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A Framework for the Design and Analysis of an Evolutionary Algorithm for Multi Travelling Salesman Problem

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Abstract

This paper mainly deals with the design of an evolutionary algorithm for a Multi Travelling Salesman problem. The solution for this problem in multi application fields becomes a highly NP hard type problems which is in need of an efficient solution. The aim of the study is to find an optimal schedule of a salesman which is formed as a multiple objective problem. The mathematical model for the Multi Objective in Multi Travelling salesman problem is stated with the corresponding notations. To get an optimal schedule an evolutionary based approach is proposed to meet the criteria. The proposed algorithm is modelled and stimulated as a program and tested with a suitable example. The output results are given as a grant chart, with the optimal sequence schedule of each salesman.

Keywords: And Approach, Criteria, Evolutionary, Expense, Minimized Minim Maximize, Multi Travelling, Optimal Schedule, Optimal, Profit, Salesman, Time The

1. Introduction

The main objective of this type of problems is to deliver the correct material in the correct time, to the correct place with the minimized expense, in minim time and also to maximize the profit. In goods allocation process the product should be transformed from different starting places to different end point places. That is from different wholesale systems the goods where transformed to different retail distributors, by means of different ways. In order to get an efficiently good transportation system to reach our criteria, a joint methods where introduced to improve the effectiveness of the solution. A developed model of the multiple travelling salesman problems (mats) stated in[2–4] which is a common simplification of a Travelling Salesman Problems (TSP) found in[10] was given as Vehicle Routing Problems (VRP) in[9]. The main objective of our problem is to get an optimal sequencing schedule so as to meet all the criteria in the applications. Here a new developed module of the Multi objective –multi travelling salesman problems (Moms) has been consider as the base of VRP in[9], TSP found in[10] and Job Shop Scheduling Problems (JSSP) in[7,15–17]. A new natural based algorithm is developed from the evolutionary approaches. This Evolutionary based approached algorithm was developed and stimulated for the Multi objective –multi travelling salesman problems (Moms). The simulated results have been tested by a suitable example and the optimal schedule of each salesman has been given with all criteria. A Grant chart representation of the stimulated output result has been expressed for better accepting the optimal sequence schedule of each salesman.

2. Multi Objective Model of (Moms)

The TSP was discussed by multi authors[2–4, 18, 19] as the salesman who starts from a starting place, travel too multi

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places only once and return to the starting place with an optimal schedule assignment. It is also defined to finding the shortest path of the salesman with minimizing the tour cost or distant. The JSSP where given in[7, 15–17] which consists of a independent set of jobs, the processing steps of each job done by a machine set is given and also consist of an ordered set work to be done on each machine. A multi travelling salesman problem (mTSP) given here can be stated from the outlook of two known problems: a generalization of the Travelling Salesman Problem (TSP) and as a special case of the Job JSSP. The Multi objective –multi travelling salesman problems (MOmTSP) consist of more than one objective criterion to be optimised using some algorithms.

2.1 Parameter of (MOmTSP)

The Following parameters where considered for a Multi Objective-Multi travelling salesman

Problem (MOmTSP)

1. i = Numbers of Salesman
2. j = Number of cities
3. $x_{i,j} = \begin{Bmatrix} 1, The\ salesman\ i\ is\ in\ the\ city\ j \\ 0, Otherwise \end{Bmatrix}$
4. E_{ij} = Expenditure of I salesman in city j
5. P_{ij} = Profit made by I salesman in city j
6. C_j = 1, the city j is without salesman.
7. M_{ix} = completion time of constrain.

Objective of (MOmTSP) whereas, to minimize the Expenditure, maximize the profit and to minimize the city without salesman.

2.2 Structure of a Multi Objective (MOmTSP)

The proposed mathematical model of a Multi objective-Multi travelling salesman (MOmTSP) is given as

$$Minimize\ Z_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} E_{ij}x_{ij} + \sum_{j=1}^{m} C_j W_1$$

$$Maximize\ Z_2 = \sum_{i=1}^{n}\sum_{j=1}^{m} P_{ij}x_{ij} - \sum_{j=1}^{m} C_j W_2$$

$$Minimize\ Z_3 = \sum_{j=1}^{m} C_j$$

Subject to

$$\sum_{i=1}^{n} x_{ij} = 1, j = 1,2,3, \dots, m.$$

$$\sum_{j=1}^{m} x_{ij} = 1, i = 1,2,3, \dots, n.$$

3. The Proposed Evolutionary Based Algorithm to Solve the (MOmTSP)

The evolutionary based algorithm has been developed by several researchers[1, 6, 8, 14, 20, 21] which were developed from natural biological world behaviours. The evolutionary approaches have been represented in multi ways as Genetic Algorithm[6], Genetic Programming[1], Evolutionary Strategies[21], Evolutionary Programming[8], and so on. In generalization evolutionary algorithms are the processes as encoding the solutions to a machine based model, collection of population as encoded solution, applying the operators such as crossover and mutation for the selected candidate solution, decoding the candidate solution and finally checking for validity of the solution the process is repeated.

3.1 Encoding

A Multi objective- Multi travelling salesman (MOmTSP), the solutions where encoded as a matrix array.

3.2 Population Formation

A set of encoded candidate solutions forms as the matrix arrays where grouped as an initial generation of populations.

3.3 Selecting Candidate Solutions

From the initially generated population a random selection process is made to get the candidate solutions for the next generation.

3.4 Operation on Candidate Solutions

The selected candidate solutions where operated the genetic operators such as crossover and mutation which is as one point cross over and multi point mutation.

3.5 Decoding

After crossover and mutation operator the resulted candidate solution where decoded and the decoded solution is checked for optimality.

3.6 End

The decoded solution which satisfies the optimality condition where replaced for the next generation in the population category. The solutions does not satisfies the optimality condition where ruled out. This process of algorithm is repeated 'n' times and the most repeated matrix array candidate solutions are given as the output.

4. Numerical Computations

A problem of 4 salesman and 3 cities with their expenditure (E) and the profit (P) for each salesman in a city is given in the Table 1.

4.1 Simulation Result

The modelled algorithm was stimulated using the MATLAB software and program is designed to solve the proposed modelled multi objective – multi travelling salesman problem (MOmTSP). The stimulated result of the numerical example stated in the Table 1 is reported as the grant chart representation as Figure 1. The optimal

Table 1. Problem of 4 salesman and 3 cities with their expenditure (E) and the profit (P) for each salesman in a city

Salesman	Cities	1	2	3
1	(E,P)	(5,11)	(2,10)	(4,12)
2	(E,P)	(8,22)	(5,12)	(4,12)
3	(E,P)	(7,20)	(4,11)	(3,10)
4	(E,P)	(4,8)	(3,10)	(5,12)

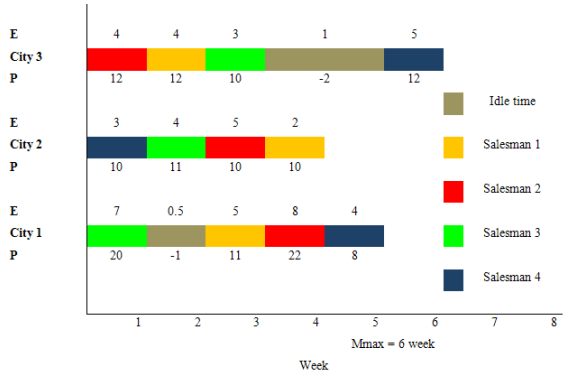

Figure 1. Grant Chart representation.

Table 2. The optimal schedule for each salesman and the optimality criterion result

Salesman 1	City 3	City 1	City 2
Salesman 2	City 3	City 2	City 1
Salesman 3	City 1	City 2	City 3
Salesman 4	City 2	City 1	City 3

Schedule of each salesman was also tabulated in Table 2. followed by it the optimality criterion result where given.

The Minimum expenditure = 4 + 4 + 3 + 7 + 4 + 5 + 5 + 2 + 8 + 3 + 4 + 5 + (3*0.5) = 55.5 units

The Maximum profit = 12 + 12 + 10 + 20 + 11 + 10 + 11 + 10 + 22 + 10 + 8 + 12 – (3*1) = 145 units

The Minimum No of cities without salesman = 3units

5. Conclusions

The objective is to derive an optimal sequencing schedule for multi salesmen working so as to meet the required criteria. A new model is developed as Multi objective travelling salesman problems (MOmTSP). Stimulation was developed using the natural based Evolutionary algorithm for the Multi objective –multi travelling salesman problems (MOmTSP). A randomly chosen numerical example has been tested using the simulation results; the optimal schedule of each salesman has been given with all criteria. A Grant chart representation of the stimulated output result has been expressed for better accepting the optimal sequence schedule of each salesman.

6. References

1. Mohammadi A, Omidvar MN, Li X, Deb K. Integrating user preferences and decomposition methods for multi-objective optimization. In Institute of Electrical and Electronics Engineers (IEEE) Congress on Evolutionary Computation; 2014 Jul. p. 421–8.
2. Carter AE, Ragsdale CT. A new approach to solving the multiple travelling salesperson problem using genetic algorithms. European Journal of Operational Research. 2006 Nov; 175(1):246–57.
3. Kiraly A, Abonyi J. Optimization of multiple travelling salesmen problem by a novel representation based genetic algorithm. 10th International Symposium of Hungarian Researchers on Computational Intelligence and Informatics; 2016 Mar 26. p. 315–26.

4. Gutting G, Punnen AP. The travelling salesman problem and its variations combinatorial optimization. Kluwer Academic Publishers, Dordrecht, the Nederland's; 2002.
5. Hu G, Yang S, Li Y, Khan SU. A hybridized vector optimal algorithm for multi-objective optimal designs of electromagnetic devices. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Magnetics. 2016 Mar; 52(3).
6. Jain H, Deb K. An evolutionary multi-objective optimization algorithm using reference-point based non-dominated sorting approach, part II: handling constraints and extending to an adaptive approach. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Evolutionary Computation. 2013; 18(4):602–22.
7. Huang Y et al. Incremental temporal reasoning in job shop scheduling repair. Institute of Electrical and Electronics Engineers (IEEE) International Conference on Industrial Engineering and Engineering Management (IEEM); 2010 Dec. p. 1276–80.
8. Cheng J, Yen G, Zhang G. A multi-objective evolutionary algorithm with enhanced mating and environmental selections. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Evolutionary Computation. 2015; 19(4):592–605.
9. Odili JB, Kadar MNM. Solving the travelling salesman's problem using the african buffalo optimization. Hinduri Publishing Corporation, Computational Intelligence and Neuroscience. 2015 Aug 27; 2016:12.
10. Peker M, Sen B, Kumru PY. An efficient solving of the travelling salesman problem: the ant colony system having parameters optimized by the Taguchi method. Turkish Journal of Electrical Engineering and Computer Sciences. 2013; 21:2015–36.
11. Cheng R, Jin Y, Narukawa K, Sendhoff B. A multiobjective evolutionary algorithm using gaussian process based inverse modelling. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Evolutionary Computation. 2015; 19(6):838–56.
12. Cavill R, Smith S, Tyrell A. Multi-chromosomal genetic programming. In Proceedings of the Conference on Genetic and Evolutionary Computation, Association for Computing Machinery (ACM) New York, USA; 2005. p. 1753–9.
13. Singh S, Lodi EA. Comparison study of multiple travelling salesmen problem using genetic algorithm. International Journal of Computer Science and Network Security (IJCSNS). 2014 Jul; 14(7):107–10.
14. Bandyopadhyay S, Mukherjee A. An algorithm for multi-objective optimization with reduced objective computations: A study in differential evolution. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Evolutionary Computation. 2015; 19(3):400–13.
15. Ponnambalam SG, Aravindan P, Rajesh SV. A tabu search algorithm for job shop scheduling. International Journal of Advanced Manufacturing Technology. 2000; 16:765–71.
16. Petrovic S, Fayad C. A genetic algorithm for job shop scheduling with load balancing. School of Computer Science and Information Technology, University of Nottingham; 2005.
17. Rajakumar S, Arunachalam VP, Selladurai V. Workflow balancing in parallel machine scheduling with precedence constraints using genetic algorithm. Journal of Manufacturing Technology Management. 2006; 17:239–54.
18. Bektas T. The multiple travelling salesman problems: an overview of formulations and solution procedures. Omega. 2006; 34:209–19.
19. Tang L, Liu J, Rong A, Yang Z. A multiple travelling salesman problem model for hot rolling scheduling in shanghaied boatman iron and steel complex. European Journal of Operational Research. 2000; 124:267–82.
20. Park YB. A hybrid genetic algorithm for the vehicle scheduling problem with due times and time deadlines. International Journal of Productions Economics. 2001; 73(2):175–88.
21. Zhu Z, Zhang G, Li M, Liu X. Evolutionary multi-objective workflow scheduling in cloud. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Parallel and Distributed Systems. 2016 May; 27(5):1344–57.