorithm is relatively novel: Xie Yong et al. developed an improved population-based incremental learning algorithm (IPBIL) [38]. Pratiwi designed an improved Bat algorithm and a cat group algorithm optimized according to the Raven search algorithm [39]. Yao et al. proposed an improved artificial bee colony algorithm IABC [40]. Wenbo Dong proposed a discrete firefly optimization algorithm for multi-target VRPTW that can be used to solve time window segmentation [41]. Wenbo's innovative three-cell MOEA-based tissue P system, PDVA, is shown in Figure 5. In the PDVA, the two mechanisms of discrete firefly evolution mechanism (DGEM) and variable neighborhood evolution mechanism (VNEM) are used as sub-algorithms in two units [42]. As shown in Figure 6, PDVA can quickly converge on high-quality solutions when dealing with VRPTW problems.

In addition, Reinhardt also applies the exact solution method based on branch and price and cutting to VRPTW [43]. Marwa designed a VND method for variable neighborhood descent [44]. Merve solves the small-scale VRPTW problem with CPLEX, and solves the large-scale VRPTW problem with a mathematical method that combines the adaptive large neighborhood search (ALNS) method with the precise method [45]. Huo Chai et al. designed a two-stage multi-objective optimization algorithm. In the first phase, a pulse algorithm is used to obtain the shortest path from the distribution center to each destination. In the second phase, the candidate transmission path is screened based on the non-designated classification genetic algorithm II (NSGA-II) [46].
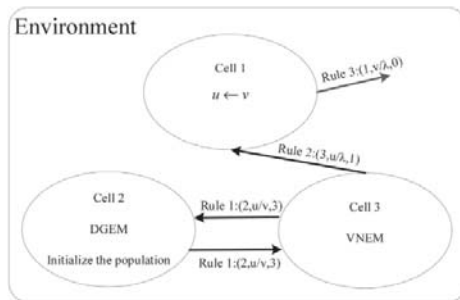
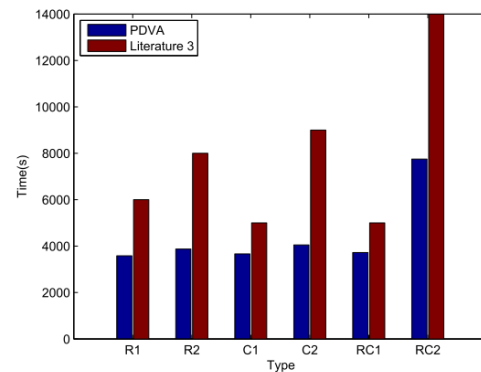**Figure 5.** Structure of a proposed tissue P system with three cells.

Figure 6. Average time for PDVA and HMOEA calculations under various issues.

2.5.2. Optimization and perfection of models. Li et al. will maximize customer satisfaction into the objective function in the model [47]. Hossein et al. incorporated customer satisfaction with customer priority into the objective function. Aiming at large-scale problems, two kinds of meta-heuristic algorithms, simulated annealing (SA) and genetic algorithm (GA), are proposed [48]. Defu Zhang et al. proceeded from the actual needs of logistics enterprises, and the pallet restrictions were added to the constraints of the model, and were solved by a hybrid method of tabu search and artificial bee colony algorithm [49].

2.5.3. Variants of the VRPTW problem. Many variants have also been derived from the recent research on VRPTW issues, as follows:

(1) a-VRPTW (Asymmetric vehicle path problem with time window)
Based on the consideration of container towing in the separation mode (in the unloading operation, the container can be separated from the truck and the empty container should be returned to the warehouse for maintenance), Yujian Song et al. studied the a-VRPTW problem with branch and price and cutting algorithm [50].

BTL-VRPTW(Dual target time, load and path dependent vehicle routing problem with time window)

Konstantinos et al. proposed and solved a dual-target time, load and path-dependent vehicle routing problem with time window (BTL-VRPTW), established a real-time traffic situation VRPTW model, and proposed network reduction method and reverse mark setting. Techniques to solve [51].

(3) (ESPPRC) The shortest path problem of the resource constraint of the negative period graph
ESPPRC's famous VRPTW column generates sub-problems for the solution. Studies have shown that when the time window is wide, the marking algorithm is not effective, and even in some cases it cannot even be applied. Jiarui Da et al. studied the ESPPRC polyhedron and determined the polyhedral dimension. Starting from the generalized cut set inequality, a new class of reinforcement inequalities is proposed, and the effectiveness of the algorithm is verified by an example [52].

(4) VRPTWDST (Vehicle path with time window and driver specific time asked)
Enlai Pu et al. proposed a hybrid differential evolution algorithm (HVDE) with high robustness and high quality solution for VRPTWDST, which uses service time and driver specific driving time to simulate the familiarity with DIF. More quality delivery service. Through simulation comparison, it is found that the driver's experience and knowledge accumulation on the path problem can effectively save the driving distance of the vehicle and improve the distribution efficiency [53].

(5) MM-TOPTW (the multimodal team orientation problem with time windows)
The Vincent study proposes a new variant of the Team Orientation Problem (TOPTW) with time windows, the multimodal team orientation problem with time windows (MM-TOPTW). Based on the standard TOPTW model, consider a variety of transportation options, including transportation costs

and transportation time. Based on this, a two-stage particle swarm optimization algorithm (2L-GLNPSO) with multiple social learning items is designed to solve this problem. A large number of cases and comparison with other algorithms show that the 2L-GLNPSO algorithm is not only suitable for solving small and medium-sized problems, but also can effectively obtain high-quality solutions for large-scale problems [54].

2.6. Multi Depot Vehicle Routing Problem with time windows (MDVRPTW)
Logistics companies often have multiple warehouses, and only one warehouse in the VRPTW problem addresses this limitation and avoids combining nearest neighbor search methods to avoid falling into local optimal solutions. Yan Kai et al proposed to use the holistic method to obtain the global optimal solution of the vehicle routing problem, and then use the intelligent optimization algorithm to select the yard for the distribution point to solve the MVVRPTW [55]. Yanfang Ma established the MDVRPTW mathematical model. An improved ant colony optimization algorithm (ACO) is proposed [56]. Fu Zhongyun et al. used the particle swarm optimization algorithm to solve the MDVRPTW problem with uncertain demand and fuzzy customer time window, in order to achieve the rapid response of the customer demand of the distribution team [57]. Cao Yun and other hybrid distribution estimation algorithms and relocation methods solve the MDVRPTW problem based on dynamic demand and time axis [58].

2.7. Multi-potted multi-vehicle heterogeneous vehicle routing problem (MDHVRPTW)
Based on the deep analysis of the actual constraints and customer needs and logistics technology, MDHVRPTW has entered the public's field of vision and has become one of the path optimization issues that current scholars are paying more attention to. MDHVRPTW is a very complex VRP variant, and there are currently few articles on its research. Bochra et al. reviewed recent research results on the multi-vehicle heterogeneous vehicle routing problem with time windows (MDHVRPTW) and its variants [59]. [60]Yuexiang Yang's improved variable neighborhood search algorithm effectively solves MDHVRPTW. [50] Proposed a mixed integer programming formula to the time-dependent MDHVRPTW. Roberto constructed a mixed integer linear system of periodic MDHVRPTW and solved it with a reactive greedy stochastic adaptive search algorithm [62].

3. Prospects for future research
Path optimization is an important part of the transportation problem, and it is also the hot spot of current transportation research. Due to the vigorous development of high technology, the refinement of customer needs, and the precision of decision-making schemes, the path optimization problem will continue to maintain or even increase its research fever.

There are many algorithms for solving the path optimization problem, and there are precise, heuristic and meta heuristic methods, especially in the natural heuristic algorithms of biological populations. However, each method has its own specific conditions, which can only solve one or two simple path problems. For practical transportation networks with complex multi-factor constraints, the applicability and interpretability are still limited. Therefore, model construction and algorithm optimization will continue to maintain the focus and hot spot of transportation research.

(1) In order to improve the precision of decision-making schemes and meet the refinement requirements of customers, future path optimization will pay more and more attention to multi-source and Depot Heterogeneous Vehicle Routing Problem with time. Windows, ie MRMDHVRPTW) model construction and algorithm optimization.

(2) The gradual expansion of the transportation business, the gradual expansion of the distribution area, the path optimization problem will raise the trend of dynamic real-time path optimization problems considering time-varying factors (such as real-time terrain, real-time traffic conditions). In my previous paper, a brief study on path optimization considering actual terrain was conducted, as shown in Figure 7, but it is limited to the static topographical factors. The distance measurement method is slightly improved, but there are still many limitations. It is hoped that there will be a large

number of path optimization results considering time-varying terrain and traffic conditions in the future. To achieve more practical and accurate path optimization.

(3) With the gradual application of new logistics modes such as multimodal transport, transport, and common distribution, new path optimization models and algorithms will be proposed. 4 In addition, the new generation of technological revolution and the vigorous development of Industry 4.0 will be based on the Internet of Things and artificial intelligence to build an intelligent transportation system has become one of the hot research directions in this field.
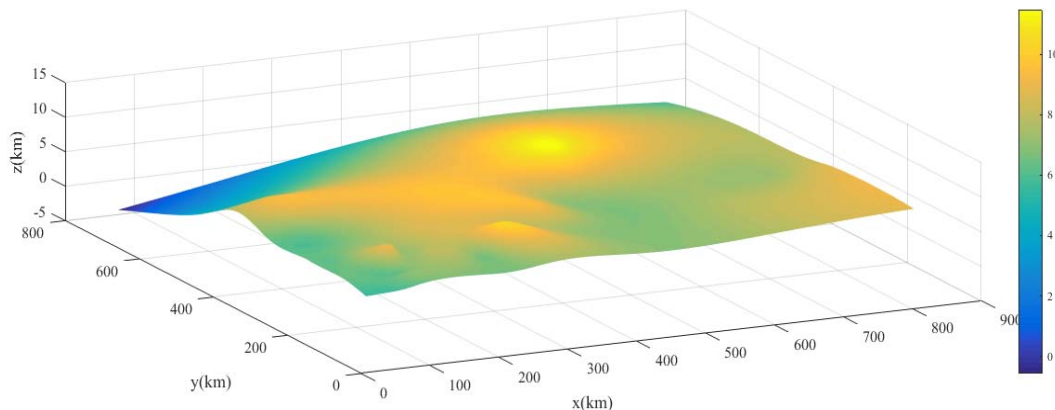

Figure 7. The topographic map of the distribution area.

References
[1]   C.Lv,The status quo, hotspots and trends of logistics research at home and abroad - a review of bibliometrics and theory , J. China's circulation economy, 2017, 31(12): 33-40.
[2]   F.Arnold, K. Sörensen, An ILP-based local search procedure for the VRP with pickups and deliveries,J. Annals of Operations Research, 2017, 259 (1-2): 327-350.
[3]   Florian A., Kenneth S., What makes a VRP solution good? The generation of problem-specific knowledge for heuristics, J. Computers & Operations Research, 2018.
[4]   D. Dechampai, L. Tanwanichkul, K. Sethanan, R. Pitakaso, A differential evolution algorithm for the capacitated VRP with flexibility of mixing pickup and delivery services and the maximum duration of a route in poultry industry, J. Journal of Intelligent Manufacturing, 2017, 28 (6): 1357-1376.
[5]   W.W. Pan , H.X. Guo, T.S. Du, X.Liu,D.Y. Wang, Research on the problem of vehicle routing for oil casing recovery and the algorithm for solving differential niche based on clearing niche, J. Chinese Management Science, 2018, (5): 118-128.
[6]   E.Teymourian, V. Kayvanfar, G.H.M. Komaki, M.Zandieh, Enhanced intelli-gent water drops and cuckoo search algorithms for solving the capacitated vehicle routing problem. Inf. Sci.2016: 334–335, 354–378.
[7]   M.C. Bouzid, H.A. Haddadene, S. Salhi, An integration of lagrangian split and VNS: the case of the capacitated vehicle routing problem, J. Computers & Operations Research, 2016.
[8]   A.A.R. Hosseinabadi, N.S.H. Rostami, M. Kardgar, S. Mirkamali, A. Abraham, A new efficient approach for solving the capacitated vehicle routing problem using the gravitational emulation local search algorithm. , J. Appl. Math. Model, 2017.
[9]   M. Akhtar,M.A. Hannan, R.A. Begum, H. Basri, E. Scavino, Backtracking search algorithm in CVRP models for efficient solid waste collection and route optimization, J. Waste Management, 2017, 61: 117-128.
[10] S.Kır, H.R. Yazgan, E. Tncel, A novel heuristic algorithm for capacitated vehicle routing problem, J. Ind. Eng. Int. 2017.

[11] P.L.N.U. Cooray, T.D. Rupasinghe, Machine learning-based parameter tuned genetic algorithm for energy minimizing vehicle routing problem, J. Ind. Eng. , 2017.

[12] X.B. Gan, L.J. Liu, N.Ben, L. J. Tan, F. F. Zhang, J. Liu, SRBFOs for Solving the Heterogeneous Fixed Fleet Vehicle Routing Problem, J. Intelligent Computing Theories and Methodologies, 2015, 9226: 725-732.

[13] D.S.W. Lai , O. C. Demirag, Janny M.Y. Leung,A tabu search heuristic for the heterogeneous vehicle routing problem on a multigraph, J. Transportation Research Part E: Logistics and Transportation Review, 2016, 86: 32-52.

[14] V.F. Yu, A.A.N. P. Redi, Y. A. Hidayat, O.J. Wibowo, A simulated annealing heuristic for the hybrid vehicle routing problem, J. Applied Soft Computing, 2017, 53: 119-132.

[15] S. Mancini,The Hybrid Vehicle Routing Problem, J. Transportation Research Part C: Emerging Technologies, 2017, 78: 1-12.

[16] J.R.M.Torres, J.L. Franco, S.N. Isaza, H.F. Jimnez, N. Herazo-Padilla, A literature review on the vehicle routing problem with multiple depots. Comput. Ind. Eng. 2015, 79: 115–129.

[17] S.Karakati˘c, V. Podgorelec, A survey of genetic algorithms for solving multi depot vehicle routing problem. Appl, J. Soft Comput. 2015, 27: 519–532 .

[18] Y.B. Luo, Y.M. Sun, P. Liao, Study on multi-warehouse location-path problem with return and soft time window, J. Operations Research and Management,2014, (5): 78-85.

[19] H. Bae, I. Moon, Multi-depot vehicle routing problem with time windows consid-ering delivery and installation vehicles, J.Appl. Math. Model. 2016, 40: 6536–6549.

[20] L.F. Zhang, F.G. Zhao, J.S.Sun , X.Y. Shi, The MDVRP problem of wartime spare parts distribution and its genetic algorithm, J. Computer Applications & Software, 2010, (2): 194-196, 273.

[21] S.Zibaei, A.Hafezalkotob, S.S.Ghashami, Cooperative vehicle routing problem: an opportunity for cost saving,J. Ind. Eng. Int, 2016, 12: 271–286.

[22] T.Yalian, An improved ant colony optimization for multi-depot vehicle routing problem, Int. J. Eng. Technol, 2016, 8(5): 385–388.

[23] Y. Luo, L.L. He, Research on Multi-warehouse Tobacco Logistics Scheduling with Transfer Library [J].Industrial control computer, 2014, (1).105-107.

[24] Dai Xi, Ye Yaohua, Wu Qinwei, Zhu Daoli.An Interactive Solution Method for Vehicle Routing Problem in Oil Distribution, J .Journal of Systems Engineering, 2009, (6): 749-753.

[25] L.Calvet, A. Ferrer, M.I. Gomes, A.A. Juan, D. Masip, Combining statisti-cal learning with metaheuristics for the multi-depot vehicle routing problem with market segmentation, J. Comput. Ind. Eng, 2016:94, 93–104.

[26] F.B. Oliveira, R. Enayatifar, H.J. Sadaeia, F.G. Guimar˜aes, Y.J. Potvin, A cooperative coevolutionary algorithm for the multi-depot vehicle routing problem, J. Exp. Syst. Appl, 2016, 43: 117–130.

[27] I. Dayarianad, T.G. Crainicbd, M. Gendreaucd, W. Reibd, A column generation approach for a multi-attribute vehicle routing problem, J. European Journal of Operational Research, 2015, 241 (3): 888-906.

[28] J. R. M.Torres, J. L. Franco, S.N. Isaza, H.F. Jiménez, N.H.Padilla, A literature review on the vehicle routing problem with multiple depots, J. Comput. Ind. Eng.2015, 79: 115-129.

[29] P.Toth, D.Vigo, Vehicle Routing: Problems, Methods and Aapplications, J. MOS-Siam Series on Optimization, 2nd edn. SIAM, Philadelphia, 2014.

[30] S.N.Kumar, R. Panneerselvam, A survey on the vehicle routing problem and its variants, J. Intell. Inf. Manage. ,2012, 4(3): 66.

[31] W.B. Fan, W.Feng, Optimization of Vehicle Routing Problem with Time Window Cigarette Logistics Based on Hybrid Genetic Algorithm, J. Modern Electronic Technology, 2018, (11): 119-123, 128.

[32] Y.Deng, W.H.Zhu, H.W. Li, Y.H.Zheng, Multi-type ant system algorithm for the time dependent vehicle routing problem with time windows, J. Journal of Systems Engineering

and Electronics, 2018, 29 (3).

[33] B.Ge, J.H. Han, W.Wei,L.Cheng, Y.Han e, A Dynamic Hybrid Ant Colony Optimization Algorithm for Solving Vehicle Routing Problem with Time Windows, J. Pattern Recognition and Artificial Intelligence, 2015, (7): 641-650.

[34] E. Osaba, R. Carballedo, X.S. Yang;I. Fister Jr., P. L.Garcia, Javier Del Ser.22.On Efficiently Solving the Vehicle Routing Problem with Time Windows Using the Bat Algorithm with Random Reinsertion Operators, J. Nature-Inspired Algorithms and Applied Optimization, 2017, 744: 69-89.

[35] M. Schneider, F. Schwahn, D. Vigo, Designing granular solution methods for routing problems with time windows, J. European Journal of Operational Research, 2017, 263 (2): 493-509.

[36] Q.Yang, Q. Chen, Z.Z. Li ,Chaotic Particle Swarm Optimization Algorithm for Vehicle Routing Problem with Time Windows, J. Computer Technology and Development, 2015, (8): 119-122, 127.

[37] P. Kirci, An optimization algorithm for a capacitated vehicle routing problem with time windows, J. Sādhanā,41, 2016, 41 (5): 519-529.

[38] Y. Xie, R. Hu, B. Qian, S.F.Chen, G.l. Zhang, X.D. Zhang, An Improved Population Incremental Learning Algorithm for Solving Vehicle Routing Problem with Soft Time Windows, J. Journal of Nanjing University of Science and Technology (Natural Science), 2016, (1): 110-116.

[39] A B Pratiwi;A Pratama;I Sa'diyah and H Suprajitno,Vehicle routing problem with time windows using natural inspired algorithms,Journal of Physics: Conference Series, 2018, Vol.974, No.1, pp: 012025

[40] B.Yao, Q. Yan, M.Zhang, Y. Yang, improved artificial bee colony algorithm for vehicle routing problem with time windows, J. Plos One, 2017, 12(9): e0181275.

[41] W.B. Dong, K. Zhou, G.X. Zhang, Modified Discrete Glowworm Swarm Optimization Algorithm Based on Time Window Division for Multi-objective, J. VRPTWJOURNAL OF INTERNET TECHNOLOGY, 2018, 19 (1): 1-13.

[42] W.B. Dong, K. Zhou, H.Q. Qi, C. He, J. Zhang, A tissue P system based evolutionary algorithm for multi-objective VRPTW, J. Swarm and Evolutionary Computation, 2018, 39: 310-32.

[43] L.B. Reinhardt, M.K. Jepsen, D. Pisinger, The edge set cost of the vehicle routing problem with time windows, J. Transp. Sci. 2016, 50 (2): 694–707.

[44] M. Harzi, S. Krichen, Variable neighborhood descent for solving the vehicle routing problem with time windows, J. Electronic Notes in Discrete Mathematics, 2017, 58: 175-182.

[45] M. Keskin,B. Çatay, A Matheuristic Method for the Electric Vehicle Routing Problem with Time Windows and Fast Chargers, J. Computers & Operations Research, 2018.

[46] H. Chai;R.C. He, C.X. Ma, C.J. Dai, K. Zhou, Path Planning and Vehicle Scheduling Optimization for Logistic Distribution of Hazardous Materials in Full Container Load, J. Discrete Dynamics in Nature and Society, 2017.

[47] M.M.Li, J. Lu, Y. An, The Problem of Assigning Vehicle Routing with Double Target Time Window Considering Customer Preference, J. Journal of Southeast University(Natural Science Edition), 2018, (3).

[48] H. Yousefi, R.T. Moghaddam, M.T.B. Oliaei, Mohammad Mohammadi;Ali Mozaffari.Solving a bi-objective vehicle routing problem under uncertainty by a revised multi-choice goal programming approach, J. International Journal of Industrial Engineering Computations, 2017, 8 (3): 283-302.

[49] D.F. Zhang, S.F. Cai, F.R. Ye, Y.W. Si, T.T. Nguyen, A hybrid algorithm for a vehicle routing problem with realistic constraints, J. Information Sciences, 2017, 394-395: 167-182.

[50] Y.J. Song, J.T Zhang, Z. Liang, C.M. Ye, An exact algorithm for the container drayage problem under a separation mode, J. Transportation Research Part E: Logistics and Transportation Review, 2017, 106: 231-254.

[51] K.N. Androutsopoulos&K.G. Zografos, An integrated modelling approach for the bicriterion

vehicle routing and scheduling problem with environmental considerations, J. Transportation Research Part C: Emerging Technologies, 2017, 82: 180-209.

[52]   J.R. Da, L.B Zheng, X.Tang, A Polyhedral Study of the Elementary Shortest Path Problem with Resource Constraints, J. Computational Logistics, 2017, 10572: 79-93.

[53]   E.L. Pu, W. Fei, Z.L. Yang;Jun Wang;Zhiming Li;Xin Huang.Hybrid Differential Evolution Optimization for the Vehicle Routing Problem with Time Windows and Driver-Specific Times[J].Wireless Personal Communications, 2017, Vol.95, No.3, PP: 2345-2357.

[54]   V. F. Yu, P. Jewpanya, C.J. Ting, A.A.N. P.Redi, Two-level particle swarm optimization for the multi-modal team orienteering problem with time windows, J. Applied Soft Computing, 2017, 61: 1022-1040.

[55]   Y. Kai, L. Aiguang, G.Jian, C.Bing. Study on multi-vehicle vehicle routing problem based on time window, J. Geospatial Information, 2017, (5): 35-38,10.

[56]   Yanfang Ma;Jie Han;Kai Kang;Fang Yan,An Improved ACO for the Multi-depot Vehicle Routing Problem with Time Windows, J.Proceedings of the Tenth International Conference on Management Science and Engineering Management, 2017, Vol.502, pp: 1181-1189.

[57]   Z.Y. Fu, Research on Multi-vehicle Vehicle Routing Problem Considering Customer Satisfaction, J. Science and Technology Economics Guide,2018,(10):248.

[58]   Y.Cao, F.H. Xiang, J.L. Mao, N. Guo, P.Y. Zhao, A Hybrid Distribution Estimation Algorithm for Vehicle Scheduling Problem with Dynamic Demand and Multiple Vehicles, J. Software guide, 2018, (1): 68-73.

[59]   B.Rabbouch, R.Mraihi,F.Saâdaoui, A Recent Brief Survey for the Multi Depot Heterogenous Vehicle Routing Problem with Time Windows, J. Hybrid Intelligent Systems, 2018, 734: 147-157.

[60]   Y.X. Yang;Y.C. Xu;L. Wang, Study on Multi Depot Heterogeneous Vehicle Routing Problem with an Improved Variable Neighborhood Search Algorithm, J.Information Technology Journal, 2013, 12(23): 7137-7142.

[61]   R.C.Funes, M. A.S.Aguilar, V. Boyer, Multi-depot periodic vehicle routing problem with due dates and time windows, J. Journal of the Operational Research Society, 2018, 69, (2): 296-306.