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Perceived Travel Time Attribute Analysis and Estimation Modelling of A Metropolitan Traffic Corridor: A Case Study of Surat, India

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Abstract

Travel time plays vital role in performance assessment and efficiency ranking of the urban corridor of the metropolitan cities from planning and management perspective and decision making processes of route choice and departure timing from commuters' point of view. Travel time can be interpreted in two terms; Measured Travel Time (MTT) and Perceived Travel Time (PTT). However, PTT is gaining more importance over MTT in recent time as the same is associated with travllers' perception in a holistic way of the entire route/corridor. Often mode and route choices and sensing of departure time are mainly based on one's perception of travel time for the trip. The present study focuses on this issue with due consideration of various PTT attributes pertaining to both socio-economic and trip attributes. Influence of socio-economic and trip attributes has been analyzed with ANOVA test to find that trip attributes matter in perception of travel time rather than the socio-economic background of the travellers. It is observed that PTT (min/km) decreases with increase in travel distance and there is also a overestimation of PTT with actual travel time by almost two-fold. Other important aspect is that of development of Perceived Travel Time Estimation Model (PTTEM) employing Fuzzy Logic with due consideration of epistemic uncertainty associated with attributes. The model finds application in formulation of necessary improvement measures to bring travel times to reasonable level.

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Keywords: Perceived travel time; socio-economic attributes; trip attributes; ANOVA test; fuzzy logic

1. Introduction

Travel time is considered as one of the most important indicators for the transport managers as well as the commuters. It has bearing on travel delays, route choice and setting of departure time on part of the trip makers. Travel time can be interpreted in two terms; Measured Travel Time (MTT) and Perceived Travel Time (PTT). MTT reflects on the realistic traffic and road situation, whereas PTT is associated with commuter's perception on holistic assessment of the entire route. As such PTT is outcome of integration of series of stimuli or enroute sequential journey episodes and it bears no straight forward relationship to physical time (Fraisse, 1984). Hence, the subjective

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duration experienced by the commuters does differ from the actual one. Perhaps, it is the reason for the commuters preferring perceived times in their travel plans to include route and departure time choice. It is also the fact that most of the commuters give weightage to the monetary benefits derivable from value of travel time perceived rather than the monetary expenditure on the trip. Hence, travel time perceived by commuters is more important than physical travel distance (MacEachren A., 1980). This fact cannot be ignored or side-tracked by the planners or managers in traffic improvement strategies and program and consider only measured travel time. However, the PTT should be considered in right perspective because of its over-estimation or under-estimation characteristics. Moreover perception of travel time is a complex phenomenon with association of uncertainty in assessment of traffic situations. Hence, an attempt has been made to study the concerned attributes and thereafter develop Perceived Travel Time Estimation Model (PTTEM) by employing soft computing technique such as Fuzzy Logic. The data-base is developed by conducting home interview survey of the commuters for the selected 12 km long corridor in Surat city, Gujarat, India.

2. Literature Support

Often travel experience does matter in travel time perception and differ from the actual travel time (Tawfik et al., 2010). Now perception of travel time is receiving more attention in transport planning (Parathasarathi et al. 2013, Vreeswijk et al. (2014)). Zhang et al. (2005) concluded in their study on freeways and ramp-meter that performance improvement of traffic control system is more appropriate taking into account the PTT as a matter of driver's acceptance rather than minimizing total absolute travel time measured. PTT varies from driver to driver or from commuter to commuter based on their perception under different traffic conditions. Drivers or commuters plan their travel accordingly (Poon and Stopher, 2011). PTT has been defined by various researchers in different ways. Victoria Transport Policy Institute (2013) considers perceived (also called cognitive) time is how users experience travel. Lee et al. (2007) defines perceived travel time as driver’s expected travel time on link before departing the origin, whereas it is considered for a route as a whole Ramazani et al. (2011). If there are two routes between O-D having the same distance, PTT may differ on the route basis. According to Szeto and Wong (2012), the PTT is considered as the sum of expected travel time and the perception error, where the perception error can be modelled by the probability distribution to capture the variation for the analysis purpose. PTT is assumed as the travel time sensed by the commuters based on the riding experience in prevailing traffic conditions, traffic environment and the trip length in the present study.

PTT is a function of commute characteristics, journey episodes, travel environments and expectancy (Li, 2003). Parthasarathi et al., (2013) considers the network variables such as relative discontinuity, street density and access control as other influencing factors in travel time perception. Driver's perception on trip durations varies with variation in traffic condition (Ushiwaka et al. 2004).The number of intersections and intensity of congestion have major bearing on perception (Zhang and Levinson, 2008).It is also to be noted that there will be variation in PTT values depending upon the road category like rural and urban roads, local and regional trips apart from traffic control measures prevailing in the system. Various socio-economic variables (age, gender, education and income) are part of the study on PTT by Burnett (1978) and Peer et al. (2014).

Overestimate or underestimate of PTT with reference to MTT is another important aspect observed by Vreeswijk et al. (2014) and Peer et al. (2014) on urban corridors and overestimation varied from 40% to 50%. Parathasarathi et al. 2013 and Vreeswijk et al. (2014) also observed higher PTT overestimation for shorter trips. Mode choice factor has considerable impact on travel time perception of individual travellers in a case study of Varotto et al. (2014) in Italy. Tang W. et al. (2013) developed departure time choice model with reference to perceived travel time, whereas Kim and Lim (2012) demonstrated route choice modelling. Khademi et al. (2014) noted certain degree of uncertainty to prevail in perception of travel time. This uncertainty originates in travellers’ judgments in cognition process of various attributes. Such uncertainty can be overcome by using soft computing technique such as Fuzzy Logic. Limited research is available on PTT characteristics and its estimation.

3. Study Objectives and Methodology

3.1. Research Objectives

The main objectives of the present study are

- To analyze the travel time attributes associated with travel time perception of commuters with reference to socio-economic and traffic characteristics of a trip on urban corridor.
- Development of Perceived Travel Time Estimation Model (PTTEM) using Fuzzy Logic approach

3.2. Research Methodology

Study methodology progresses from first phase of data collection and data base development for the defined objectives. Focus of second phase is on analysis of attributes for their influence on PTT, whereas development of fuzzy logic model for estimation of perceived travel time are part of the third phase. Data base development is based on the home interview of the commuters pertaining to the trips on the study corridors. The data is related to both socio-economic attributes and trip travel time experience by the commuters. The statistical analysis was carried to realize the perceived travel time variation and weightage of the attributes. The identified input variables are considered in development of PTTEM by employing fuzzy logic to recognize the uncertainty prevailed in attributes.

4. Study Corridor Features

A stretch of nearly 12 km of Udhana –Sachin corridor in South-West zone, Surat City in South Gujarat has been selected for the study purpose. The corridor links the Udhana Junction on the ring road and Unn Junction on other end passing through commercial, residential and industrial areas (Fig. 1).It is an important corridor as regional traffic from neighbouring State of Maharashtra enters into the city. The corridor is of six lanes of which two central lanes are reserved for Bus Rapid Transit Systems (BRTS) and remaining four lanes are used for mixed traffic, two lanes on either side of the BRTS lanes.

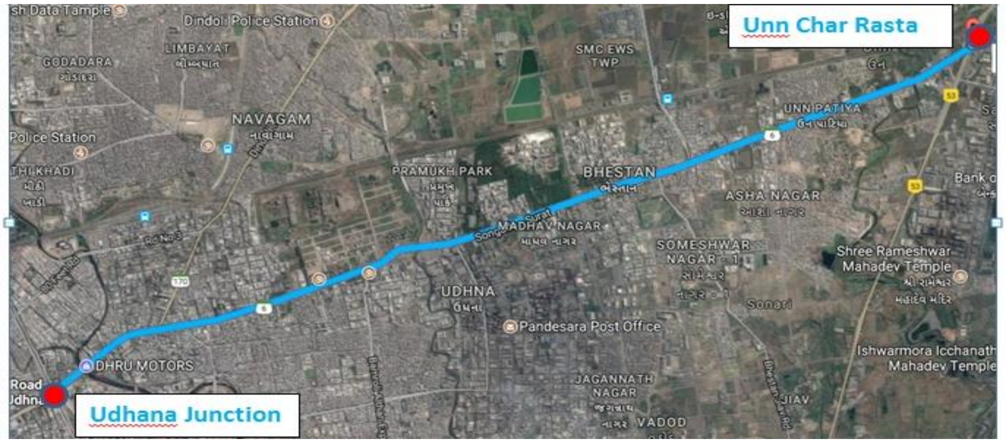


Fig. 1. Location map of the study corridor

5. Study Survey

The catchment areas were identified in a preliminary survey for home interview purpose and interviews were carried with the commuters passing on the study corridor for their work activities. For this purpose, a questionnaire was designed and updated in second stage, based on the pilot study to realize the responses from the commuters. A map of study corridor indicating the location of intersections and distances was enclosed with the questionnaire for the reference of commuters. The questionnaire included various socio-economic attributes such as occupation, income level, age, education and vehicular ownership in part I, whereas trip attributes such as traffic conditions/congestion, traffic environment, trip distance and perceived travel time in part II. Origin and destination of each trip has reference to study corridor only and not the distances from home to corridor point or from corridor point to the destination. As such perceived time is quoted for the corridor trip length travelled on corridor. Nearly 300 samples were collected in random way during peak periods in the morning and evening. The questionnaires were distributed by the trained enumerators in the morning period to highlight the objective and attributes particulars, so as to collect the realistic and reliable information for the study. Subsequently, filled up questionnaires were collected in the evening or at the convenient time stated by them. There was scope for the enumerators to interact with the commuters and enhance the data reliability.

The commuters were expected to rate in the four scales 1 to 4 for the attributes of traffic conditions and traffic environment. The linguistic expressions used are Low (L), Medium (M), High (H) and Very High (VH) for traffic conditions, whereas in case of traffic environment as Good (B), Medium (C), Poor (D) and Very Poor (E). The ratings are based on the experiences and visual impression of the commuters. Degree of vehicle movement for the **'traffic conditions'** and the road side level of haphazard parking and pedestrian disturbance for the **'traffic environment'** are considered as the main factors for qualitative assessment by the commuters.

6. Analysis of PTT

6.1. Statistical Measures of PTT Values

PTT is the time stated by the commuters for their trips on the corridor based on their day to day travel experience. It varies from person to person depending upon one's visual assessment and his vehicle movement. In the present study the O–D points of the commuters are on the corridor itself related to their destination and their trip lengths vary from 1 km to 12 km and so is the travel time that they perceive. The statistical measures of PTT values of the study are provided in five slots of trip length on the corridor as shown in Table 1. Average PTT values are provided on distance travelled in column II and per km basis in column III. Former provides the range of PTT values from 9 min to 40 min for the distance varying 1 km to 12 km in ascending order. However, it is interesting to note the average value of PTT on per km basis decreases from 6.2 min to 3.5 min indicating the decrease in perception error (Fig. 2, PTT/km).This has impact on travel time profile in lowered values with increase in travel distance (Fig. 2, PTT). Similar are the observations of **Parathasarathi et al. 2013** in this regard. The overall average PTT/km is 5.47 min. Standard deviation is observed to decrease with increase in trip length.

Table 1. Statistical measures of PTT (min)

Distance (km)	Average (PTT)	Average (PTT/KM)	Min (PTT/KM)	Max (PTT/KM)	Std. Dev (PTT/KM)
0-2.5	9	6.20	2.5	10.0	2.0
2.5-5	21	5.60	2.0	8.8	1.5
5-7.5	31	4.82	2.9	8.0	1.0
7.5-10	36	4.13	2.5	5.6	0.9
10-12	40	3.47	2.5	5.0	0.8

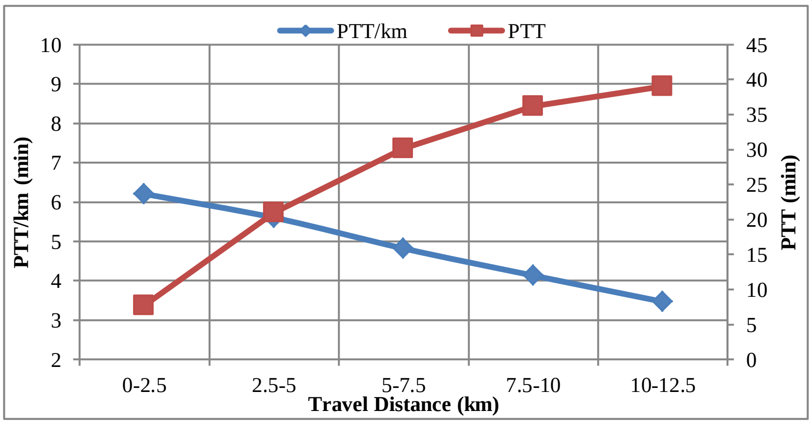


Fig. 2: PTT for travel distance

6.2. PTT Profile on Time Basis

The peak and off peak PTT time profile can be clearly observed for both morning and evening periods (Fig. 3). The off peak reduced value is between 1300 hours to 1700 hours. Indirectly the profile reflects the PTT values with reference to traffic situation prevailing on the corridor. The MTT values during peak and off peak periods are 2.8 min/km and 2.5min/km respectively, against the average value of 6.1 min/km and 4.5 min/km for peak and off peak periods respectively pertaining to PTT (Table 2). As such the survey reflects the two fold overestimation of PTT compared to MTT. Such overestimations of PTT are also observed by **Vreeswijk et al. (2014) and Peer et al. (2014)**.

Table 2. Ratio of PTT to MTT

Time Period	MTT (min/km)	PTT (min/km)	PTT/MTT	Remark
Peak Period	2.8	6.1	2.17	Overestimated
Off Peak Period	2.5	4.5	1.80	Overestimated

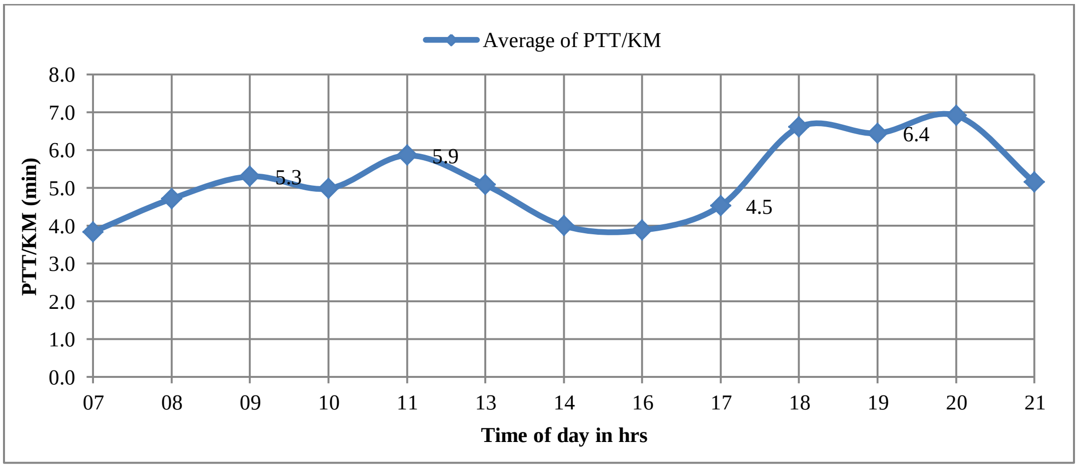


Fig. 3: PTT with respect to time of day

7. ANAYLYSIS OF PTT ATTRIBUTES

7.1. Socio-economic Attributes

The income, vehicle ownership, occupation, age and education are the socio-economic attributes considered in the present study for the analysis purpose. These attributes are divided into various sub-groups as shown in Table 3 for detailed analysis to understand the likely impact on perception of travel time, if any. These are the personal characteristics pertaining to the commuter who has been interviewed. The PTT data has been sorted for all the sub-groups with reference to four levels of traffic conditions namely low (L), medium (M), high (H) and very high (VH) and are provided in Table 4 along with sample size in bracket. Scanning of data for sub-groups of each attribute, if considered by particular level of traffic condition, the noted PTT values seem not to make significant variations. However, one can observe that there is increasing trend in PTT values from low traffic to a very high traffic level as anticipated. To understand the impact of socio-economic attributes of PTT values at micro level considering sub-groups specified in each attribute is further subjected to ANOVA test and it has been found that except education attribute, there is no significant influence on the PTT values with the observed value of F and p value as mentioned in the Table 5. These are also the observations made by Burnett (1978). It is further noted that as far as low income sub-group (<Rs 10,000) is concerned, the PTT value is quite high with compare to other higher income groups (Table 4) and it is obviously due to lower level of education in this group.

Table 3. Socio-economic attributes

Attributes	Subgroups
Income (INR, 000)	<10, 10-25, 25-50, >50
Vehicle Ownership	1,2,3, >4
Occupation	Upper Level Officer (ULO), Mid-Level Officer (MLO), Lower Level Officer (LLO), Business (Upper), Business (Lower)
Age (Year)	<26, 26-35, 36-45, >46
Education	Non-Metric, Metric, Graduate

Table 4. PTT/km for socio-economic attributes (min)

Income (Rs)	Low	Medium	High	Very High	Average
<10,000	5 (2)*	5.10 (4)	7.29 (4)	5.83 (2)	5.94 (12)
10,000-25,000	3.35 (9)	4.54 (45)	5.82 (49)	6.93 (23)	5.39 (126)
25,000-50,000	3.79 (6)	4.56 (26)	5.82 (46)	7.11 (20)	5.63 (98)
>50,000	2.83 (2)	4.62 (25)	5.26 (21)	6.78 (16)	5.32 (64)
Vehicle Ownership					
1	3.5 (12)	4.5 (37)	5.7 (54)	6.5 (15)	5.15 (118)
2	3.5 (4)	4.5 (26)	5.7 (30)	7.4 (20)	5.62 (80)
3	-	4.9 (15)	5.8 (12)	7.0 (15)	5.92 (42)
>4	4.2 (3)	4.62 (22)	5.4 (24)	6.4 (11)	5.44 (60)
Occupation					
Middle Level Officer	3.38 (4)	4.28 (9)	5.47 (16)	6.58 (13)	5.35 (42)
Lower Level Officer	3.22 (6)	4.28 (35)	5.77 (35)	6.71 (16)	5.20 (92)
Business Upper	4.83 (2)	4.80 (30)	5.49 (32)	6.72 (18)	5.49 (82)
Business Lower	3.73 (7)	4.88 (26)	6.29 (37)	7.71 (14)	5.87 (84)
Age					
<26	3.33 (2)	4.66 (12)	6.72 (15)	5.56 (7)	5.62 (36)
26-35	4.30 (7)	4.67 (26)	6.01 (26)	7.10 (24)	5.68 (90)
36-45	2.64 (6)	4.39 (51)	5.37 (51)	7.25 (25)	5.15 (108)
>46	4.00 (4)	4.79 (28)	5.78 (28)	6.92 (15)	5.64 (66)
Education					
Non-Metric	3.40 (5)	4.96 (19)	6.42 (19)	7.39 (9)	5.76 (52)
Metric	4.33 (6)	4.70 (45)	5.87 (44)	7.34 (25)	5.66 (120)
Graduate	3.20 (8)	4.26 (36)	5.48 (57)	6.37 (27)	5.18 (128)
Average	**3.61 (19)**	**4.59 (100)**	**5.77 (120)**	**6.92 (61)**	**5.47 (300)**

***( ) Sample Size**

Table 5: ANOVA Test- Socio-economic attributes

Variable	Group	F Value	P Value	F-Critical	Influence
Income (0000)	<10 , 10-25 , 25-50, >50	0.846	0.470	2.635	No
Vehicle Ownership	1, 2, 3, >4	2.006	0.113	2.635	No
Occupation	ULO, MLO, LLO, Business (Upper), Business (Lower)	2.428	0.066	2.636	No
Age	<26, 26-35, 36-45, >46	2.056	0.106	2.635	No
Education	<10th , 10th-12th , >12th	3.403	0.035	3.026	Yes

7.2. Analysis of Trip Attributes

Trip attributes considered in this study are Traffic Conditions (TC), Traffic Environment (TE) and Travel Distance. 'TC' is visualized in terms of traffic intensity, congestion and vehicle kinematics of acceleration, deceleration, stop and move situations and queue or platoon movement. On the other hand, 'TE' refers to pedestrian interruptions by encroaching on carriage way or road crossing and haphazard kerb parking. Both these attributes are perceived by the commuter for his trips whenever he passes this corridor through his visual and situation cognizance pertaining to his travel distance. These three attributes are further sub-grouped in four levels to subject ANOVA test for their significant impact through F and p values as shown in Table 6.The statistical analysis indicated rejects the null hypothesis that there is no influence of each level for particular attribute with higher 'F' values compared to critical one i.e. there is significant influence of the trip attributes on PTT values. Similarly very low 'p' values further support the proposition.

Table 6. ANOVA Test -Trip Attributes

Variable	Group	F Value	p Value	F-Critical	Influence
TC (Congestion)	Low, Medium, High, Very High	47.461	0.000	2.635	Yes
TE	Good, Medium, Poor, Very Poor	39.490	0.000	2.635	Yes
Trip Distance (km)	<2.5, 2.5-5, 5. -7.5, 7.5-10, >10	14.601	0.000	2.402	Yes

Further, effect of four levels of TC as well as TE on PTT/km is shown in Fig. 4 (a) and 4 (b). It can be observed that as congestion level increases PTT also increases. The variation is from average 3.61 min/km to 6.92 min/km during low to very high traffic conditions. With increment in traffic congestion, the traffic environment degrades and PTT values increase.

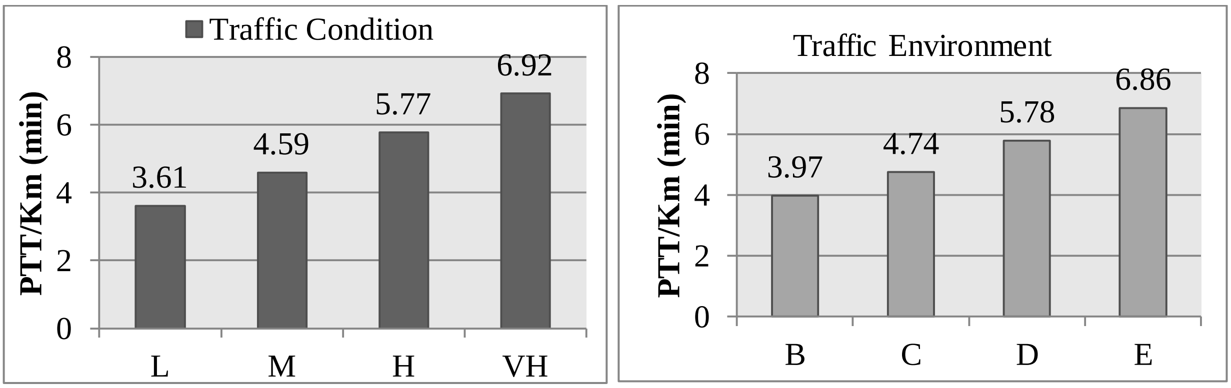


Fig. 4. PTT/km for TC and TE (a) Sub-groups of TC; (b) Sub-groups of TE

8. Development of Perceived Travel Time Estimation Model (PTTEM)

As mentioned earlier fuzzy rule based approach has been adopted to address the uncertainty prevailing in human perception in rating of attributes. The technique has been used in most of the projects involving human decision process wherein vagueness and impreciseness normally prevails.

8.1. Model Structure

Fuzzy rule base works in three stages as briefed below.

Phase I – Fuzzification

Fuzzification is the important step in the fuzzy logic theory, which converts crisp inputs into fuzzy sets. Membership function is the mathematical expression that deals with the fuzziness of the fuzzy sets.

Phase II –Fuzzy Inference System

Fuzzy Inference is a process of mapping given input to an output which provides a basis from which decisions can be arrived at. Here, *Mamdani* fuzzy inference system is used for the development of the model. Fuzzy rule based system is generated based on the association between the input and the output variables.

Phase III – Defuzzification

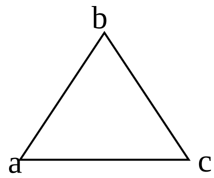
It is essentially a closing phase where, fuzzy output values are converted into crisp values to realize the impacts in realistic terms. The centroid method is used for defuzzification to obtain the crisp outputs.

8.2. Fuzzification of Attributes

'TC', 'TE' and Travel Distance (km) are considered as the inputs for the present model with reference to the PTT attribute analysis as discussed earlier. Among the socio-economic attributes, 'education' attribute, though has indicated its influence on PTT, is ignored for its marginal 'F' value as compared to trip attributes. Categorization of variables in linguistic terms, the membership shape adopted and input ranges for particular input level, etc., are as shown in Table 7. Cluster technique has been adopted for Membership Functions (MFs) for 'Travel Distance, and 'PTT' and five clusters are emerging as shown in Fig. 5(a) and 5(b). Here, triangular membership functions (MFs) are preferred in case of 'TC' and 'TE' for their simplicity as shown(Fig. 6 (a) and 6 (b)).The following expressions (1) and (2) provide μ(x) values for triangular and trapezoidal membership functions respectively.

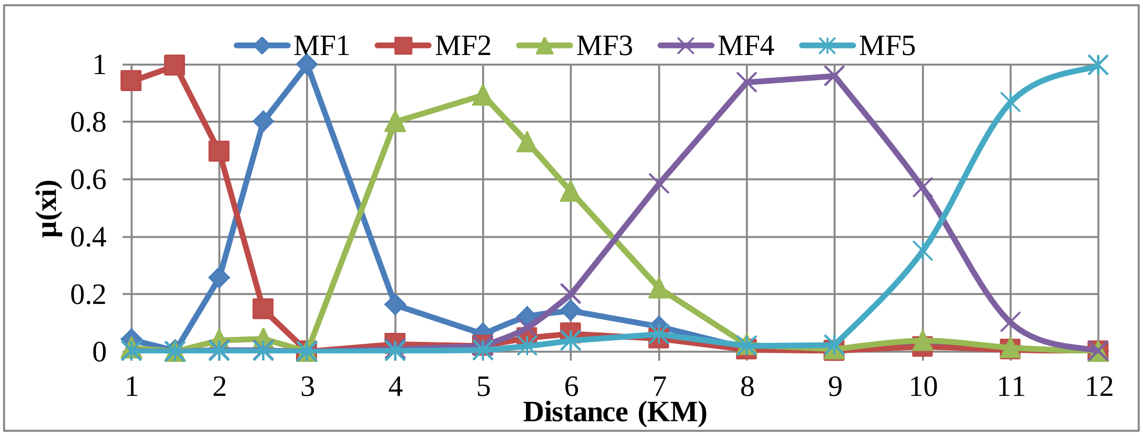
MFs of Triangular Shape

$$\mu_A(x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & x \geq c \end{cases} \qquad \ldots\ldots\ldots\ldots (1)$$



MFs of Trapezoidal Shape

$$\mu_A(x; a, b, c, d) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1 & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & x \geq d \end{cases} \qquad \ldots\ldots\ldots.(2)$$



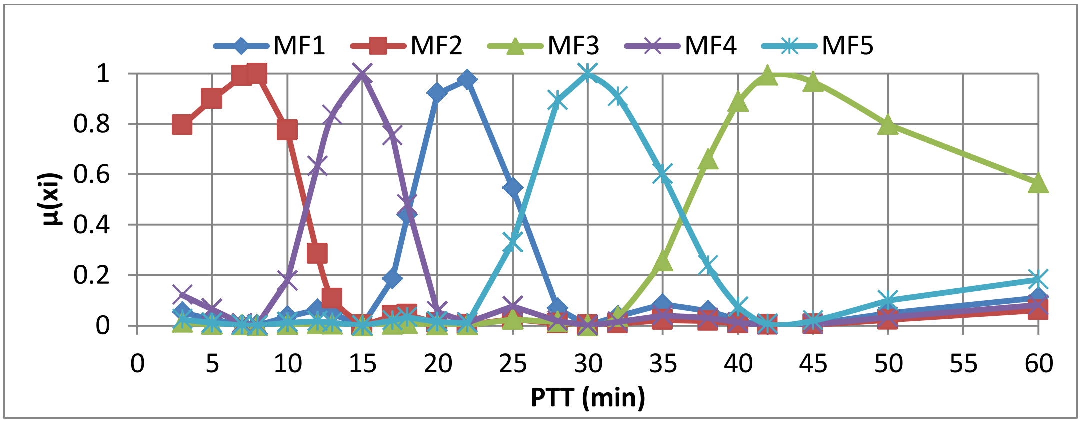


Fig. 5. (a) Clustering – Distance; (b) Clustering – PTT

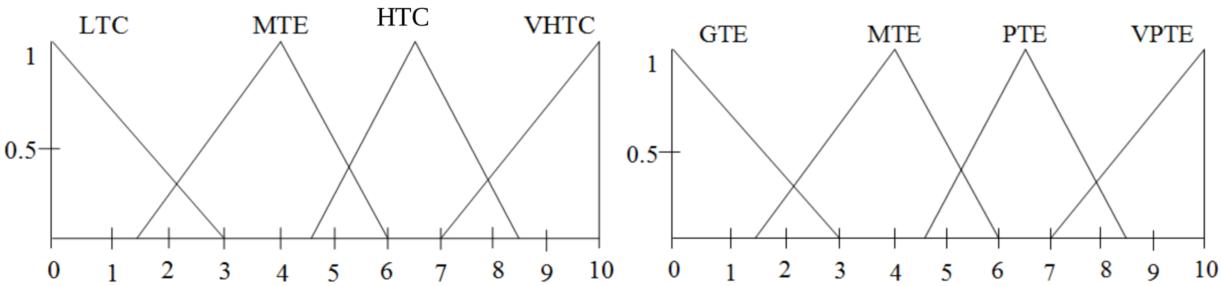


Fig. 6 (a) MFs – ‘TC’; (b) MFs – ‘TE’

Table 7. MFs and range particulars

Variable	No. of MFs	Linguistic Variable	Type of MFs	Fuzzy No.
TC	4	Low (LTC)	Triangular	[0 0 3]
		Medium (MTC)	Triangular	[1 4 6]
		High (HTC)	Triangular	[4.5 6.5 8.5]
		Very High (VHTC)	Triangular	[6.75, 10, 10]
TE	4	Good (GTE)	Triangular	[0 0 3]
		Medium (MTE)	Triangular	[1 4 6]
		Poor (PTE)	Triangular	[4.5 6.5 8.5]
		Very Poor (VPTE)	Triangular	[7, 10, 10]
Travel Distance (km)	5	Very Short (VSS)	Trapezoidal	[0 0 1.25 2.5]
		Short (SS)	Triangular	[1.8 3 4.5]
		Medium (MS)	Triangular	[3.5 5.3 7.5]
		High (HS)	Triangular	[6 5.25 10.5]
		Very High (VHS)	Trapezoidal	[9 11.5 12 12]
PTT (min)	5	Very Low (VLTT)	Trapezoidal	[0 0 5 15]
		Low (LTT)	Triangular	[7.5 15 21]
		Medium (MTT)	Triangular	[17 22.5 29.5]
		High (HTT)	Triangular	[25 33 43]
		Very High (VHTT)	Trapezoidal	[38 49 60 60]

8.3. Fuzzy Rule Framing

Fuzzy inference is a process of mapping given input to an output that provides a basis from which decisions can be derived. Fuzzy rule based system is generated in association of inputs with the output variable. Here with 4 levels of 'TC' and 'TE' and 5 levels of travel distance, total 80 **'IF- Then'** rules (4*4*5) were framed. Few fuzzy based rules are mentioned below for illustration.

IF<*TC is low*> and <*TE is good*> and <*Distance is very short*>**THEN**<*PTT is Very low*>

IF <*TC is medium*>and <*TE is Poor*> and <*Distance is Medium*>**THEN**<*PTT is medium*>

IF<*TC is high*>and <*TE is Poor* > and <*Distance is high*>**THEN** <*PTT is high*>

IF<*TC is very high*>and <*TE is very poor*> and <*Distance is very high*>**THEN**<*PTT is very high*>

The first part of **'IF-Then'** rule is referred to as **antecedent** and **consequent** to second part.

8.4. Defuzzification and Model Validation

The fuzzy inference system provides fuzzy outputs which need further conversion to crisp value through deffuzication process. The centroid method has been adopted in defuzzification process, where algebraic summation of fuzzy output from the model is obtained. The typical MatLab snapshot (Fig. 7)for the three inputs values of TC, TE and Travel Distance as 5, 5, and 6 km respectively provides the output value of PTT as 23.1 min from the developed model PTTEM .

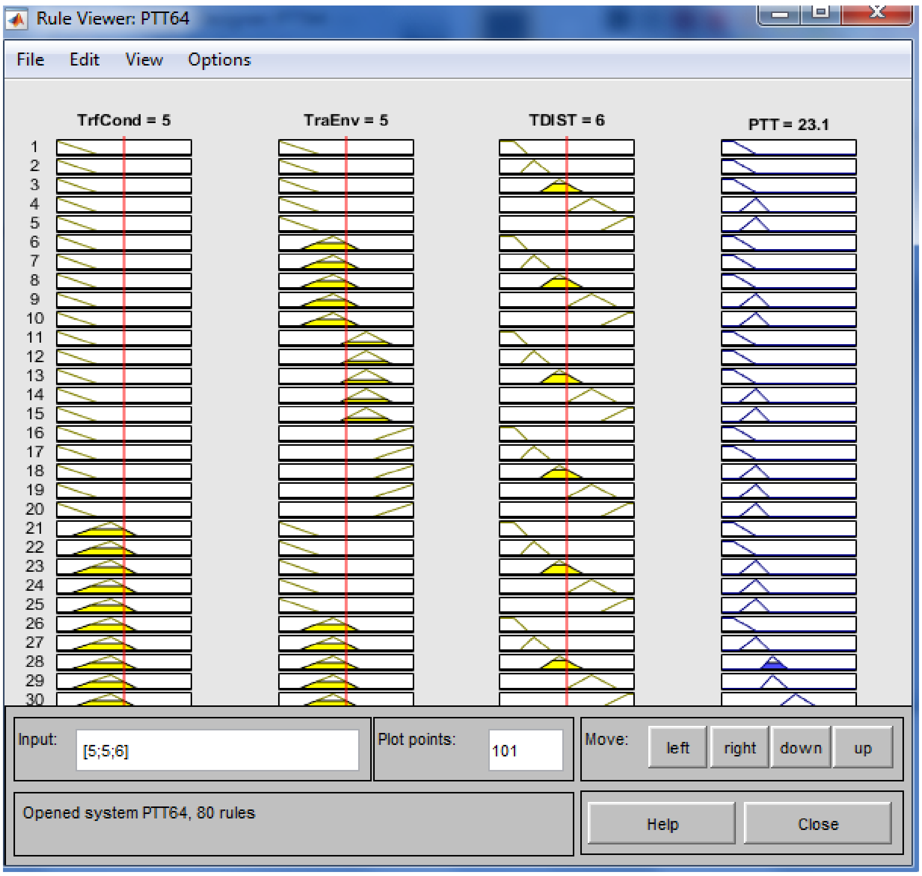


Fig. 7. Typical MatLab Snapshot of Rule Viewer Window

The field observed PTT values and model output values are validated with value of R^2 0.86 as shown in Fig. 8 indicating satisfactory agreement. Furthermore, accuracy of the model is checked by Root Mean Square Error (RMSE) value and is found quite reasonable.

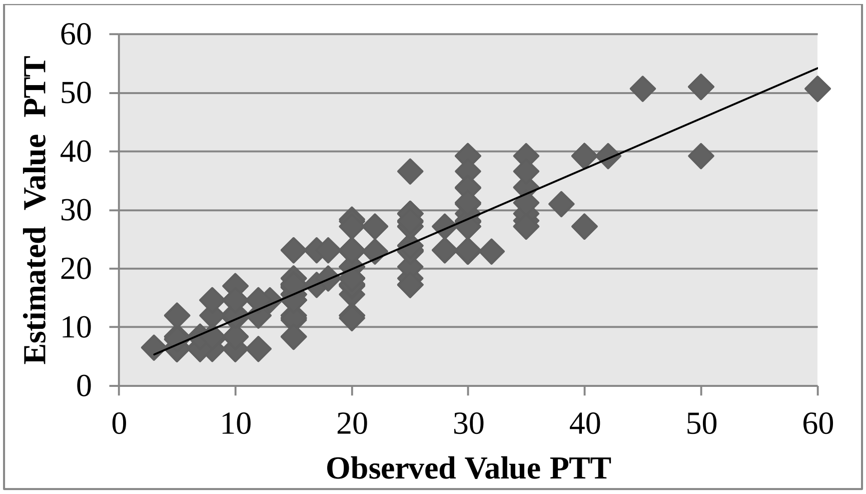


Fig. 8. Observed Vs Estimated PTT

9. Discussion and Conclusion

Performance of an urban traffic corridor whether for particular segment or the entire route is normally measured in terms of travel time and travel time variation. Travel time measurement on perception basis plays a vital role in realizing human response to various traffic attributes as trip maker is ultimate corridor user. Identification of attributes pertaining to PTT and the analysis is a rather complex process as human decision behaviour is involved. The PTT attributes can be stratified in two groups on the basis of socio-economic and trip attributes. Attributes such as income level, occupation pattern, vehicle ownership, age and education, etc. belong to the former and traffic condition/congestion, traffic environment and travel distance are the part of latter group. The ANOVA test carried over these attributes at micro level clearly indicated that the socio-economic attributes have hardly any influence on perception of travel time. The study highlights the fact that **'Traffic Conditions'** and **'Traffic Environment'** comprising haphazard kerb parking and pedestrian interruptions and the **'Travel Distance'** on the corridor are the prime factors of the travel time perception of the commuters.

The study reveals that the difference between the perceived travel time and the measured average travel time decreases with the trip distance i.e. perceived error is high for shorter trips compared to longer trips. PTT in the study indicated dropping from 6.2 min/km to 3.47 min/km (44%) with reference to short trip length of 1.5 km to long trip 12 km. Another important observation of the study is regarding perceived and measured travel time ratios, the high ratio is observed as 2.7 and 1.8 during peak and off peak periods respectively.

As epistemic uncertainty prevails in ratings of traffic conditions, traffic environment and in judgment of perceived travel time, fuzzy logic approach has been advocated in developing the Perceived Travel Time Estimation Model (PTTEM).As the some of the attributes are qualitative in nature, linguistic expression and relevant rating are adopted. The model developed here operates on Mamdani Fuzzy Inference System. The developed PTTEM finds application in providing the feedback by the commuters in regard to prevailing traffic situations as conceived by them, so that the traffic and transport planners can reinforce their traffic improvement measures. It provides the scope for understanding the hidden forces behind the particular travel attributes which is often missing in measured attributes in the field surveys. Often commuters' decision on mode, route choice and departure time choice are based on perceived travel time for their trips.

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