Trip Distribution Model for Delhi Urban Area Using Genetic Algorithm

Shivendra Goel¹, J.B. Singh², Ashok K. Sinha³

¹Research Scholar, Shobhit University, Meerut 250110, India, shivendragoel@gmail.com
²Professor, Shobhit University, Meerut 250110, India, jbs.tomar@shobhituniversity.ac.in
³Professor, ABES Engg. College, Ghaziabad 201009, India, aksinha@computer.org

Abstract. As the society evolves it generates transport demand. An estimate of the volume of trips between zones is a necessary step in transportation studies. The classical transportation planning methods are based on simple extrapolation of trends. Some mathematical models like linear programming models have also been used by researchers for estimating traffic generation for future period. This paper presents a model for trip distribution in Delhi Urban Area using Genetic Algorithm. This model has been used for trip distribution in all zones of Delhi Urban Area. This model is applied on the real set of data on passengers trips generated and passengers trips attracted in all zones of Delhi Urban Area, which in turn gives satisfactory results which can be applicable in current and future scenarios. This work analyzes and compares the result of this model with Linear programming model for trip distribution.

Keywords: Genetic Algorithm(GA); Linear programming models; GA Based Trip Distribution model; Delhi Transport Corporation (DTC).

1 Introduction

1.1 Different Phases of urban Transportation Planning

Trip generation is the first step in the conventional four-step urban transportation Planning process, widely used for forecasting travel demands. It predicts the number of trips originating in or destined for a particular traffic analysis zone. Urban area is divided into several traffic zones which are the clusters of households and socio-economic activities.

Trip distribution (or destination choice or zonal interchange analysis), is the second component (after trip generation, but before mode choice and route assignment) in the traditional four-step urban transportation planning process. This step matches trip makers’ origins and destinations to develop a “trip table” a matrix that displays the number of trips going from each origin to each destination. Gravity model, entropy maximization models are widely used for trip distribution analysis [15].

Mode choice analysis is the third step in the conventional four-step urban transportation Planning process. Trip distribution's zonal interchange analysis yields a set of origin destination tables followed by; Mode choice analysis allows the modeler to determine which mode of transport will be used.
Traffic assignment concerns the selection of routes between origins and destinations in transportation networks. It is the fourth step in the conventional urban transportation planning process.

Trip distribution models are intended to produce the best possible predictions of travelers’ destination choices on the basis of trip generation and attraction information for every travel zone and generalized cost of traveling between each pair of zones [6].

Many scientific disciplines have contributed toward analyzing problems associated with the transportation problem, including operation research, economics, engineering, Geographic information science and geography. It is explored extensively in the mathematical programming and engineering literatures.

Estimating trip distribution for future period is a challenging task. George Dantzig[1] adapted the simplex method to solve the transportation problem formulated earlier by Hitchcock and Koopmans, but this simplex method is used by researchers for estimating trip distribution generation for future period[2-5].

The Linear programming based transportation models are applicable only to problems where the constraints and objective function are linear. Secondly, the most serious disadvantage of linear programming models is their failure to deal with demand uncertainties in any explicit way.

The subsequent section of this paper is organized as follows. Section 2 focuses on the proposed model of the trip distribution problem using Genetic Algorithm. This model presents a method for estimating the parameters, describes the main characteristics of the data used for calibration. Section 3 sets out the main results of the calibration process based on real set of data of Delhi Urban Area. Section 4 compares the result of proposed model with Linear programming model for trip distribution. Finally, Section 5 sums up the main conclusions of our analysis.

2 Proposed Solution

Genetic Algorithm based Trip distribution model is developed for solving the above stated problem. This model uses the goodies of Genetic Algorithm in Trip distribution. Model is stated as follows:

\[ F_{ij} = \{P_i, A_j, C_{ij}\} \]

Where:

- \( F_{ij} \) = trip distribution,
- \( P_i \) = total passengers generated at \( I \),
- \( A_j \) = total passengers attracted at \( j \).
- \( C_{ij} \) = Cost of Passenger trip from zone \( i \) to zone \( j \).

The number of origin zones, \( i = 1, 2, \ldots, n \)

The number of destination zones, \( j = 1, 2, \ldots, m \)

The implementation of the above model is as follows:

\[ \sum_{j=1}^{m} F_{ij} = P_i, \quad i = 1, 2, \ldots, n \ldots (i) \]

\[ \sum_{i=1}^{n} F_{ij} = A_j, \quad j = 1, 2, \ldots, m \ldots (ii) \]

Now, fitness function returns min (\( y \)) such that.

\[ y = \sum_{i=1}^{n} \sum_{j=1}^{m} (C_{ij} \times F_{ij}) \ldots (iii) \]
Selection Operator. The selection operator chosen is the Roulette wheel selection. In roulette wheel selection individuals are assign a probability of being selected based on their fitness criterion, \( p_i = f_i / \sum f_j \). Where \( p_i \) is the probability that individual \( i \) will be selected, \( f_i \) is the fitness of individual \( i \), and \( \sum f_j \) represents the sum of the fitness of all individuals in the population. Alike to using a roulette wheel, fitness of an individual is represented as in proportion slice of wheel. Wheel is then spinning and the slice underneath the wheel when it stops determines which individual becomes a parent[21].

Crossover ERO. Standard crossover operator is chosen for manipulating the above representation. This operator is ERO (Edge Recombination crossover Operators) are designed to manipulate permutations. ERO is an operator that creates a path that is similar to a set of existing paths (parents) by looking at the edges rather than the vertices [16,21].

Mutation Rate. Mutation becomes significant at what time after some generations the number of different strings decreases because burly individuals start dominating. In a condition of burly dominance of a few strings, the crossover operator alone would not bring any changes and the search for a best solution would be ended. To partially move the search to new locations in the solution space, mutation operator randomly alters genes. A mutation rate of 0.15 was taken for genetic algorithm. The number of generations considered in the algorithm was 1000.

3. Results

Following Table 3.1 shows the data of Trips Generation and attraction from each zone and Table 3.2A and Table 3.2A shows the data of Fare (in Rs.) from one zone to another DTC and Figure1 shows the flow chart of the work and Table 3.3 A and Table 3.3B is computed based on the proposed solution shows the number of passenger trips from one zone to another.

3.1. Result Comparison with Linear Programming Model

The model in section 2 is also implemented in Linear Programming [18]. Proposed Genetic Algorithm model for trip distribution and the Linear Programming Model for trip distribution are applied on the above set of inputs. It gives the following results shown in table 4.1.

The Linear Programming model is as follows:

\[
\text{min cost } z = \sum_{i=1}^{n} \sum_{j=1}^{m} (C_{ij} \times T_{ij})
\]

Subject to:

\[
\sum_{j=1}^{m} T_{ij} = P_i \quad (i=1,2,\ldots,n)
\]

\[
\sum_{i=1}^{n} T_{ij} = A_j \quad (j=1,2,\ldots,m)
\]

Where:

- \( T_{ij} \) = trip distribution,
- \( P_i \) = total passengers generated at \( i \), \( A_j \) = total passengers attracted at \( j \).
- \( C_{ij} \) = Cost of Passenger trip from zone \( i \) to zone \( j \), \( z \) = min cost.
- \( i \) = number of origin zones,
- \( j \) = number of destination zones.
Table 4.1

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Linear Programming Based Model.</th>
<th>GA Based Trip Distribution model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status of Solution</td>
<td>Infeasible</td>
<td>Feasible</td>
</tr>
<tr>
<td>Number of results achieve in 81 Links of each connected Zones</td>
<td>9</td>
<td>76</td>
</tr>
</tbody>
</table>

The above result show in Table 4.1 shows that result achieved from Linear Programming Based Model is not up to the mark as the number of input variables increases in the above said problem it gives Infeasible solution.

Conclusion

Genetic Algorithm Based Trip Distribution model is proposed and applied on the real set of data which gives satisfactory solution which is easily applicable and compared with other models as well, as in this paper one can easily observed that a Linear Programming based model gives infeasible solution for the complex problems as stated above.

References

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<table>
<thead>
<tr>
<th>Zones</th>
<th>No. of passengers trips Generated from each Zone 2005</th>
<th>No. of passengers trips Attracted at each Zone 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>1730400</td>
<td>1742229</td>
</tr>
<tr>
<td>West</td>
<td>1239400</td>
<td>1247895</td>
</tr>
<tr>
<td>North</td>
<td>1050200</td>
<td>1082715</td>
</tr>
<tr>
<td>South</td>
<td>1039600</td>
<td>1070185</td>
</tr>
<tr>
<td>North</td>
<td>413040</td>
<td>387163</td>
</tr>
<tr>
<td>Central</td>
<td>449850</td>
<td>364808</td>
</tr>
<tr>
<td>South</td>
<td>1079600</td>
<td>1090338</td>
</tr>
<tr>
<td>East</td>
<td>417710</td>
<td>420582</td>
</tr>
</tbody>
</table>
Fig1: Flow Chart of the Work

<table>
<thead>
<tr>
<th></th>
<th>South</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>655870</td>
<td>8075670</td>
</tr>
<tr>
<td></td>
<td>669756</td>
<td>8075670</td>
</tr>
</tbody>
</table>

Table 3.2A [11] Fare (in Rs.) from one zone to another DTC
Table 3.2B [11] Fare (in Rs.) from one zone to another DTC

<table>
<thead>
<tr>
<th>Zones</th>
<th>North-West</th>
<th>West</th>
<th>North-East</th>
<th>South-West</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-West</td>
<td>311362.2</td>
<td>255176.24</td>
<td>193723.56</td>
<td>204619.64</td>
<td>102607.29</td>
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<tr>
<td>West</td>
<td>228355.73</td>
<td>207938.77</td>
<td>155817.9</td>
<td>155925.33</td>
<td>74638.957</td>
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<tr>
<td>North-East</td>
<td>206580.07</td>
<td>168001.77</td>
<td>139392.48</td>
<td>134685.36</td>
<td>57646.102</td>
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<tr>
<td>South-West</td>
<td>215947.05</td>
<td>142818.54</td>
<td>148187.49</td>
<td>127592.1</td>
<td>70667.657</td>
</tr>
<tr>
<td>North</td>
<td>137912.11</td>
<td>56694.95</td>
<td>70954.626</td>
<td>97627.821</td>
<td>nil</td>
</tr>
<tr>
<td>Central</td>
<td>118064.18</td>
<td>56255.003</td>
<td>79815.038</td>
<td>55539.371</td>
<td>nil</td>
</tr>
<tr>
<td>South-East</td>
<td>216067.9</td>
<td>171129.77</td>
<td>156765.22</td>
<td>132039.11</td>
<td>57385.51</td>
</tr>
<tr>
<td>Zones</td>
<td>Central</td>
<td>South-East</td>
<td>East</td>
<td>South</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>------------</td>
<td>-----------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>North-West</td>
<td>141148.23</td>
<td>232265.14</td>
<td>132562.79</td>
<td>156934.92</td>
<td></td>
</tr>
<tr>
<td>West North-East</td>
<td>54718.191</td>
<td>189071.99</td>
<td>80578.686</td>
<td>92354.446</td>
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</tr>
<tr>
<td>South West</td>
<td>61650.691</td>
<td>120431.3</td>
<td>60874.884</td>
<td>100937.33</td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>269,72442</td>
<td>40538.431</td>
<td>nil</td>
<td>21392.96</td>
<td></td>
</tr>
<tr>
<td>Central South-East</td>
<td>nil</td>
<td>83045.249</td>
<td>13806.873</td>
<td>57981.452</td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>78684.484</td>
<td>140181.66</td>
<td>67371.104</td>
<td>59975.242</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>11859.551</td>
<td>85630.076</td>
<td>842.04374</td>
<td>57976.718</td>
<td></td>
</tr>
</tbody>
</table>