Issues and Solution for Multi-Objective Transportation Problem

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Abstract

In recent time transportation plays an important factor for economic growth of a nation. Together transportation and mobility are directly involved with growth of financial system of a nation and for that improved transportation infrastructure necessary. Also, modification in basic mathematical structure of transportation is required like simple objective function can be modified by multi objective function. This paper discusses multi-objective transportation problem, its different solution with limitation and provide better solution to avoid some limitation of multi-objective TP.

Introduction

Transportation is an important part of a developed society. It is not possible for each individual of family to produce his own food, clothing, etc. Goods can be produced more efficiently in factories, large farms, etc. but this necessitates the movement of both goods and people. The whole structure of society involves a trade-off between the economies of scale and focusing activities or groups of activities (factories, schools, office buildings, and cities) and the cost of transporting people from home to work places and goods from factories to consumers thus, the structure generates a problem known as Transportation Problem. The Transportation Problem is a classic Operations Research Problem where the objective is to determine the schedule for transporting goods from source to destination in a way that minimizes the shipping cost while satisfying supply and demand constraints. Although it can be solved as a Linear Programming problem, other methods exist.

The Transportation Problem (TP) was first developed and proposed by F. L. Hitchcock since 1941[1], [2]. It usually aims to minimize the total transportation cost [3]-[7]. Other objectives that can be set are a minimization of the total delivery time, a maximization of the profit, etc. The

Hitchcock-Koopman's transportation problem is expressed as a linear transportation model as follows:

$$\text{Minimize } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

$$\text{Subject to } \sum_{j=1}^{n} x_{ij} = a_i, i = 1,2,.....,m \quad (Supply)$$

$$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2,.....,n \quad (Demand)$$

$$x_{ij} \geq 0 \quad for\ all\ i\ and\ j$$

Where,

$x_{ij} =$ the amount of goods moved from origin i to destination j

$c_{ij} =$ the cost of moving a unit amount goods from origin i to destination j

$a_i =$ the supply available at each origin i

$b_j =$ the demand available at each destination j

$m =$ total number of origins (Sources)

$n =$ total number of destinations (Sinks)

This problem can be solved by classical transportation methods [17].

The transportation problem makes an important role in real life as for example minimization of total cost, consumption of certain scarce resources such as energy, total deterioration of goods during transportation, vehicle scheduling in public transit etc. From the investigation, the entire existing objectives in single objective transportation models are represented by quantitative information. This may cause the negligence of some crucial points which cannot be described by quantitative data [12], [13]. Real life decision making takes into account multiple, often conflicting, criteria. For example in shortest path problem, where cyclists aims to reach their destination in minimal time but along a safe route[9].

Factors that may influence route choice are road traffic, road condition and presence of dedicated cycling facilities. Therefore, it is reasonable to formulate cyclist route choice as a bi-objective problem with travel time as one objective, whereas all other route choice factors are combined into a second objective that we call attractiveness. That means in reality, considering only one objective of TP is not sufficient because it may not lead to the practical optimal solution. Thus the Decision Maker (DM) is rather to pay attention on several objectives on same time or in other words we can describe this as the limitation of single objective TP. This limitation can be sought out by generating multi-objective TP.

Multi-Objective Transportation Problem (MOTP)

The multi-objective transportation model is set to solve the transportation problem simultaneously associated with several objectives. Normally, existing multi-objective transportation models use a minimization of the total cost objective as one of their objectives. The other objectives may concern about delivery time, quantity of goods delivered, underused capacity, reliability of delivery, energy consumption, safety of delivery, etc. The multi-objective transportation problem with k objectives can be represented as [8]

$$\min f_1(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} c^1_{ij} x_{ij}$$

$$\min f_k(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} c^k_{ij} x_{ij}$$

$$\sum_{j=1}^{n} x_{ij} \le a_i, i = 1,2,.....,m \qquad \textit{for all i.}$$

Subject to

$$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2,.....,n \qquad \textit{for all j.}$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \text{ and } x_{ij} \ge 0 \ \textit{for all i and j}$$

Where c^k_{ij} represents the coefficients related to x_{ij} variable for objective k.

There are many researchers adapting this model for their computational researches [1], [4], [16] and many applications of MOTP in real life problems. For example cyclist route problem [9].

MOTP another application is highly seems to be in urban transportation as we know that transportation and its environmental impacts are a major component of urban environmental management. At the same time, transportation and mobility are an important part or urban economics and the quality of life. To analyse urban transportation and its environmental impacts, a comprehensive, interdisciplinary approach is needed. No single model can cover the range of spatial and temporal scales and processes involved. This leads to a multi-tiered approach and a cascade of models to describe alternative urban development and transportation scenarios and their multi-criteria assessment and comparative analysis [10].

Most of existing research works of a transportation problem has considered depot to customer relationship. However, the relationship between customer and customer is also critical because in fact vehicle route for each depot does not move from depot to customer and returns back from customer to depot as in the transportation model, it

moves from depot to customer and moves forward to the other customers. So, it needs also to consider customer to customer relationship to obtain the neighbourhood customers. Then, two objectives are concerned. The first objective is to minimize the total transportation cost which is the baseline objective for all transportation models. It is the depot to customer relationship consideration using quantitative data. The second objective is to minimize the overall independence value between customer and customer, which means the consideration of customer to customer relationship [11]. And, finally this problem introduces an important MOTP to real world.

Recently there have been many studies to solve multiobjective transportation problem in which Michalewicz et al applied GM(Genetic Algorithm) to solve MOTP, L Li and K. K. Lai et al applied fuzzy approach to solve MOTP, Mistuo Gen et al used spanning tree concept for it. Here whatever solution we obtained by different approaches depends on the accuracy of past data gathered. So solution of MOTP is accurate provided the data is accurate and hence sometimes due to data error, solution of transportation problem fails. For example suppose our multiobjective transportation problem involves two parameters time and cost and our objective is to optimize both the parameters, but these two parameters depend on several other parameters like vehicle type, road condition, climatic conditions, traffic volume, RTO, PWD operations and so on.

The solution of MOTP depends on data related to cost and time from origin and destination which may not always correct due to some factors stated above and hence it is difficult to find actual optimum cost and time in practical world and in this case our transportation problem solution fails. To avoid such situation it is necessary to use Information communication Technology and Knowledge based system which will provide accurate data with its tools and techniques. So the main objective of this paper is to develop a set of mathematical techniques which is useful to find

accurate solution of multi-objective as well as simple objective transportation problem with information communication technology. This researcher work also discussed how to improve road condition. For that researcher have developed mathematical technique on the basis of past study which may highly beneficial for road management sector to improve road condition. This work also discussed prediction technique which finds traffic volume on the road so people can easily get idea about cost and timing of travelling.

Proposed Information Communication Technology Based Module:

Transportation Data Collection Module

Data plays main role in decision-making process [15]. True data helps to discover knowledge, while affected data leads to improper knowledge. Transportation data is too much complex because so many parameters are included like Road condition, Season wise time differences, Climatic conditions, Traffic condition, RTO rules etc. Thus the following method is suggested for data collection.

According to above module different users are interacting with the system for data entry. All these users are required to enter data with the interface of the system. All users are required to be expert in data entry. They may have little domain of knowledge of transportation so that data entry can be proceed in a proper way. Also the unnecessary data can be restricted for collection. Experts are also connected with the system; they are required to store/edit useful information related to the transportation i.e. which route is best with time and cost for a user in specific season with respect to the road condition, traffic volume, climatic conditions ,PWD operations etc.?　Various other sources of data also exist in the system that provide data related to transportation and can affect in decision-making process. Based on the above described transportation data collection module a data accuracy model is established to obtain better
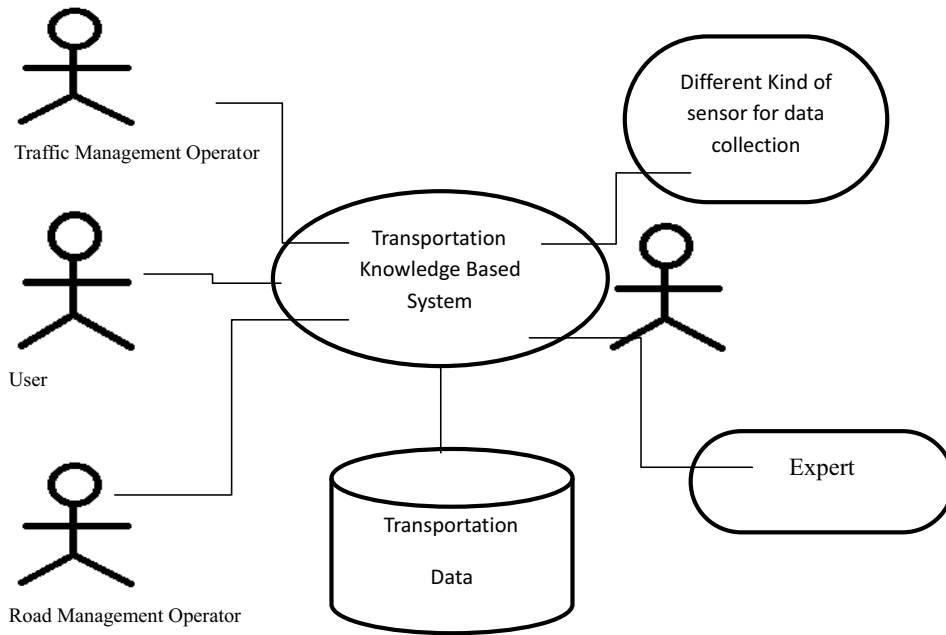
Fig: Transportation Data Collection Module

solution of the multiobjective transportation problem.

Set of Tools and Mathematical and Statistical Techniques:

For finding the better knowledge, a set of technique is required which is discussed as follows:

(1)   Fake data identification tool: This module can easily identify the fake data and remove from the data base. Eg: suppose user inserts data of Traffic and some electronics device or sensor collects that data but if data is improper then with this tool it is easily identified and thereafter removed from the database.

(2)   Predictive Mathematical Model and Numerical Technique: These mathematical and statistical techniques play significant role for finding trends of data like: Road condition or Traffic condition data having some fixed trend. Such data can be converted in numerical form, thereafter easily predicts trend of traffic condition season wise and time wise on the road. Similar job

can be done for the road condition.

(3)   Road Condition: This technique finds road roughness index which is useful to predict which road is better to travel and alarms for the improvement of road condition.

(4)   Developed Database and data warehousing technology (M. A. King, J. F. Elder IV et al. (1998)) can be used to store and retrieve large amounts of data; it can be in form of both text and image.

(5)   Transportation Algorithm: Simple and Multi-objective technique and algorithm can be directly used according to users problem.

(6)   To find out the optimum pattern from large amount of data, here we use Data mining techniques (Cheng Soon Ong, MIMOS Berhad (2000)), (S. Lawrence, K. Bollacker et al., (1999)) which could give potential useful advice. Also, modelling and simulation technology can be used for prediction.

(7)   For finding out the risk in two or more best ways researcher have developed risk analysis tools,

which can be useful for selecting optimum pattern for users.

(8)   Internet Technology played an important role for communication between users, experts-and our system. Note that users can have Internet connectivity M. A. King, J. F. Elder IV et al. (1998), if telephone service is available. In fact, under Optimum system, it is sufficient for a village to have a phone connection so that Internet could be accessed.

(9)   A template is a set of styles and page layout settings that determines the appearance of a document. This template matches the printer settings that will be used in the proceeding and the CD-Rom. The use of the template is mandatory.
All above techniques play significant role for extracting better knowledge.

Knowledge Discovery

Successful application of knowledge discovery requires a user and task-centred view, focussing on the nature of the interactions between humans and that lead to discovery of knowledge [19]. Knowledge discovery has been described as the process of identifying and extracting useful and understandable information from large data sets [18].The aim of this methodology is to processing on past data and extracting knowledge through it. Once data is collected from the users, database would contain valuable information for knowledge –based system to make decision for extracting best knowledge for the transportation problem. Process model for discovery of knowledge using application is described above. We focus on selection of route for Multi-objective transportation in day to day life, but same selection model can be applied for selecting best fertilizer, irrigation method etc. in agriculture by changing appropriate parameter.

Conclusion

Decrease in cost, time and other factors in transportation problem , if proposed transportation model based system developed with discussed mathematical techniques then it will be highly beneficial for users as well as operators of transportation system.

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