APIEMS 2010 Conference Proceedings

11th Asia Pacific Industrial Engineering and Management Systems Conference 2010

in conjunction with the

3rd ASEAN University Network Southeast Asia Engineering Education Development Network (AUN/Seed-Net) Regional Conference for Manufacturing

and the

14th Asia Pacific Regional Meeting of the International Foundation for Production Research (IFPR-AP)

December 7-10, 2010

Renaissance Melaka Hotel, Melaka, Malaysia

Organized by:

Center for Product Design and Manufacturing, University Malaya

Universiti Teknologi Malaysia

Universiti Malaysia Pahang

The Institution of Engineering Designers

Asia Pacific Industrial Engineering and Management Society

Industrial engineering was sprouted from major engineering disciplines that called for better professional understanding of industrialisation. Ever since, our discipline has been the star role player in confronting emerging industries; be it manufacturing, service, high tech products, outer space technology, information technology, industrial policy, ergonomics, and now world's greatest concern, sustainable development. The Core value of APIEMS is associating and exchanging the better industrial engineering education, researches, and exchange information from different countries.

APIEMS initiated from two conferences held in 1998 China-Japan Joint Conference on industrial engineering and management in Beijing, China, and orea-Japan Joint Conference on industrial engineering and management in Taejon, Korea, produced some excellent results and the two were merged to form a single conference in the following year 1999, when the 2nd APIEMS conference was held at Kanazawa, Japan.

Since then the APIEMS has rapidly emerged as an important forum for exchange of ideas and information about latest developments in the field of industrial engineering and management system among professionals from Asia-Pacific countries, namely, Australia, China, Hong Kong, Indonesia, Japan, Malayasia, Philippines, South Korea, Taiwan and Thailand. APIEMS conferences serve not only as a forum for exchanging idea and information but also facilitates collaborations among delegates and participants from different countries, culture and institutions, besides providing the much needed exposure to new research efforts and findings.

APIEMS also publishes an official journal Industrial Engineering and Management Systems (IEMS). This is a truly international journal that reports original quality work in the areas of industrial engineering and management systems, with focus works that inform and educate, along with articles offering theoretical and academic insights into important issues, novel industrial applications and case

Executive Committee

President	Bernard Jiang
President-elect	Chi-Hyuck Jun
Vice Presidents	Abdul Hakim Halim Baoding Liu Takashi Oyabu Zahari Taha
Former Presidents	Voratas Kachitvichyanukul Anthony SF Chiu Erhan Kozan Hark Hwang Mitsuo Gen Kin Keung Lai Tsong-Ming Lin

APIEMS Board Members

- Chan, Hing Kai
- Chien, Che Fu
- Chung, Min K.
- Fung, Richard
- Fan, Shu-Kai(Morris)
- Gao, Jin Wu
- Gen, Mitsuo
- Hakim Halim, Abdul
- Hirakawa, Yasuhiro
- Hirokazu Kono
- Huang, Chin-Yin
- Huang, Guo Quan(George)
- Hwang, Hark
- Huynh Trung Luong
- Ho Thanh Phong
- Irohara, Takashi
- Ilkyeong, Moon
- Ishii, Kazuyoshi
- Jiang, Bernard
- Jun, Chi-Hyuck
- Jung, Mooyoung
- Kachitvichyanukul, Voratas
- Kim, Byung-In
- Kim, Kap Hwan
- Kim, Kwang-Jae
- Kono, Hirokazu
- Kozan, Erhan
- Lai, Kin Keung
- Lee, Jaewook
- Lee, Young Hae
- Liao, CJ
- Liu, Baoding
- Lin, Tsong Ming
- Mak, Kai Ling
- Nakashima, Kenichi
- Nambo Hidetaka
- Nose, Toyokazu
- Oyabu, Takashi
- Peng, Jin
- Pujawan, Nyoman
- Ruiqing, Zhao
- Sethanan, K.
- Shayan, Ebrahim
- Siriban-Manalang, Anna Bella
- Taha, Zahari
- Takahashi, Katsuhiko
- Tamaki, Kinya
- Tan, Kim Hua
- Tsai, Du-Ming
- Tseng, Ming-Lang

- Tzeng, Gwo-Hshiung
- Wang, Mao-Jiun
- Wang, Kuo-Ming
- Wei, Yiming
- Wu, David M.
- Yang, Lixing
- Yang, Shanlin
- Yenyaree, Pisal
- Yusuf, Sha'ribin Mohd

Topics

1. Artificial Intelligence in IE
2. CAD/CAM/CIM
3. Decision Making Models and Analysis
4. Decision Support Systems and Management
5. Engineering Economy and Cost Analysis
6. Enterprise Information System/ ERP
7. Environment Friendly Technologies
8. Facilities Design and Location
9. Flexible Manufacturing Systems
10. Green Design/Green Manufacturing
11. Health Care Management
12. Human Computer Interaction
13. Human Factors/Industrial Ergonomics
14. Human Resource Management
15. Inventory System and Management
16. Lean Manufacturing
18. Management Information System
19. Manufacturing Management
20. Manufacturing Process
21. Manufacturing/Industrial Automation/Robotics
22. Management of Technology and Innovations
23. Operations Research / Optimization
24. Productivity and Business Strategies
25. Product Design/Development
26. Project Management
27. Production Systems Design, Planning and Control
28. Quality Cost, Reliability and Maintenance
29. Quality Engineering
30. Soft Computing /Heuristics
31. Small and Medium Enterprises and IE
32. **Supply Chain Management and Logistics**
33. Service Systems and Management
34. Systems Simulation
35. System Engineering and Management
36. Total Quality Management
37. General

Session: Supply Chain Management and Logistics

Paper 546: An Integrated Structure for Supply Management Using Quality Function Deployment and Mixed-integer Programming Model546.pdf

Paper 547: A Stochastic Programming Based Approach for Supply Chain Network Design under Uncertain Processing Costs 547.pdf

Paper 558: Production Policies of Perishable Product and Raw Materials 558.pdf

(http://www.apiems.org/archive/apiems2010/paper.php)

Solving an Extended Logistic Model by Hybrid Genetic Algorithm

Admi Syarif [1] **Mitsuo Gen**† [2]
[1] Departement of Mathematics, Lampung University,
Bandar Lampung, Indonesia, 35148
Email: admisyarif@unila.ac.id
[2] Fuzzy Logic System Institute, Japan
mitsuogen@gmail.com
and
Adiguna Setiawan
Departement of Mathematics, Lampung University,
Bandar Lampung, Indonesia, 35148
Email: adiguna_s@students.unila.ac.id

Abstract - *In recent decade, there have been intensive research works on logistics design system because of its great use in public distribution. Huge research efforts have been devoted to studying many variants of logistic problems. The common objective is to determine overall production strategy, inventory strategy and flow of products through some facilities in order to minimize cost or maximize profit. In this paper, we introduce a more realistic logistics model that includes transportation model and multi-depot Vehicle Routing Model. By assuming that the plant capacities and the customer demand are known in advance from past statistical data, we examine how the distribution centers should be designed and how the product should be produced and transported. We propose a genetic algorithm approach which is hybridized with a local search method to solve the problem. We report several numerical experiment results to show the effectiveness of the proposed method.*

Keywords: *Logistics, Vehicle Routing Problem, Genetic Algorithm, and Local Search.*

1. INTRODUCTION

The logistic problem is known as one of important combinatorial optimization problems that has taken great interest of the researchers. Huge research efforts have been devoted to studying logistic problems since 1941 where Hitchcock described the problem as Transportation Problem (TP). Thousands of papers have been written on many variants of logistics problems such as Traveling Salesman Problem (TSP), Vehicle Routing Problems (VRP), Production Distribution and Inventory Problem (PDI), Supply Chain Management (SCM) and so on (Geoffrion and Graves.1974); Gen and Cheng, 1997).

For the real-world applications, it is often represented as an integrated multi-stage problem (Das and Heragu, 1988; Heragu, 1997). The common objective is to determine overall production strategy, inventory strategy and flow of products through some facilities in order to minimize cost or maximize profit (Syarif, Yun and Gen, 2002).

Since it was introduced by Holland (1975), GA has been intensively used for solving various combinatorial optimization problems including TP, VRP, TSP, Scheduling and so on (Gen and Cheng, 2000). It has been shown that GA can give good solutions within reasonable time. In order to increase the performance of GA, some researchers hybridize GA with local search method.

In this paper, we introduce a more realistic logistics model (tsLP) that combines transportation model and multi-depot Vehicle Routing Problem (mdVRP) Model. By assuming that the plant capacities and the customer demand are known in advance from past statistical data, we examine how the distribution centers should be designed and how the product should be produced and transported. It is clear that this problem is NP-complete because of NP-completeness of mdVRP (Toth and Vigo, 2001). Thus, it is

†Corresponding Author: gen@flsi.or.jp

unlikely that exact polynomial time algorithm exist to solve this problem. To solve this problem, we develop a GA approach hybridized with 2-opt.

The rest of this paper is organized as follows: The design of this problem is given in Section 2. In Section 3, we describe the design of our algorithm proposed in this paper including the chromosome representation, genetic operators and the selection methods. In Section 4, numerical experiment results are presented to demonstrate the efficiency of the proposed method. Finally, some concluding remarks are given in Section 5.

2. PROBLEM STATEMENT

As stated earlier, in this paper, we concern with a logistics model that combines transportation problem (TP) model and multi-depot Vehicle Routing Problem (mdVRP) Model. Here, we assume that sets of customers, DCs and Plants within a certain coordinate location are known in advance. We associate a non-negative customer demand and plant capacities from past statistical data. We define the travel cost corresponding to *travel distance*. This model is restricted to logistics problems for which travel distances are symmetric. There are enough identical vehicles of capacity to serve customer demand.

Our purpose is to determine the transportation network to satisfy the DC demand and vehicle routing with minimum distance in such a way that:

1) Each customer is serviced by a *DC*,
2) Each route starts and ends at the same *DC*,
3) Each customer is visited exactly once by a vehicle,
4) Total customer demand for each route does not exceed the vehicle capacity,
5) Total product transported to each *DC* is equal to the *DC* demand,
6) Total product shipped from each plant does not exceed its capacity.

From the above explanation, this model can give the answers for the following questions:
1) From which DC a is serviced,
2) On which route a customer served.
3) The sequence of customers on the route
4) Transportation pattern to serve DC from each plant.

3. DESIGN OF ALGORITHM

In this Section, we shall propose our basic concepts and searching procedures for the proposed method. Basically our proposed method includes an integrated two mains (mdVRP and TP) GA solvers.

3.1 Representation

To determine the vehicle route from each DC, we adopt two stages procedure that assign custom the closest DC and then solve a VRP from each DC as illustrated in the following Figure.

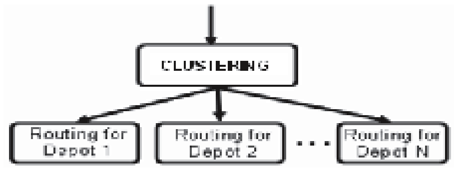

Figure 1. Two stage procedure for routing

To represent the chromosome, we use permutation-based representation. Initially all customers are clustered to their nearest DC in terms of Euclidean distance. This strategy is simple, fast and viable since no capacity limit is imposed on each DC (Ombuki and Hanshar, 2004). The clustering phase is done to determine a list of customer number assigned to each DC. We show the illustration of the chromosome representation for this phase in the following Figure 2 when the logistics system is consisting of 4 DCs and 38 customers:

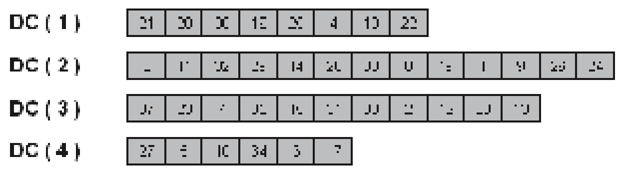

Figure 2. Chromosome for Routing Phase

To determine the vehicle route, the customer is assigned to the vehicle with *left-to-right scan* procedure (Gen and Cheng, 1997). It is a sequential adding procedure which assigns customers to vehicles. When adding a new customer to a current vehicle, it is necessary to check the capacity feasibility for the customer. If it is feasible, the customer is assigned to current vehicle; otherwise, the customer is assigned to a new vehicle.

We also adopt permutation-based representation to determine the transportation graph from the plant to DC with minimum cost. Based on the information on the previous phase, we can determine the necessary demand of each DC. The decoding procedure for this phase is done by the following procedure:

Procedure: decoding
Input: Permutation-based chromosome
For $l = 1$ **to** mn

- Let k be the content of l–th digit in the chromosome;
- Determine of the plant index (i) and DC index (j)

$$i \leftarrow \frac{(k-1)}{n} + 1$$

$$j \leftarrow (k-1) \bmod n + 1$$

- The number of product shipped from plant i to DC j is determined as follows:

$$x_{ij} \leftarrow \min(a_i, b_j)$$

- Update the plant capacity and DC demand

$$a_i \leftarrow a_i - x_{ij}$$

$$b_j \leftarrow b_j - x_{ij}$$

next i
Output: Number of product transported from each Plant to each DC

3.2 Genetic Operator

Crossover:
Crossover is known as the most important recombination operator in GA. Here we adopt, PMX (Partial Mapped Crossover) introduced by Goldberg and Lingle (1985). This method can be viewed as a development of two-point crossover method for binary representation of chromosomes and subsequently be repaired. PMX crossover process is done as follows:

Procedure : <u>PMX</u>

Step 1 : Select a section of chromosome randomly

Selected sub string

Parent 1	1	7	2	3	4	6	5	8
Parent 2	4	6	3	5	7	1	8	2

Step 2 : Exchanged each sub string

Parent 1	1	7	3	5	7	6	5	8
Parent 2	4	6	2	3	4	1	8	2

Step 3 : Determine the mapping of genes in each substring

3	5	7
2	3	4

$2 \Leftrightarrow 3 \Leftrightarrow 5$

$4 \Leftrightarrow 7$

Step 4 : Update chromosome with information on Step. 3

Parent 1	1	4	3	5	7	6	2	8
Parent 2	7	6	2	3	4	1	8	5

Mutation :
Mutation is usually used to prevent premature lost of information. It is done by exchanging the information within a chromosome. In this paper, we use the inversion mutation that selects two positions within a chromosome at random and then inverts the sub-string between these two positions.

Parent	4	6	3	5	7	1	8	2
Offspring	4	6	3	1	7	5	8	2

Evaluation :
As in nature, it is necessary to provide driving mechanism for better individuals to survive. Evaluation is to associate each chromosome with a fitness value that shows how good it is based on its achievement of the objective function. The higher fitness value of an individual, the higher its chances for survival for the next generation. So the evaluation plays a very important role in the evolutionary process. For this problem, we used the objective function (total travel distance) as the fitness value

Selection :
In the genetic algorithm, the role of selection is to determine the set of chromosome that will go for the next generation. For the selection methods, we use elitist strategy to enforce the best chromosome into the next generation.

3.3 Local Search

It is easy to understand that a tour is said to be good if there is no cross in it. Therefore, finding an algorithm to eliminate those crosses would increase the quality of the solutions. Here, we include 2-Opt algorithm in our GA approach. This method is often used in repairing the tour. The principle of this method is to remove the two sides so that the outlines tour into two paths and then connect back the other way.

The algorithm can be elaborated as follows: Select the *customer* for each i (i = 1, 2, …, n) where n is the number of customers. Suppose A is the *customer* that was selected, check whether there is a cross between A trajectory formed from *customer* to *customer B* where, B is the *customer* that arrived after the *customer A* with arbitrary trajectories. Parameters of a tour that includes crossing can be described as follows: assumed *customer A* is the *customer* that was selected, *next (A)* is the *customer* came after *customer A* tour in the sequence, and B any different from the *customer next (A)* and *customer A*. Tour can now be corrected if only if:

$$d(A,next(A))+d(B,next(B)) > d(next(A), next(B))+d(A,B)$$

To illustrate the above algorithm, consider Figure 3. Suppose that the customer now selected is the third customer, and customer 4 is the next city selected arbitrary.

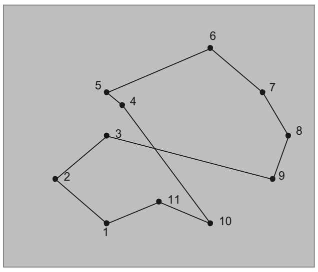

Figure 3. Tour with a cross tour

Obviously, that distance $d(3,9)+d(4,10) > d(9,10)+d(3,4)$. Therefore, 2-opt algorithm can be implemented to improve the tour so the tour generated depicted Figure 4 the following:

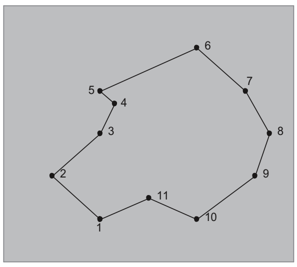

Figure 4. Result of 2-opt algorithm

4. NUMERICAL EXPERIMENTS

To confirm its effectiveness, the proposed method was implemented in PHP and run on PC Core to Duo. As the test problems, we modify the benchmark problems of mdVRP as follows:

Table 1. Design of test problems

Test Problem	Case Problem		
	Plant	DC	Customers
mod_p01	3	4	50
mod_p03	6	5	75
mod_p07	7	4	100

Other necessary data including coordinate and capacity of the plants are randomly generated. The traveling cost is assumed to be depending on the distance. We run our proposed GA with p_C= 0,4 and p_M= 0,2. For all test problems, the proposed algorithm was run 10 times. We note its best, average and worst results for each test problem. The convergence of generation is shown in Figure 5 and the computational result is shown in Figure 6.

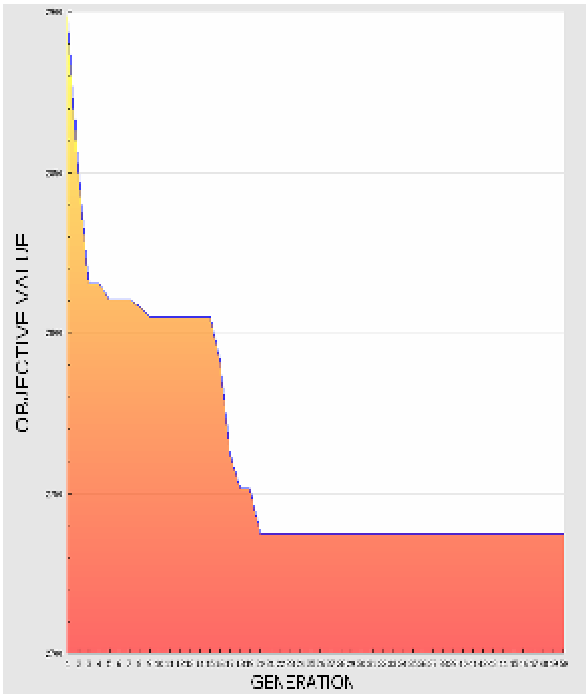

Figure 5. Objective values in generation

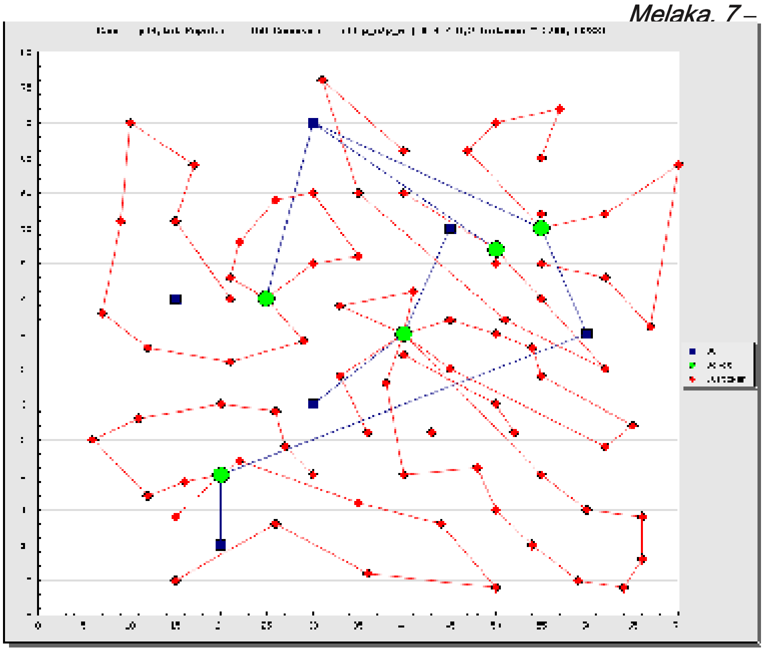

Figure 6. Computational result for mod_p03

Table 2: Computational Result

Test Problem	Parameter GA		Computational Result		
	Pop_Size	Max_Gen	Best	Worst	Average
mod_p01	100	500	1303,634262	1325,214491	1312,061944
mod_p03	150	500	2736,902881	2799,240190	2768,485920
mod_p07	200	500	3348,854060	3390,518180	3366,211420

5. CONCLUSION

In this paper, we developed a realistic logistics model that includes the determination of vehicle routing with time window. As this is an NP-hard problem, we proposed a hybridized Genetic Algorithm approach to determine the best heuristic solutions to the problem in real time. In order to increase the performance of our algorithm, we hybridized GA with local search method. To demonstrate the effectiveness of the proposed GA approach, we have carried out the numerical experiments after modifying the benchmark problems of mdVRP. It was shown that the proposed method could give good heuristic solutions.

ACKNOWLEDGMENT

The work of first author is supported by research grant from the Ministry of National Education, Republic Indonesia (Hibah Bersaing), 2010.

REFERENCES

Geoffrion, A., and G. Graves. (1974) Multicommodity Distribution System Design by Benders Decomposition. *Management Science*, 29, 5, 822-844.

Gen, M., & Cheng, R. (2000). *Genetic algorithms and engineering optimization*, John Wiley & Sons, New York

Gen, M., Cheng, R. & Lin, L. (2008). *Network models and Optimization: Multiobjective Genetic algorithms Approach*, Springer, London.

Syarif, A, Yun, Y. and Gen, M. (2002). Study on Multi-Stage Logistics Chain Network: A Spanning Tree Based Genetic Algorithm, *Computers & Industrial Engineering*, vol.43, nos.1-2, pp.299-314, 2002.

Hitchcock, F. L., The Distribution of a Product from Several Sources to Numerous Localities, *J. Math. Phys*, Vol. 20, pp. 24-230, 1941.

Holland, J., *Adaptation in Natural and Artificial Systems*, University of Michigan Press, 1975 and MIT Press, 1992.

Das, C. and Heragu, S., A Transportation Approach to Locating Plants in Relation to Potential Markets and Raw Material Sources, *Decision Sciences*, Vol. 19, No. 4, pp. 819-829, 1988.

Heragu, S., *Facilities Design*, PSW Publishing Company, 1997

Ombuki, B. and Hanshar, F. An Effective GA for the Multi-depor Vehicle Routing Problem, Technical Report, Brock University, 2004

Toth, P., and Vigo, D. The vehicle Routing Problem, Society for Industrial and Applied Mathematics, 2001.

AUTHOR BIOGRAPHIES

Admi Syarif is a lecturer at Dept. of Mathematics, Faculty of Mathematics and Sciences, Lampung University. He is now also a director of research center of Lampung Univeristy. His papers have been published and accepted in *Journal of Plant Engineer Society of Japan, International Journal of Computer & Industrial Engineering* and *Journal of Intelligent Manufacturing and so on.* He can be reach at *admi_syarif@unila.ac.id*

Mitsuo Gen is a visiting scientist at Fu zzy Logic Systems Institute, Japan sinc e August 2009. He was Professor at Gra duate School of Information, Productio n and Systems, Waseda University, Jap an from April 2003 to July 2009. He re ceived a PhD in Engineering from Kog akuin University, Japan in 1975 and a PhD in Informatics from Kyoto University, Japan in 2006. He was a Lecturer during 1974-1980, an Associate Professor during 1980–1987, a Professor during 1987–2003 at Ashikaga Institute of Technology, Japan. He was a Visiting Assoc. Prof. at the Univ. of Nebraska-Lincoln, USA in 1981–1982 and a Visiting Prof. at Univ. of California at Berkeley, USA in 1999-2000.

His research interests include Genetic Algorithms, Neural Network, Fuzzy Logic and their applications to Scheduling, Logistics Network, and Reliability Design. He has authored 5 books, such as *Genetic Algorithms and Engineering Design*, 432pp, John Wiley & Sons, New York (1997), *Genetic Algorithms and Engineering Optimization*, 512 pp, John Wiley & Sons, New York (2000) with Dr. R. Cheng and *Network Models and Optimization: Multiobjective Genetic Algorithms,* 710pp, Springer, London (2008) with Dr. R. Cheng and Dr. L. Lin. He edited *Intelligent and Evolutionary Systems*, 240pp, *Studies in Computational Intelligence*, vol. 187, Springer-Verlag, Heidelberg, 2009 with Dr. D. Green, Dr. O. Katai, Dr. B. McKay, Dr. A, Namatame, Dr. R. Sarker & Dr. B. T. Zahng. He published *Introduction to Evolutionary Algorithms*, 418pp, Springer, London (July 2010) with Dr. Xinjie Yu. His Email address is gen@flsi.or.jp or mitsuogen@gmail.com.

Adiguna Setiawan is a student at Computer Science Department, Lampung University. His interest is on Heuristic Method and Optimization. His email address is adiguna_s@student.unila.ac.id