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Customized Fitness Function of Evolutionary Algorithm for Optimization of Car Park Space

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Abstract: ***Parking space is an area designated for parking. Presently, parking spaces are claimed to have a very high value due to its high demand. Thus, there is a need to ensure that the parking spaces are constructed with maximum capacity to avoid a waste area. Due to that, the empty space should be managed efficiently prior the parking facilities construction process. This study proposed a customized fitness function of Evolutionary Algorithm (EA) for optimization of car park space. There are two major factors that have been considered in customizing the fitness function which are the number of parking spaces and the feasibility of the surrounding areas. The parking design is divided into three different types which are parallel, diagonal, and perpendicular. Whereas, the feasibility of the surrounding areas considers the size of the area, traffic flow, expansion capability and another few factors as well. The implementation of the customized fitness function into EA technique which is Genetic Algorithm (GA) was found to produce potential solutions to the current difficulties in optimizing car park space. It is believable that the proposed study could be useful in accommodating higher numbers of parking spaces in the future.***
Keywords: ***Customized Fitness Function, Evolutionary Algorithm (EA), Genetic Algorithm (GA), Car Park Space, Optimization.***

I. INTRODUCTION

Transportation plays an important and strategic role in the development of a nation, particularly in distributing the product of the development for all citizens [1]. The general problem that happens in urban transportation is a traffic jam. One of the factors which increase the traffic congestion is caused by the reduction of road diameter due to bad habits of street parking on the roadside. This traffic jam has a huge effect to nation such as excessive use of fuel which resulted in a large number of economic losses. Hence, an effort is needed necessarily on the management of parking problem to reduce the traffic jam.

Parking lots are essential elements of any transportation system as they have an influence on the overall performance of the transportation system. At the present time, there is a significantly increasing demand for parking spaces due to the increase in the number of vehicles. The shortage of the number of spaces created a challenge to utilize the parking areas more efficiently [2]. Accordingly, an efficient car park design is desired to increase the performance of the overall transportation system.

Parking conflicts are among the most common problems in infrastructure planners [3] as it contributes to the major expense to society [4]. These problems can be most often described either in terms of supply or in terms of management. Parking management refers to the process of optimizing the use of parking policies which result in more efficient use of *parking* resources. An optimal parking strategy is useful in producing an optimal number of parking spaces that leads to a various socio-economic and environmental benefits. An improved management is often the best solution to parking problems in which all factors are taken into the consideration. Management solutions tend to be significantly optimum than increasing supply as they tend to support more strategic objectives. Some of these objectives are to improve to user options and quality of service, facility cost savings and revenue generation which improve the transportation infrastructure.

Parking can be a huge challenge additionally. It is claimed that the major problem of the car park space is the insufficiency of available parking spaces and inefficient usage of available facilities [5]. Several studies of parking spaces problem have been conducted from the management and administrative points of view. However, it is acceptable that mathematical models and optimization could provide a substantial solution to the parking problem.

A desire to achieve optimality is one of the most underlying precepts in the world today. Optimization is a process of making a system or decision as functional or effective as possible. It is also known as mathematical programming, which aids in finding solutions that give maximum performance, profit, and output, at a minimum cost, waste or unhappiness [5].

In another note, Evolutionary algorithms (EA) are population-based metaheuristic optimization algorithms that use biology-inspired mechanisms and survival of the fittest theory in order to refine a set of solution iteratively [6]. An optimization attempts to optimize an objective or fitness function by searching for the best set of decision variables that obey the given constraints [7].

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Thus, based on the car park space problems discussed, this paper presents a study on a customized fitness function of EA technique which is Genetic Algorithm (GA) in overcoming the current difficulties of car park space optimization.

II. PREVIOUS WORKS AND APPLICATIONS

Various works has been conducted in the optimization of car park space presently. Chiu [8] developed a multi-objective linear integer programming model which decides the optimum allocation of the off-street parking facilities. It was noted that it will be a waste of the public investment if the public facilities are not used for multiple purposes, mainly with the relatively high land cost in the urban area.

Batabyal and Nijkamp [9] calculated the probability distribution function of parking violators. It is done by analysing the university parking issues by determining the mean parking time of an appearance car for both short term and long term parkers and computing their probability distribution function in the previous studies on parking problem.

Sattayhatewa and Smith [10] modelled an evaluation of parking lot choice by considering three major factors which are parking cost, driving time, and walking time. It is claimed that the proposed evaluation could be used to analyse the current traffic conditions, enhance the traffic conditions and assess various operational and management policies for special events.

Mouskos, Tvantzis, Bernstein and Sansi [11] developed a Parking Reservation System (PRS) which is formulated using a deterministic dynamic. It is used to perform a parking space assignment with a minimum parking cost. It is also used to assist the users in securing a parking space either before or during their trip. It was noted that crowding in metropolitan areas is often caused majorly because people drive around “in circles” until they find a parking space.

Furthermore, a web-based “Parking Reservation System” (Web-PRS) using Extensible Markup Language (XML) files was initiated to give the travellers the power or ability to reserve a parking space within the environment of their destination [12].

Thompson and Richardson [13] explain the parking choice behaviour of motorists in urban areas as a search process. A model which is used to consider the relationships among the utility of a car park was developed. The application of the model found that due to the uncertain nature of the car parking system, motorists parking search experience does not lead to better choices.

Department of Transportation was carried out a study in finding the optimal parking angle for a given lot dimension in the City of Los Angeles. Based on the City of Los Angeles’s Department of Building and Safety standards, the angle dimensions were considered in the study. It was concluded in the study that many calculations on parking lots with different dimensions need to be performed in order the find the most effective parking angle [2].

Thus, based on the on-going works on the optimization of parking space issues, the study on the customized fitness function of Evolutionary Algorithm (EA) is proposed. It is believable that proposed study could be useful in accommodating higher numbers of parking spaces in the future optimally.

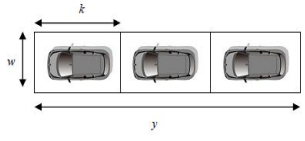
III.METHODOLOGY

The methodology of this study focuses on the customized fitness function of Evolutionary Algorithm (EA) calculation. The customized fitness function considered two major factors, which are the number of parking spaces and the feasibility of the surrounding areas, which contribute to the optimization of the car park space construction.

A. Parking Design

The parking design is divided into three different types which are parallel, diagonal, and perpendicular [14] as described further in Table I.

TABLE I
PARKING DESIGN

Type	Description	Illustration
Parallel	The vehicle is in a line with the front bumper and facing the back bumper of an adjacent vehicle	

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Diagonal	The vehicle park at an angle less than 90°, which could be 30°, 45° and 60°, to an aisle, curb or wall.	
Perpendicular	The vehicle park next to each other, perpendicular to an aisle, curb or wall.	

Parallel parking is the most regular design of the car park side of the road and it can be used in parking lots and parking structures. It works well in extremely narrow, linear spaces but it is difficult to manoeuvre for most drivers and is an inefficient use of on-street space [5]. The diagonal parking refers to the cars that are arranged at an angle to the aisle which is at an acute angle with the direction of approach. Whereas, perpendicular parking is a side by side parking, perpendicular to an aisle, curb or wall. This type of parking is common in an off-street parking lot where the driver can either park with a back-in or head-in parking style.
For every particular empty space, the numbers of parking space produced are varied based on the type of parking design. Table II tabulates the equation (1) – (7) which involved in calculating the number of parking spaces.

TABLE II
CALCULATION FOR NUMBER OF PARKING

Type	Equation	Description
Parallel	$No.\ of\ parking = \frac{y}{k}$ (1)	k = length lane (fix) w = width lane y = length space
Diagonal	$No.\ of\ parking = \frac{Area\ parking}{Min space}$ (2)	x = curb length z = depth θ = angle k = length lane (fix) w = width lane (fix) $\tan\theta = \frac{w}{z}$ (3) $z = \frac{w}{\tan}$ (4) $Min space = (w \times k) + \frac{1}{2}x(z \times w)$ (5)
Perpendicular	$No.\ of\ parking = \frac{Area\ parking}{Min space}$ (6)	$Min space = k \times w$ (7) k = length lane (fix) w = width lane (fix)

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B. Feasibility of the Surrounding Areas

The next measure is the feasibility of the surrounding areas. There are several parameters which are taken into consideration as illustrated in Fig. 1 which are:

1) Traffic flow: the traffic congestion could be low, moderate, or heavy traffic.
2) Expansion capability: the capability of the empty space to be expanded in the future.
3) Access from roadway network: the distance of the empty space to the main road. If it is easy to access from roadway network it is the best fitness.
4) Location complexity: the physical condition of the empty space.

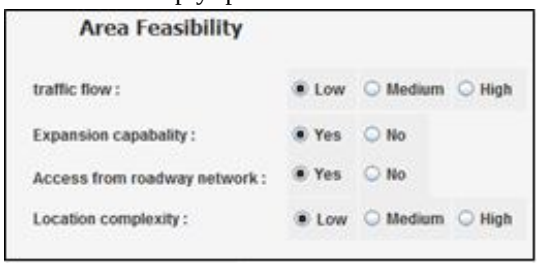

Fig. 1 Parameters selection

Each selection of parameters is assigned to a weightage based on its significance. The weightage values are significant as it will be used further in the customized fitness function calculation. The weightage assigned to each parameter as tabulated in Table III.

TABLE III
WEIGHTAGE OF PARAMETERS

Parameter	Weightage				
	Low	Medium	High	Yes	No
Traffic flow	1	2	3	-	-
Expansion capability	-	-	-	2	1
Access from roadway network	-	-	-	2	1
Location complexity	3	2	1	-	-

C. Customized Fitness Function Evaluation of Evolutionary Algorithm (EA)

EA are population-based metaheuristic optimization algorithms that use biology-inspired mechanisms and survival of the fittest theory in order to refine a set of solution iteratively [6]. Several EA methods based on natural evolution and genetic processes have been proposed.

Genetic algorithm (GA) is a class of evolutionary algorithms made popular by John Holland and his colleagues during the 1970s. It has been widely applied to find exact or approximate solutions to optimization and search problems [15].

1) The basic steps in GA as stated in [16] which are
a) Initialization of population (chromosomes).
b) Calculation of fitness function for optimization.
c) Selection of which chromosomes will reproduce.
d) Crossover to produce next generation of chromosomes
e) Mutation of chromosomes in new generation

The performance of GA algorithm is highly depends on the method used to encode the candidate solutions into chromosomes and the particular criterion for success, or particularly what the fitness function is actually measuring. Due to this importance of the fitness function, the customized fitness function for optimization of car park space is emphasized in the study.

As mentioned, the customized fitness function considered two major factors, which are the number of parking spaces and the feasibility of the surrounding areas, which contribute to the optimization of the car park space construction.

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Accordingly, the customized fitness function is calculated based on the summation of fitness function 1 and fitness function 2 as illustrated in Fig. 2.

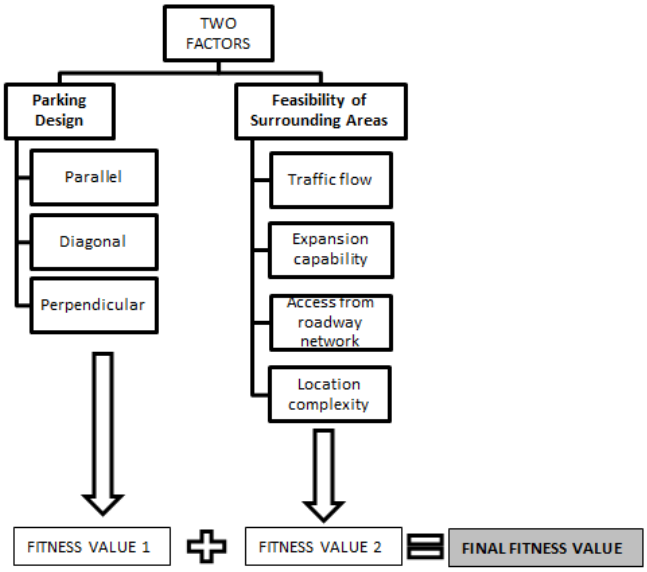


Fig. 2 Illustration of customized fitness value calculation

Several steps of calculations are involved in measuring each fitness function 1 and fitness function 2 which finally produce the final fitness function. The equation (8), (9) and (10) are tabulated in Table IV.

TABLE IV
CUSTOMIZED FITNESS VALUES EQUATIONS

Fitness Value	Equation
Fitness Value 1	$\frac{No.\ of\ parking\ of\ each\ parking\ design}{Total\ no.\ of\ parking} \times 1$ (8)
Fitness Value 2	$\frac{Total\ calculated\ weightage}{10} \times 1$ (9)
Final Fitness Value	$\frac{Fitness\ Value\ 1 + Fitness\ Value\ 2}{2}$ (10)

The final value of the customized fitness function is in the range of 0 to 1. It is used to measure the optimal level of the particular empty space for car park space construction. The higher value of the fitness function indicates the most optimal particular empty space it represents.

IV. DISCUSSION

The fitness function is the function that the algorithm is trying to optimize. The word “fitness” is taken from the evolutionary theory [16]. It is used to test and quantify how `fit' each potential solution is. The fitness function is one of the most pivotal parts of the algorithm. The fitness function must be more sensitive than just detecting what is a `good' chromosome versus a `bad' chromosome. Yet, it needs to accurately score the chromosomes based on a range of fitness values, so that a somewhat complete solution can be distinguished from a more complete solution.

The different fitness function used in the optimization process will significantly affect the performance of the algorithm differently [17]. Thus, solution procedure for customization of fitness function of EA for optimization of car park space is presented in this study.

Several measures of effectiveness from different aspects on the parking demand are incorporated into the proposed fitness function. The number of parking spaces produces based on particular parking design, and the feasibility of the surrounding areas, which

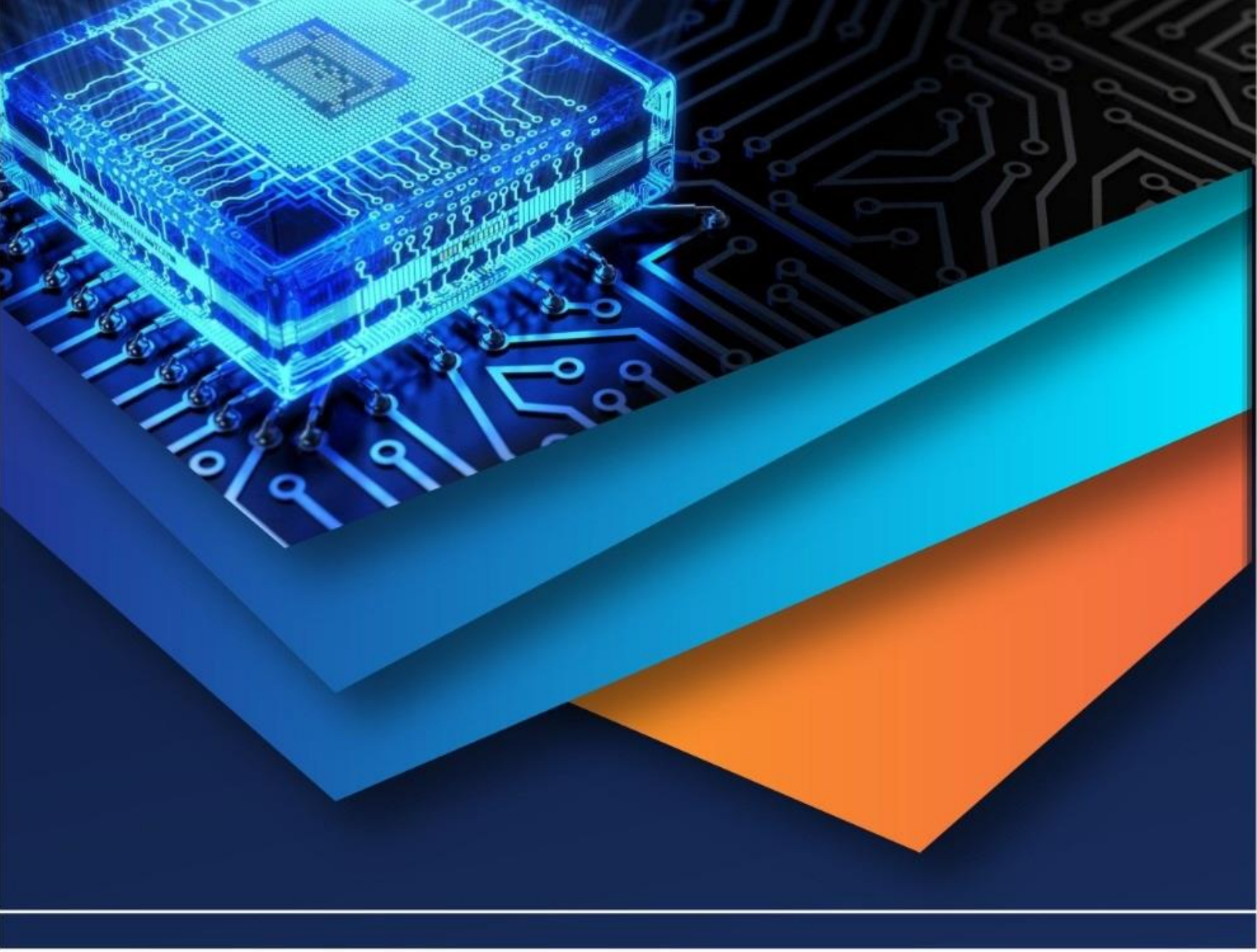
contribute to the optimization of the car park space construction are considered. The first measure of parking designed is divided into three different types which are parallel, diagonal, and perpendicular. The number of car park space produced by each type of parking design reflected the effectiveness of the fitness function. On the other hand, the feasibility of the surrounding areas include several parameters which are the size of area, traffic flow, and expansion capability, access from roadway network and location complexity. Each selection of parameters is assigned to a weightage based on its significance, in which to be used in the customized fitness function calculation.

The feasibility of different aspects is incorporated in improving the effectiveness of the fitness function. The combination of the two measures produced the final customized fitness function. The implementation of the customized fitness function into EA technique which is GA was found to produce reasonable solutions to the current difficulties in optimizing car park space. The solution of this customized fitness function can provide following information for the decision makers to determine the optimal type of parking design, the optimal number of parking spaces, and the optimal locations of the parking facilities.

Yet, one area that deserved for the enhancement of future research is the estimation of the construction cost. Due to the significant impact of the factors on the result of the problem, a suitable method to estimate the cost is critical to the success of the proposed study. Finally, it is believable that the proposed study could be useful in accommodating higher numbers of parking spaces in the future.

REFERENCES

[1] S. Munzir, M. Ikhsan, Z. Amin, “Linear Programming for Parking Slot Optimization : A Case Study” at Jl . T . Panglima Polem Banda Aceh, pp. 462–472, 2010.
[2] A. S. Abdelfatah, M. A. Taha, “Parking Capacity Optimization Using Linear Programming”. Journal of Traffic and Logistics Engineering, 2(3), 176–181, 2014. http://doi.org/10.12720/jtle.2.3.176-181
[3] E. Bash, Ph.D Proposal, October 2015. http://doi.org/10.1017/CBO9781107415324.004
[4] A. Rao, “Improving Parking Garage Efficiency using Reservation Optimization Techniques”, Thesis submitted to the Graduate School-New Brunswick Rutgers, The State University of New Jersey, 2011.
[5] L. O. Joel, “Model and Solutions to Campus Parking Space Allocation Problem”, 2013, 211559858.
[6] R. N. S. Malhotra, Y. Singh, “ Genetic algorithms: Concepts, design for optimization of process controllers”, Comput. Inform. Sci., 4: 39-54, 2011, DOI: 10.5539/cis.v4n2p39
[7] W. L. Winston, J. B. Goldberg, “Operations Research: Applications and Algorithms”, 4th Edition, Cengage Learning, Belmont, 2004.
[8] H. M. Chiu, “A Location Model For The Allocation Of The Off-Street Parking Facilities”, Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 1344 - 1353, 2005.
[9] A. A. Batabyal, P. Nijkamp, “A Probabilistic Analysis of Two University Parking Issues”, April 2008, RIT Economics Department Working Paper No. 08-05. Available at SSRN: https://ssrn.com/abstract=1119372 or http://dx.doi.org/10.2139/ssrn.1119372
[10] P. Sattayhatewa, R. L. Smith, “Development of Parking Choice Models” for Special Events, Transportation Research Record, Transportation Research Board, 2003, no 1858, 31-38.
[11] K. Mouskos, J. Tvantzis, D. Bernstein, A. Sansi, “Mathematical formulation of a deterministic Parking Reservation System (PRS) with fixed costs”, Proc. 10th MELECON, 2000, vol. 2, pp. 648–651.
[12] W. Sun., C. K. Mouskos., D. Bernstein, “A web—based parking reservation system”, Proceedings of the 82nd Annual Meeting of the Transport Research Board, Washington DC, 2003.
[13] R. G. Thompson, A. J. Richardson, “A parking search model, Transportation Research”, Part A: Policy and Practice 32(3), 159-170, 1998.
[14] K. Abdullah,., N. H. Kamis, N. F. N. Azahar, S. F. Shariff, Z. C. Musa, “Optimization of the parking spaces: A case study of Dataran Mawar, UiTM Shah Alam”, CHUSER 2012 - 2012 IEEE Colloquium on Humanities, Science and Engineering Research, (Chuser), 684–687. http://doi.org/10.1109/CHUSER.2012.6504399
[15] L. Scrucca, “GA : A Package for Genetic Algorithms in R”, 53(4), 2013, DOI: 10.18637/jss.v053.i04.
[16] J. Carr, “An Introduction to Genetic Algorithms”, pp. 1–40, 2014.
[17] N. M. Razali, J. Geraghty, Genetic Algorithm Performance with Different Selection Strategies in Solving TSP, International Conference of Computational Intelligence and Intelligent System, 2011.



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