9th Urban Mobility India Conference & Expo 2016
Planning Mobility for City's Sustainability

FUZZY LOGIC BASED HUMAN PERCEPTION MODEL FOR PUBLIC TRANSPORT PLANNING: A CASE STUDY OF THIRUVANANTHAPURAM CITY

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OUTLINE

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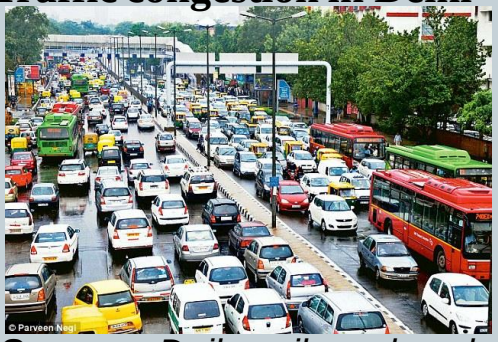
INTRODUCTION

- Road-traffic problems such as, congestion, delays and road accidents, which becomes a serious threat to the many cities.

- The total registered vehicles in the country grew at a Compound Annual Growth Rate (CAGR) of 10.5% between 2002 and 2012 (*Road Transport Year Book 2011-12*).

- 2001-2011 data reveals that growth rate of registered motor vehicles becomes almost three times the growth rate of road network.

Traffic congestion in Delhi



Source : *Dailymail.co.uk website*

In 2014

5 lakh	1.46 lakh	5 lakh
Road accidents	Death	Injured

more than **16 lives every hour on average**

Source: *Ministry of road transport & highways transport research wing*

Solution to these problem :
Use of **Public Transport.**

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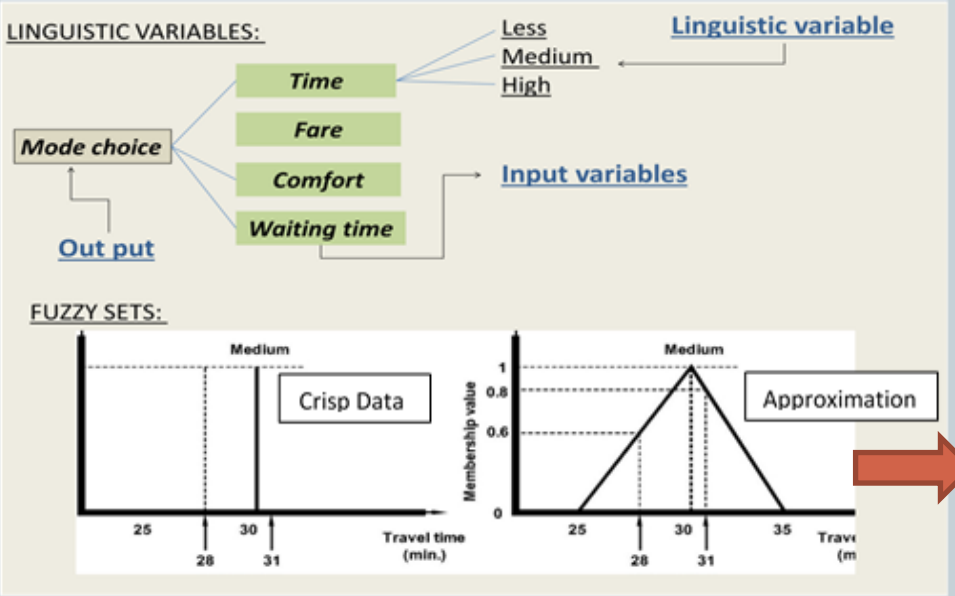
HOW THEY MAKE DECISION? WHICH MODE DO THEY CHOOSE?

CONCEPT OF FUZZY LOGIC



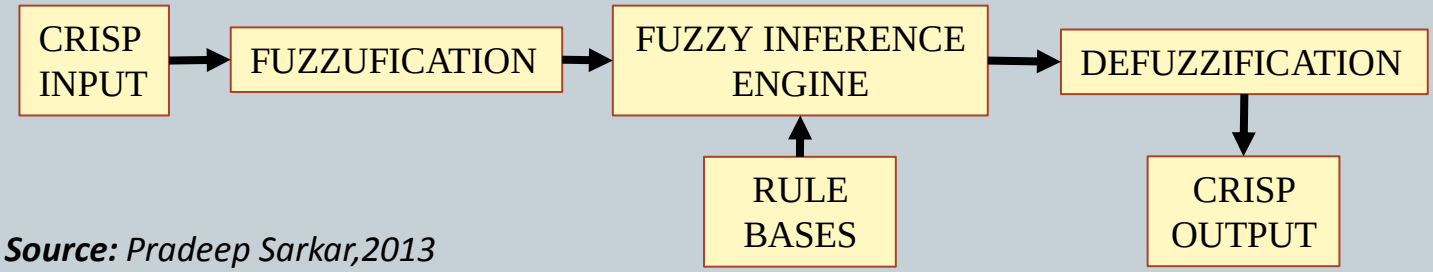
Fuzzy logic has the ability to tackle such kind of small variations and considered approximations.

Source: *Author*

- Fuzzy logic comprises of key elements namely ***Input variables, Output variables, Linguistic variables, membership functions*** **and** ***rules.***
- If travel time is one of the parameter then its linguistic variables are ***Less, Medium and High,*** which explains the range for respective variables.
- Input parameters are called as ***fuzzy sets*** and have linguistic variables with corresponding ranges.
- In simple language IF X AND Y, THEN Z rules.

FUZZY INFERENCE SYSTEM

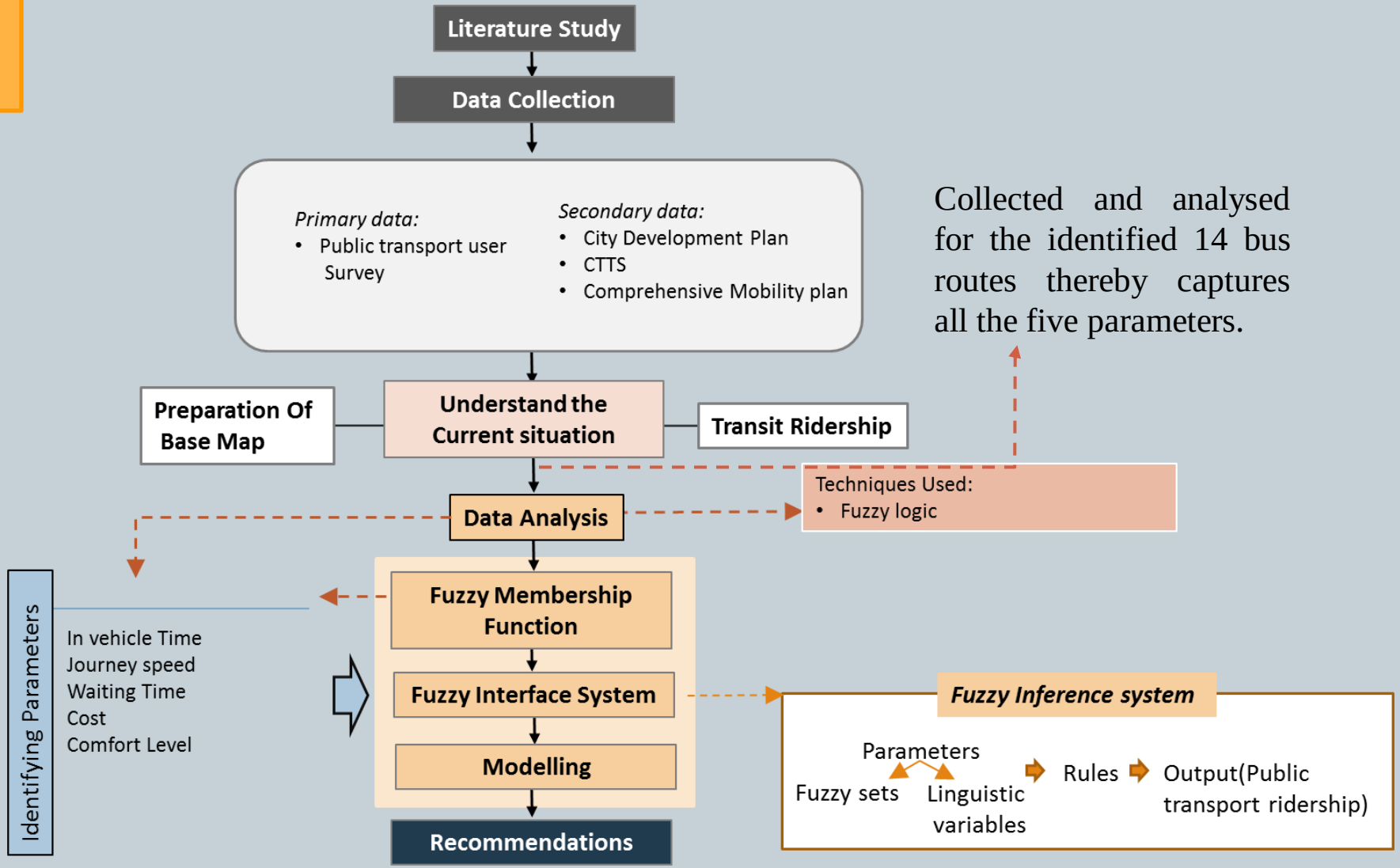
Components of fuzzy inference system



Source: *Pradeep Sarkar,2013*

- Input variables are given in the form of crisp values which gone through a process of fuzzufication, where every input variables are analysed and ranges are made considering appropriate membership functions.
- Later set of combinations of rules are made and are loaded in the fuzzy inference engine.
- Fuzzy logic mechanism deals with **rules** → captures the psychology of travellers on different variables.
- Generating Rules: experts advice (or) ANFIS (Adaptive Neuro Fuzzy Inference System) method.

METHODOLOGY OF STUDY



Collected and analysed for the identified 14 bus routes thereby captures all the five parameters.

Source: *Author*

DATA SAMPLE

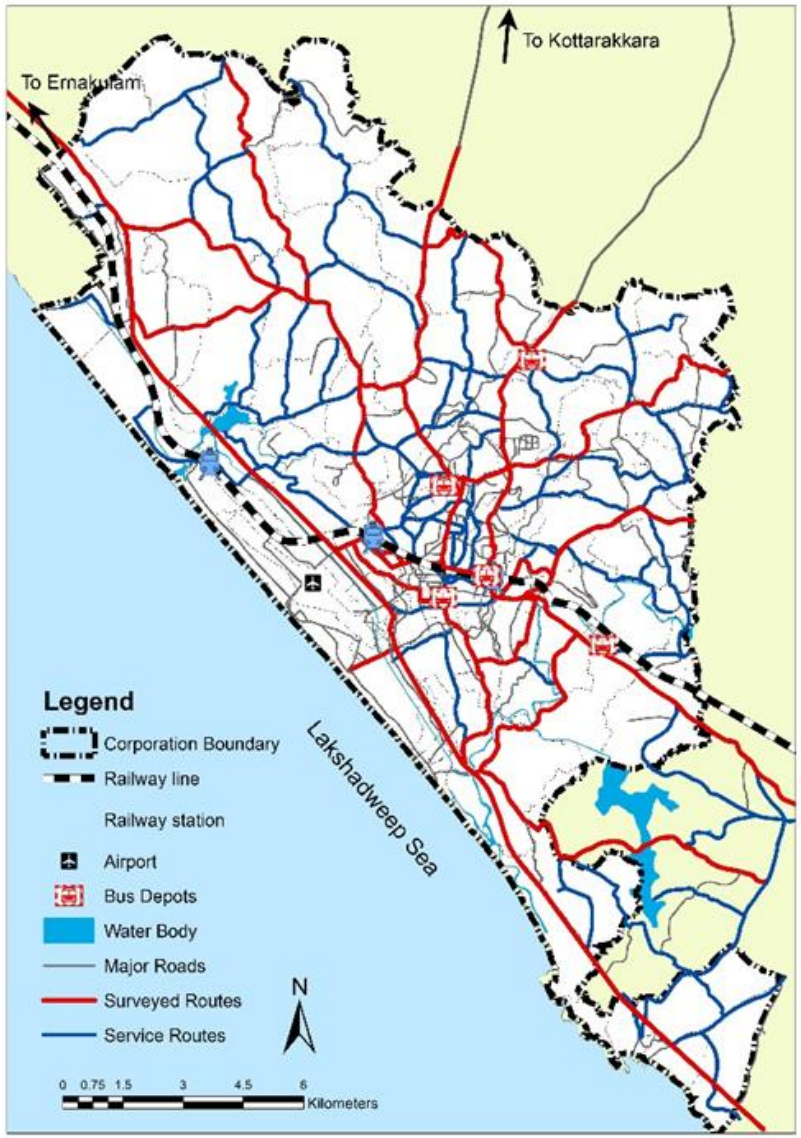
- Total of 14 routes are surveyed in which 450 samples out of 530 samples were useful for the model.
- Mode choice is restricted to two modes namely car and bus.
- The survey data of five attributes on in-vehicle time, discomfort, journey speed, Travel cost and waiting time.
- Discomfort level is taken as dummy variable through stated preference questionnaire.

List of routes selected for the study

NO:	Route Name	Max Passenger Count
Route 1	Ef-Technopark-Attingal	103.00
Route 2	Ef- Karamana--Thrikannapuram	80.00
Route 3	Ef- Moonamode	104.00
Route 4	Ef-Kazhakuttam	92.00
Route 5	Ef-Kovalam	71.00
Route 6	Ef-Peroorkada	62.00
Route 7	Malayam-Ef	82.00
Route 8	Ef- Bheenapalli	100.00
Route 9	Ef-Papanamcode	81.00
Route 10	Ef- Pothencode	74.00
Route 11	Ef- karumam	54.00
Route 12	Ef- Attukal-Maruthoorkadavu	81.00
Route 13	Ef- Peringamala	51.00
Route 14	Ef-Vizhinjam	110.00
	Avg:	83.14

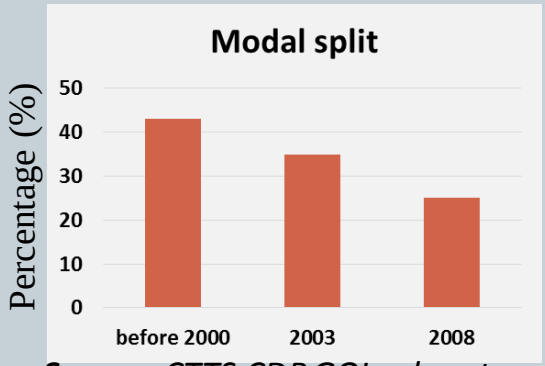
Source: *Primary survey,2015*

STUDY AREA CHARACTERISTICS



Source: *Prepared using GIS tool*

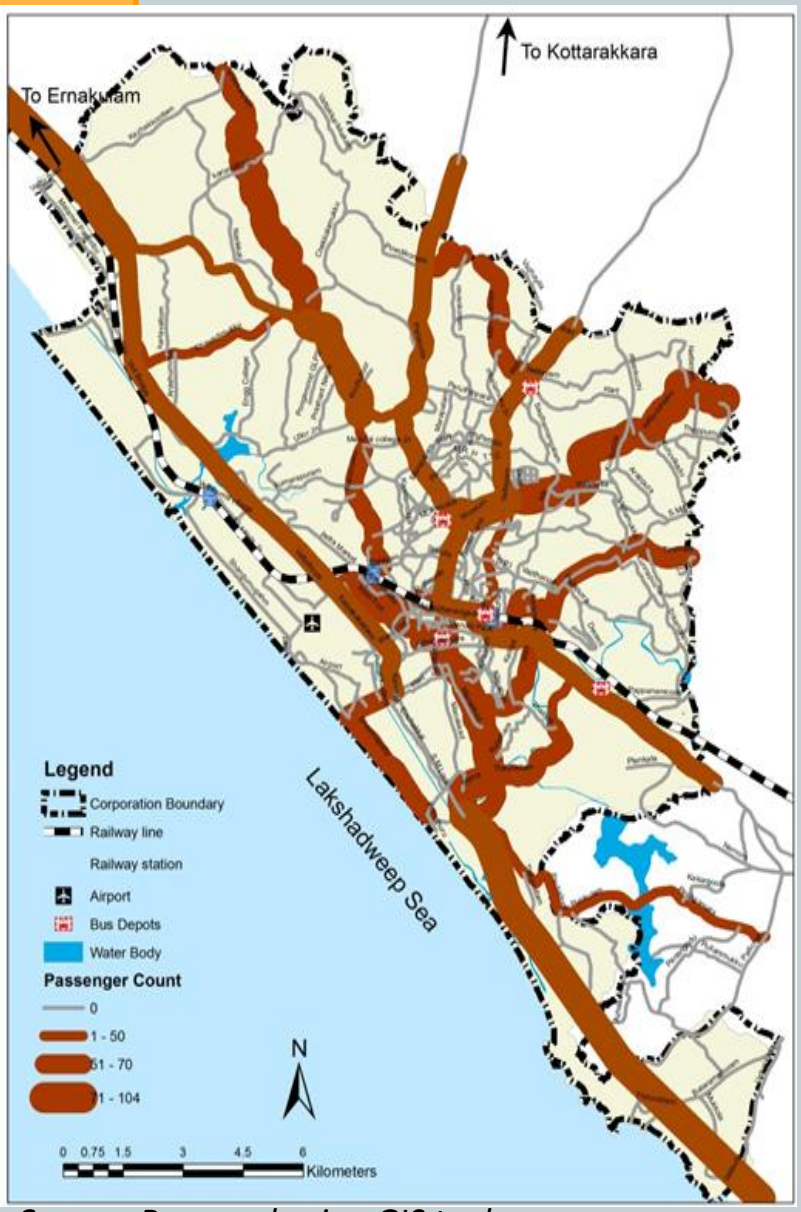
- Population = 7,43,691 persons (Census 2011).
- Area: 141.74 sq.km.
- Total road length = 2586 km.
  - Major Roads length = 390 km (15.08%)
- Road density = 18 km per sq.km.
- A declining trend in modal split.



Source: *CTTS,CDP,GOI urban transport,2008*

- **Need for study to capture the behaviour of different mode users.**

STUDY AREA AND CHARACTERISTICS



Source: *Prepared using GIS tool*

- The passenger count at a particular bus stop is also an important parameter to judge the performance of Public Transport in the city.
- Passenger count was calculated using Boarding and alighting at various bus stops.
- Used for calculating Level of Comfort experienced by the commuters.
- The existing service is not able to cater to the demand.
- The passenger count is more on the routes where **frequency is inadequate → Waiting time is more.**

LOS	Level of Comfort in Public Transport
1	<=1.5
2	1.5-2.0
3	2-2.5
4	>2.5

Source: *Service level benchmarks, MOUD*

Level of Comfort = Passenger Volume / Total Seats

MODELLING

Generate input output data for the base year

Set Initial Membership function for Input-output Layer

Generating rule base for the model

1. **In-vehicle time**
2. **Discomfort level**
3. **Waiting time**
4. **Journey speed**
5. **Travel cost**

- Fuzzy sets are created for each membership functions with appropriate ranges for the respective linguistic variables

Membership function levels of variables

Attributes	Fuzzy sets		
In-vehicle travel time (min per km)	Small, [2,4]	Medium, [3,5]	Large, [4,7]
Discomfort level	Low, [1,2]	Average, [1.5,2.5]	High, [2,3]
Waiting time (min)	Less, [2,8]	Medium [5,11]	More, [8,14]
Journey Speed (kmph)	Low, [9,21]	Medium, [15,27]	High, [21,33]
Travel cost (paise per km)	Cheap, [7,38.6]	Moderate, [22.8,54.4]	High, [38.6,70]

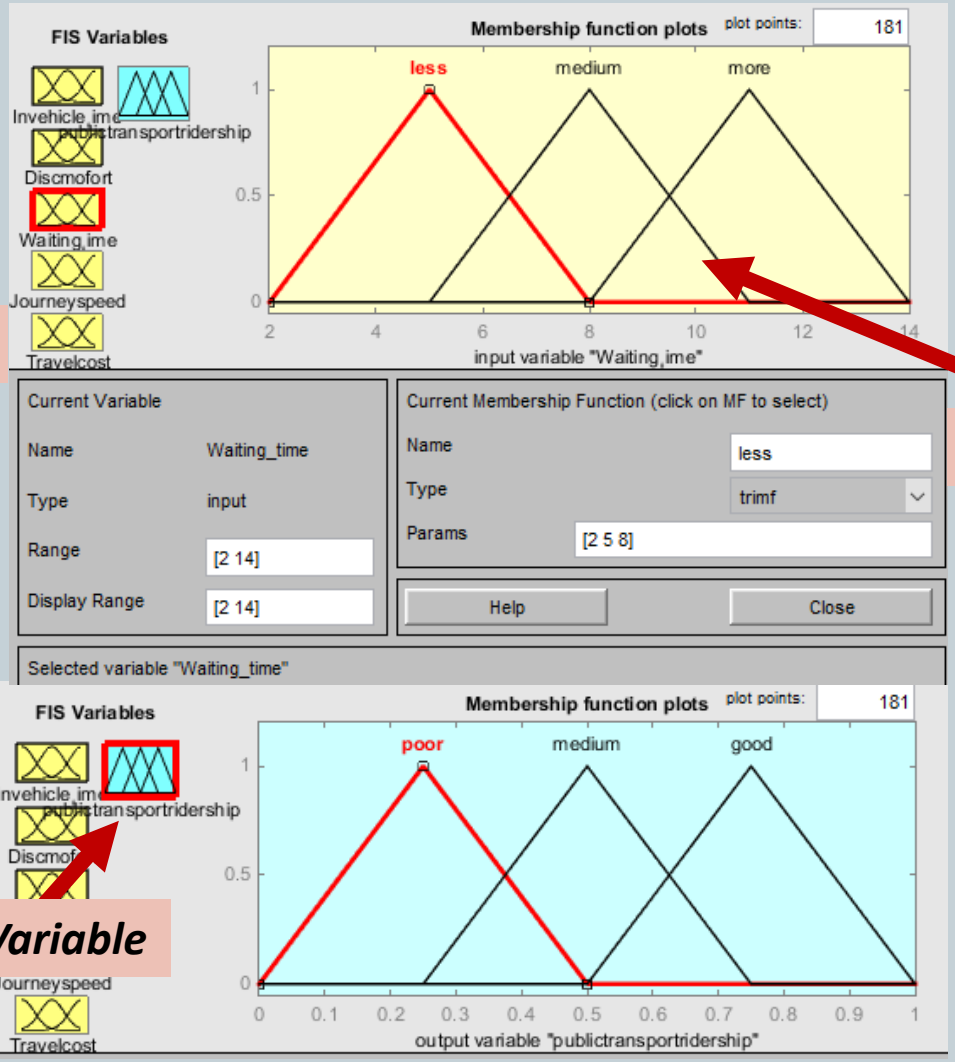
Source: *Author*

- The rules created are purely based on people's perception on each attributes, where perceptions are obtained from bus passenger survey.

IF TRAVEL TIME IS "LOW" and TRAVEL COST is "LOW"
THEN PROBABILITY OF CHOOSING PT is " ? "

IF TRAVEL TIME IS "HIGH" and TRAVEL COST is "LOW"
THEN PROBABILITY OF CHOOSING PT is " ? "

IF TRAVEL TIME IS "HIGH" and TRAVEL COST is "HIGH"
THEN PROBABILITY OF CHOOSING PT is " ? "



Input Variable

Area of Approximation

Output Variable

output membership function have range [0,1] which depicts the probability of choosing public transport.

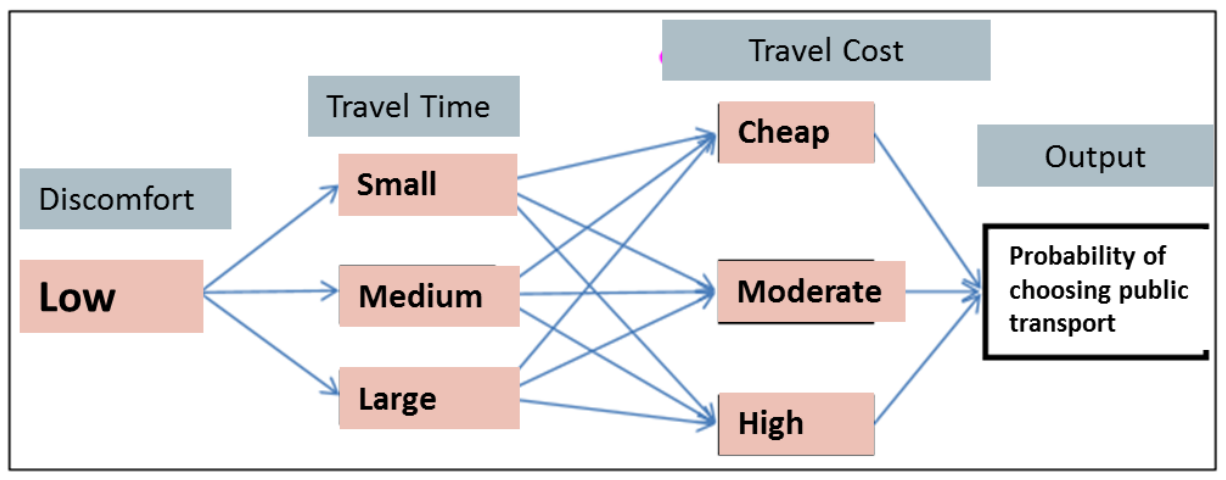
Sample rules:

1. If (invehicle_time is small) and (Discomfort is low) then (public_transport_ridership is good)
2. If (invehicle_time is medium) and (Discomfort is low) then (public_transport_ridership is medium)
3. If (invehicle_time is large) and (Discomfort is high) then (public_transport_ridership is poor)

RULE BASE & VALIDATION

- Total 180 rules are generated in the fuzzy inference system.
- Validation of model using base data.
- Iterations are carried out by changing the membership functions and rules to reduce variations.
- In real world, 3-4 parameters influence the human psychology.

Combination of rules of one linguistic variable



Source: *Author*

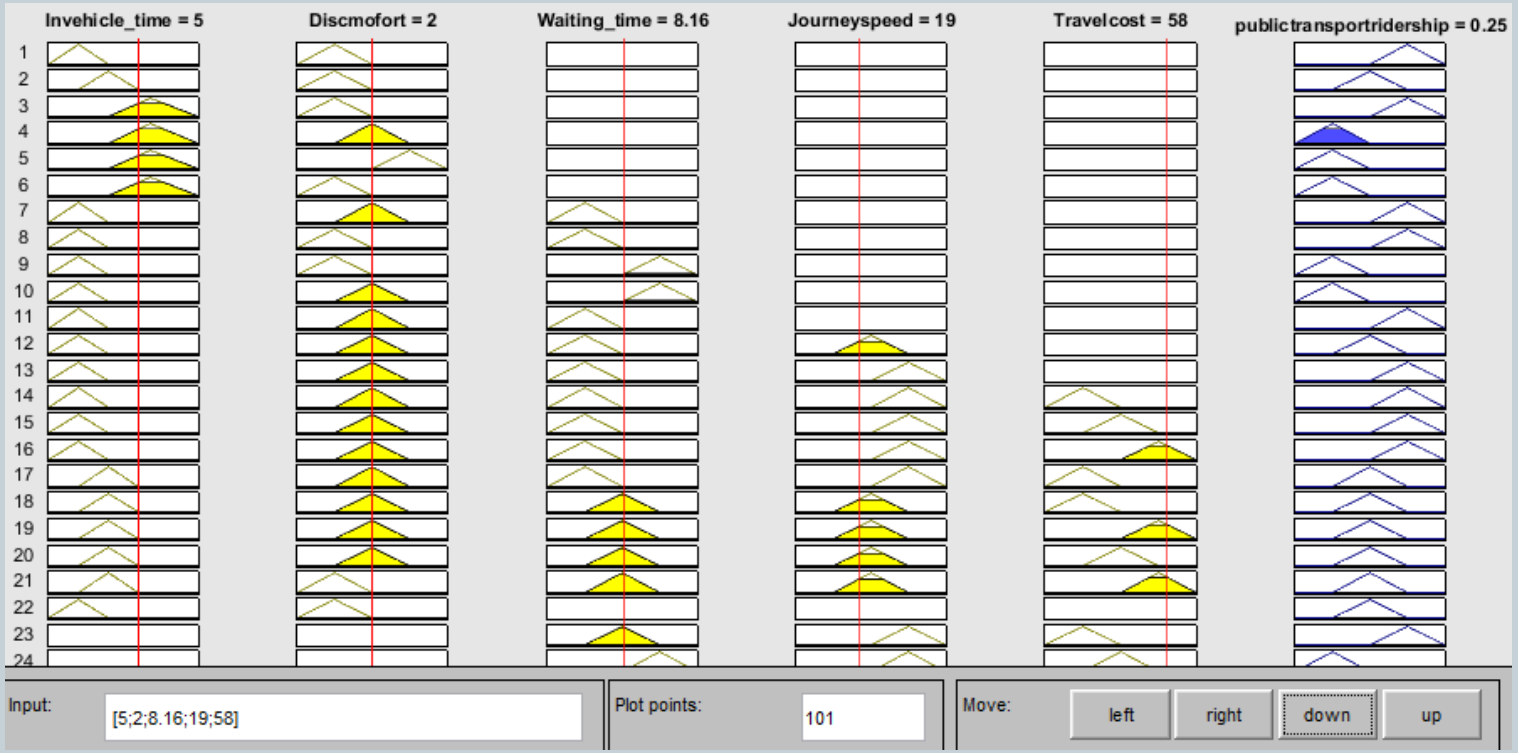
For one variable: 12 x 3 =36

5 variables : 36 x 5 = 180 combinations

RULE BASE & VALIDATION

- Model validation is carried out through iterations.
- Deviation from the base data
- Deviation reduced by changing the membership function and rules accordingly.

Fuzzy logic based human perception model generated in MATLAB 2011



***Source**: Research output generated in MATLAB platform*

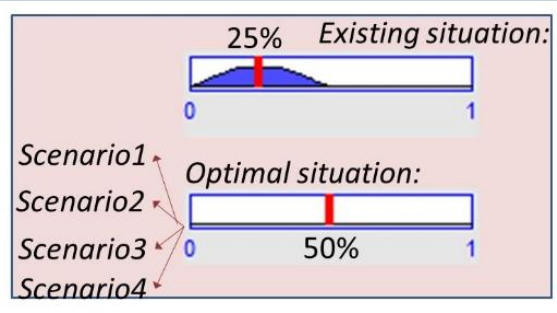
SCENARIO BUILDING

- Changing each attribute values, 4 scenario for optimal condition are obtained using fuzzy logic.
- These scenario are the optimal condition where public transport ridership will be 50%.
- These scenarios may help the decision makers to increase the ridership of public transport in respect to people's perception on mode choice.

Formulation of scenario using human perception model

Scenario	1	2	3	4
Invehicle time (min per km)	5	3	4	3
Discomfort level	3	2	1	1
Waiting time (min)	4	8	12	16
Journey Speed (kmph)	20	18	25	30
Travel cost (Paise per km)	58	20	100	125

Source: *Output from the model*



CONCLUSION

- With the help of fuzzy logic technique, a model has been developed to increase the ridership of public transport with specific reference to generalised cost.
- The usage of public transport increases with the change in the attributes from 25% to 50% with existing human perception captured through the primary survey.
- Worth mentioning factor is that the waiting time and the travel time holds highest priority for the commuters.
- Thus changing values for these attributes is largely reflecting the increase in ridership.
- Fuzzy logic based human perception model may help the transport authorities to focus special attention to improve up on the required area.
- Prioritization of best scenario can be done by applying it on ground.

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