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# A GM Method for Solving Solid Transportation Problem

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## ABSTRACT

'GMmethod' is proposed to solve Solid Transportation Problem which uses the concept of modular arithmetic. In this method given problem with three constraints is solved by considering three different forms and minimal answer (maximal answer) from allanswers of possible forms is considered as best settlement solution of given minimization (maximization) STP. Proposed method is structured in an algorithm and illustrated by numerical examples. It is also coded in MATLAB for the user to use it with ease.
**Keywords:**Solid Transportation Problem, GM method, MATLAB, Modular Arithmetic.

## I. INTRODUCTION

Transporting the goods from one end of the globe to other with minimum cost and maximum profit has become a challenging task now-a-days known as Transportation Problem (TP). While achieving the aim of minimizing cost or maximizing profit along with the reduction of travelling cost through supply and demand constraint one more constraint conveyances i.e. mode of transportation which can be done through trucks, cargo flights, ships, trains etc. is taken into account.Such type of TP having three constraints is Solid Transportation Problem first introduced by Shell **[1]**. STP is the extension of classical TP where we have different ways of transporting goods from origin to destination which is widely applicable in public transport systems. Importance of well-planned Transport system can be realized if we have an eye on worldwide expanding market due to online sell and purchase throughout the globe which can be done through heterogeneous ways of transport like air-ways, road ways, and railways or through sea etc. Considering conveyances along with supply and demand points to STP Haley **[2]** described the way of getting solution for such problems. Bit *et al.***[3]** solved multi objective STP through fuzzy programming. Kocken *et al.***[4]** suggested parametric method to generate all optimal solutions of FSTP. Sobana **[5]***et al.* solved STP in fuzzy approach. Zavardehi *et al.***[6]** solved STP by metaheuristics. Jimnez *et al.***[7]** solved STP by Genetic Algorithm. Different recent ways to solve TP are studied by Ghadle *et al* [8]. Ghadle *et al.***[9, 10]** developed a new approach of modular arithmetic to solve TP and the same approach is extended to solveAP, BCTP, FrTP.In this paper, author have extended the concept of modular arithmetic in GM method to solve STP, here given

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problem with three constraints is solved by considering three different forms and minimal answer (maximal answer) from all is considered as best settlement solution of given minimization (maximization) STP.

## II. MATHEMATICAL MODEL

Consider a TP having m sources, n destinations and v conveyances. A mathematical model for STP can be given

Min $S(x) = \sum_{a=1}^{m} \sum_{b=1}^{n} \sum_{v=1}^{k} c_{abv} x_{abv}$

Such that,

$\sum_{b=1}^{n} \sum_{v=1}^{k} x_{abv} = p_a$ ; $for\ a = 1,2,\dots,m.$ ----- (i)

$\sum_{a=1}^{m} \sum_{v=1}^{k} x_{abv} = q_b$ ; $for\ b = 1,2,\dots,n.$ ----- (ii)

$\sum_{a=1}^{m} \sum_{b=1}^{n} x_{abv} = r_v$ ; $for\ v = 1,2,\dots,k.$ ----- (iii)

$x_{abv} \geq 0;\ \forall\ a = 1,2,\dots,m;\ b = 1,2,\dots,n;\ v = 1,2,\dots,k.$ ------ (iv)

Where,

$p_a$ – Amount of product available at supply point

$q_b$ – Amount of product demanded from destination point

$r_v$ – Amount of product transported by v conveyances

$x_{abv}$ – Amount of product transported from source *a* to destination *b* through $v^{th}$conveyance

$c_{abv}$ - Cost of per unit of product to be transported from source *a* to destination *b* through $v^{th}$conveyance

$p_a > 0;\ q_b > 0;\ r_v > 0 \forall\ a = 1,2,\dots,m;\ b = 1,2,\dots,n;\ v = 1,2,\dots,k.$

Here, our aim is to minimize the cost of STP having objective function *S(x)* and satisfying (i) to (iv)

## III. PROPOSED GM METHOD TO SOLVE STP:

1. Let *S(x)* be given STP. Solve it in three different possible forms so as to get all possible solutions.
2. First consider given problem in the form of Supply-Demand-Conveyance and solve it by “Ghadle-Munot Algorithm”. Let $S_1$ be the solution obtained in this step.
3. Now reform the table of given STP in the form of Supply-Conveyance-Demand and solve it by “Ghadle-Munot Algorithm”. Let $S_2$ be the solution obtained in this step.
4. Again reform the table of given STP in the form of Conveyance-Demand-Supply and solve it by “Ghadle-Munot Algorithm”. Let $S_3$ be the solution obtained in this step.
5. Let S= min { $S_1, S_2, S_3$}
6. S would be best settlement solution of given STP

We will have a look on working of this algorithm through following numerical examples.

Example:

A mobile manufacturing company in China wants to sell its product from three different cities where the manufacturing plants are located to three different countries via three different modes of transportation. the value of transporting the mobile from a particular city

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to a particular country via a particular conveyance with its maximum capacity of carrying productis mentioned in the following table along with its unit cost of transportation from source a to destination b via conveyance v. solve the given STP to minimize the cost.

| | | | | | | | | | | Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Conveyance | $V_1$ | | | $V_1$ | | | $V_1$ | | | 10 |
| | | $V_2$ | | | $V_2$ | | | $V_2$ | | 13 |
| | | | $V_3$ | | | $V_3$ | | | $V_3$ | 8 |
| | $D_1$ | | | $D_2$ | | | $D_3$ | | | Supply |
| $S_1$ | 3 | 6 | 7 | 2 | 8 | 6 | 5 | 6 | 1 | 10 |
| $S_2$ | 3 | 1 | 5 | 0 | 2 | 7 | 7 | 3 | 4 | 12 |
| $S_3$ | 7 | 0 | 2 | 3 | 6 | 2 | 4 | 5 | 3 | 9 |
| Demand | 5 | | | 15 | | | 11 | | | |

Step II.

First consider given problem in the form of Supply-Demand-Conveyance and solve it by "Ghadle-Munot Algorithm".

After solving the table which is already in given form we get the allocations which fully satisfies supply demand and conveyance capacity as $x_{132} = 6$; $x_{133} = 4$; $x_{221} = 10$; $x_{222} = 1$; $x_{232} = 1$; $x_{312} = 5$; $x_{323} = 4$; with cost 53 say $S_1$.

Step III.

Now reform the table of given STP in the form of Supply-Conveyance-Demand and solve it by "Ghadle-Munot Algorithm".

| | | | | | | | | | | Demand |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination | $D_1$ | | | $D_1$ | | | $D_1$ | | | 5 |
| | | $D_2$ | | | $D_2$ | | | $D_2$ | | 15 |
| | | | $D_3$ | | | $D_3$ | | | $D_3$ | 11 |
| | $V_1$ | | | $V_2$ | | | $V_3$ | | | Supply |
| $S_1$ | 3 | 2 | 5 | 6 | 8 | 6 | 7 | 6 | 1 | 10 |
| $S_2$ | 3 | 0 | 7 | 1 | 2 | 3 | 5 | 7 | 4 | 12 |
| $S_3$ | 7 | 3 | 4 | 0 | 6 | 5 | 2 | 2 | 3 | 9 |
| Capacity | 10 | | | 13 | | | 8 | | | |

After solving we get the allocations which fully satisfies supply conveyance and demand capacity as $x_{123} = 6$; $x_{133} = 4$; $x_{212} = 10$; $x_{222} = 1$; $x_{223} = 1$; $x_{321} = 5$; $x_{332} = 4$; with cost 53 say $S_2$

Step IV.

Again reform the table of given STP in the form of Conveyance-Demand-Supply and solve it by "Ghadle-Munot Algorithm".

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| | | | | | | | | | | Demand |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination | $S_1$ | | | $S_1$ | | | $S_1$ | | | 10 |
| | | $S_2$ | | | $S_2$ | | | $S_2$ | | 12 |
| | | | $S_3$ | | | $S_3$ | | | $S_3$ | 9 |
| | $V_1$ | | | $V_2$ | | | $V_3$ | | | Supply |
| $D_1$ | 3 | 3 | 7 | 6 | 1 | 0 | 7 | 5 | 2 | 5 |
| $D_2$ | 2 | 0 | 3 | 8 | 2 | 6 | 6 | 7 | 2 | 15 |
| $D_3$ | 5 | 7 | 4 | 6 | 3 | 5 | 1 | 4 | 3 | 11 |
| Capacity | 10 | | | 13 | | | 8 | | | |

After solving we get the allocations which fully satisfies supply conveyance and demand capacity as $x_{123} = 5$; $x_{212} = 10$; $x_{221} = 2$; $x_{222} = 2$; $x_{223} = 1$; $x_{323} = 3$; $x_{331} = 8$; with cost 49 say $S_3$

Step V.

Let S= min { $S_1, S_2, S_3$}

Here, $S = min \{53,53,49\} = 49$

So, best settlement solution of given STP is with minimal cost 49 and allocations are corresponding to $S_3$.

Example 2 :

A Garments factory in Gujrat wants to sell its product from three different cities where the manufacturing factories are located to three different cities of India via three different modes of transportation. Value of transportation from a particular city to a particular city via a particular conveyance with its maximum capacity of carrying product is mentioned in the following table along with its unit cost of transportation to destination b from source a via conveyance v. solve the given STP to minimize the cost.

| | | | | | | | | | | Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| Conveyance | $V_1$ | | | $V_1$ | | | $V_1$ | | | 12 |
| | | $V_2$ | | | $V_2$ | | | $V_2$ | | 15 |
| | | | $V_3$ | | | $V_3$ | | | $V_3$ | 10 |
| | $D_1$ | | | $D_2$ | | | $D_3$ | | | Supply |
| $S_1$ | 5 | 8 | 9 | 4 | 10 | 8 | 7 | 8 | 3 | 12 |
| $S_2$ | 5 | 3 | 7 | 2 | 4 | 9 | 9 | 5 | 6 | 14 |
| $S_3$ | 9 | 2 | 4 | 5 | 8 | 4 | 6 | 7 | 5 | 11 |
| Demand | 7 | | | 17 | | | 13 | | | |

Step II.

First consider given problem in the form of Supply-Demand-Conveyance and solve it by "Ghadle-Munot Algorithm".

After solving the above given table which is in desired form we get the allocations which fully satisfies supply demand and conveyance capacity as

$x_{111} = 6$; $x_{131} = 6$; $x_{222} = 7$; $x_{232} = 7$; $x_{312} = 1$; $x_{323} = 10$; with cost 137 say $S_1$

.Step III.

Now reform the table of given STP in the form of Supply-Conveyance-Demand and solve it by "Ghadle-Munot Algorithm".

| | | | | | | | | | | Demand |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination | $D_1$ | | | $D_1$ | | | $D_1$ | | | 7 |
| | | $D_2$ | | | $D_2$ | | | $D_2$ | | 17 |
| | | | $D_3$ | | | $D_3$ | | | $D_3$ | 13 |
| | $V_1$ | | | $V_2$ | | | $V_3$ | | | Supply |
| $S_1$ | 5 | 4 | 7 | 8 | 10 | 8 | 9 | 8 | 3 | 12 |
| $S_2$ | 5 | 2 | 9 | 3 | 4 | 5 | 7 | 9 | 6 | 14 |
| $S_3$ | 9 | 5 | 6 | 2 | 8 | 7 | 4 | 4 | 5 | 11 |
| Capacity | 12 | | | 15 | | | 10 | | | |

After solving we get the allocations which fully satisfies supply conveyance and demand capacity as $x_{111} = 6$; $x_{113} = 6$; $x_{212} = 10$; $x_{222} = 7$; $x_{223} = 7$; $x_{321} = 1$; $x_{332} = 10$; with cost 165 say $S_2$.

Step IV.

Again reform the table of given STP in the form of Conveyance-Demand-Supply and solve it by "Ghadle-Munot Algorithm".

| | | | | | | | | | | Demand |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination | $S_1$ | | | $S_1$ | | | $S_1$ | | | 12 |
| | | $S_2$ | | | $S_2$ | | | $S_2$ | | 14 |
| | | | $S_3$ | | | $S_3$ | | | $S_3$ | 11 |
| | $V_1$ | | | $V_2$ | | | $V_3$ | | | Supply |
| $D_1$ | 5 | 5 | 9 | 8 | 3 | 2 | 9 | 7 | 4 | 7 |
| $D_2$ | 4 | 2 | 5 | 10 | 4 | 8 | 8 | 9 | 4 | 17 |
| $D_3$ | 7 | 9 | 6 | 8 | 5 | 7 | 3 | 6 | 5 | 13 |
| Capacity | 12 | | | 15 | | | 10 | | | |

After solving we get the allocations which fully satisfies supply conveyance and demand capacity as $x_{123} = 7$; $x_{212} = 12$; $x_{221} = 2$; $x_{222} = 2$; $x_{223} = 1$; $x_{323} = 3$; $x_{331} = 10$; with cost 125 say $S_3$

Step V.

Let S= min $\{S_1, S_2, S_3\}$

Here, $S = min \{127,165,125\} = 125$

So, best settlement solution of given STP is with minimal cost 125 and allocations are corresponding to $S_3$.

## IV. RESULT:

Proficiency of the proposed algorithm is investigated through numerical examples. The optimal solution of the above examples are very close to solution by D. Anuradha's method but proposed method is more simple because here given STP is transformed to three different forms and solved as TP. This approach minimizes complexity and time to solve the example; its MATLAB coding makes it more-handy for the user. This method can be extended to multi objective STP, SAP etc.

## V. CONCLUSION:

In conclusion we have developed an efficient and novel way to solve STP which uses Ghadle-Munot algorithm and is extended to obtain best settlement solution of given STP. It will help decision maker to take appropriate decision about logistics related issues in real life. It is widely applicable in public transportation systems.

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