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# APPLICATION OF FUZZY INFERENCE SYSTEM TO EXPLORE THE BUS LEVEL OF SERVICE OF GAZIPUR CITY

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## ABSTRACT

*Measuring performance of diverse transport facilities is essential to identify gaps and problems in service level and solve those deficiencies by improving quality in a systematic way. Assessment of service quality (SQ) based on user preferences has become a primary concern for the transportation specialists. Most of the people in the developing countries like Bangladesh prefer bus as their main transport mode. The objective of this research is to find out bus level of service of Gazipur territory using fuzzy inference system. For the purpose of the study, 400 data based on users' perspective were collected from the different bus stops of Gazipur. Total 22 qualitative and quantitative attributes were selected according to transport expertise' opinion for the survey. According to the analysis, punctuality and reliability found to be the most significant attributes, which support the user-stated preferences. But presently service quality was not at the satisfactory level, 64% passenger thought the service quality was poor to attract new users toward bus as a mode of transport. However, only 3% were highly satisfied with current service quality, 27% thought service was good. So, better bus service could plummet not only the traffic congestion but also increase the standard of city living to enticing mass users toward it.*

**Key Words:** *Fuzzy inference system, Service quality, Attribute, Transport*

## 1. INTRODUCTION

Cities play an indispensable role in promoting economic progress and prosperity of a country. The well-developed transportation system of a city is not only crucial for the mobility of resources but also for healthy living. As Bangladesh is a developing country has the vision to be reached in the standard of a developed country in upcoming years, so well planned public transportation system is inevitable(Hossain, 2006).Dhaka is one of the biggest megacity facing the problem of unbearable traffic congestion, unnecessarily burning of fuel, traffic-related pollutions, and safety, which are responsible for the huge amount of economic loss about US550 millions in each year(Hoque, 2004). Weak infrastructure (only 6% paved road), inappropriate transportation system, rapid growth of migrated population in Dhaka as business, political and cultural hub of Bangladesh, are responsible for worsening the roadway ambience, decreasing vehicular flow and deteriorating the overall performance of traffic system. Meanwhile, In Tokyo has 16% road of the total area of the city and 25% of total area in the majority of other developed cities (Habib, 2005). Indisputably, the excess presence of small vehicles (73.33% small private car and motorcycle), while only 1.65% registered public vehicles (bus, minibus) are present in Dhaka city(Khan, 2013). According to Economist Intelligence Unit (EIU 2016), Dhaka becomes the 4th worst city in the world because of poor infrastructure and violence. Public transport service quality assessment is not only vital for the improvement of user satisfaction, it also gives an overview to transport policymakers to ameliorate their perception about to develop future transportation

system(Pandit, 2013).Level-of-Service is a common measure to define good, poor and acceptable service levels for various service attributes of public transport based on user discernment(Pandit, 2013). An amendment of public bus service quality can reduce traffic congestion, air and noise pollution and energy consumption as users would prefer public services than individual transports(Cuomo, 2000). Adaptive neuro-fuzzy inference system proceeds the advantages of both ANN and fuzzy inference system in one. After generated input-output by training, the ANFIS can be used to recognize data that is similar to any of the examples shown during the training phase(Abdulkadir, 2006).

Gazipur is a newly growing industrial city of Bangladesh, the planned public transportation system is very crucial for healthy city living. Existing public transport service quality valuation of a newly growing city helps transport specialists to make the better decision on future transportation system to increase the quality of service, mobility, reduce pollution and provide vigorous city life to its residents. Otherwise, Gazipur will face numerous problems in upcoming days that Dhaka faces today due to the lacking of proper transportation planning. The objective of this research is to find out the bus level of service of Gazipur territory using fuzzy inference system and to recommends possible outlines to improve service quality.

## 2. METHODOLOGY

### 2.1 Data Collection and Study Area

Gazipur is a newly growing industrial city, has been selected as study area. According to transport experts, 22 attributes were selected to carry out the research. The target sample was 600 according to the demography and standard sample size practice. However, random data samples were restricted to 480 due to the unwillingness of the commuters, rush hour office/home movement, and other impending situations. After filtering the anomalies, the remaining final sample size was 400.The survey format was designed to explore the service quality of public transport system of Gazipur city. The sample is randomly divided into two sub-samples: a training sample consisting of 80% (320) of whole sample set and a forecasting sample which includes 20% (80) of the sample set and the model was developed and tested using ANFIS GUI of MATLAB 14.

### 2.2 Method

ANFIS tool has been used to determine the bus level of service of the study area as the technique has widely been applied in different fields like data classification, automatic control, expert system, decision making, robotics, time series analysis, pattern classification, system identification, and so on. The fuzzy inference system (FIS) is based on the concepts of fuzzy set theory. The first step in ANFIS modeling is the identification of the input and output variables. In Sugeno fuzzy inference system, two typical IF/THEN fuzzy rules can be stated when a set of two inputs (x, y) and one output (f) is measured:

Rule 1: IF x is A1and y is B1, THEN f1=p1x+q1y+r1

Rule 2: IF x is A2and y is B2, THEN f2=p2x+q2y+r2

Where, p1, p2, q1, q2, r1, and r2 are linear parameters; A1, A2, B1 and B2 are nonlinear parameters.

The ANFIS architecture consists of five-layers: fuzzification, fuzzy AND, normalization, defuzzification, and the output layer. These layers are connected to each other through direct links and nodes.The first layer is the fuzzy layer, in which all nodes are adaptive nodes. The membership relationship between the output and input functions of this layer given below.

$$O_i^1 = \mu_{A_i}(x); i = 1,2$$

$$O_j^1 = \mu_{B_j}(y); j = 1,2$$

Here, *x* and *y* are the input of nodes *Ai* and *Bj* respectively. *Ai* and *Bj* are the linguistic labels used in the fuzzy theory for dividing the membership functions.
All the nodes are fixed nodes in the second layer. They perform as a simple multiplier and are labeled with M. The outputs of this layer are firing strengths and the relationship given below.

$O_i^1 = w_i = \mu_{A_i}(x)\mu_{B_j}(y)$ ; *i =1,2*

The nodes are also fixed nodes in the third layer. They are labeled with N, indicating that they perform as a normalizer to the firing strengths from the previous layer. The outputs of this layer are called as normalized firing strengths which can be represented as:

$O_i^3 = \overline{w_i} = \frac{w_i}{\sum w_i}$ ;*i=1, 2*

In the fourth layer, the nodes are adaptive nodes. For a first order Sugeno model, the output of each node in this layer is simply the product of the normalized firing strength and a first order polynomial and the output given below.

$O_i^4 = \overline{w_i} f_i = \overline{w_i}\ (p_i x + q_i y + r_i)$; i=1, 2

In the fifth layer, the only one single fixed node performs the summation of all incoming signals that are labeled with ∑ and the overall output of the model can be expressed as.

$$O_i^5 = \sum_{i=1}^{2} \overline{w_i} f_i = \frac{\sum_{i=1}^{2} w_i f_i}{\sum w_i} \text{ ; i=1, 2}$$

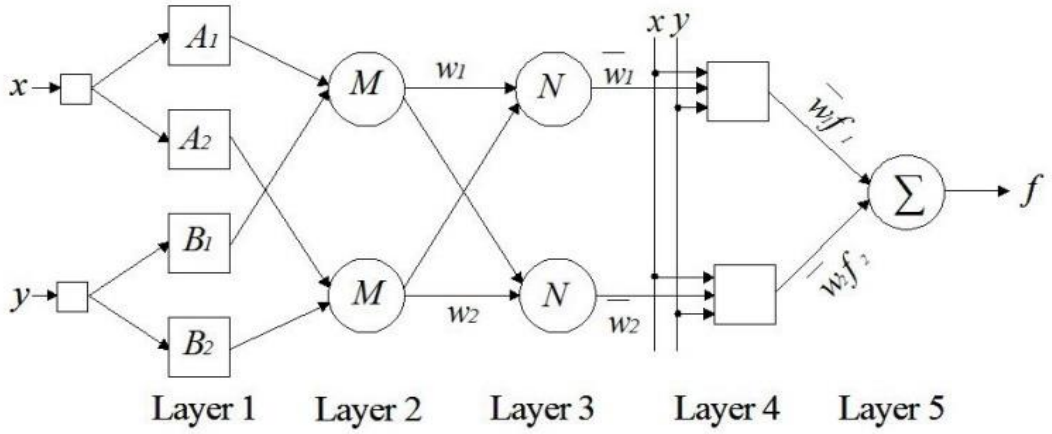


Figure 1: Architecture of Adaptive Neuro-Fuzzy Inference System (ANFIS)

### 2.3 Models Evaluation

To evaluate the performance of the model root-mean-square error (RMSE), correlation co-efficient (R) have been used.
Correlation co-efficient(R) is defined as:

$$R = \frac{\sum_{i=1}^{N}(O_i - O_{avg})(P_i - P_{avg})}{\sqrt{\sum_{i=1}^{N}(O_i - O_{avg})^2}\sqrt{\sum_{i=1}^{N}(P_i - P_{avg})^2}}$$

Where,
$O_{avg}$=mean of target classes; $O_i$ = $i^{th}$target class; $P_{avg}$= mean of predicted classes; and $P_i$ = $i^{th}$predicted class.
Root-mean-square error is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(O_i - P_i)^2}{N}}$$

Where,
*N* = total number of observations
Here, the lesser the value of 'R' and greater the value of 'RMSE', the corresponding attribute is more significant and vice versa.
Service quality (Sq),

$$s_q = \frac{X}{5}$$

Where,
*X*= Average weightage of scaling value 1-5 for each attribute.In where multiply by 5 with rank 1, 4 with rank 2, 3 with rank 3, 2 with rank 4 and 1 with rank 5.
According to public opinion, when the value of service quality (Sq) of an attribute is higher than others, then the attribute represents higher significant than other attributes.

## 3. ANALYSIS AND FINDINGS

### 3.1 Monthly Income

Total 400 bus users participated in the survey, among them 77% were male and 23 % female in Gazipur city. Nearly 30% bus user had monthly income 10-20k taka and normally generated at least 2 trips daily. About 19.5% passenger had monthly income 10k or less, 21.5% had 20-30k and 17.25% had 30-40k respectively. However, only 11.75% had monthly income more than 40K. Overall scenario clear the perception that most of the bus users were middle-class.

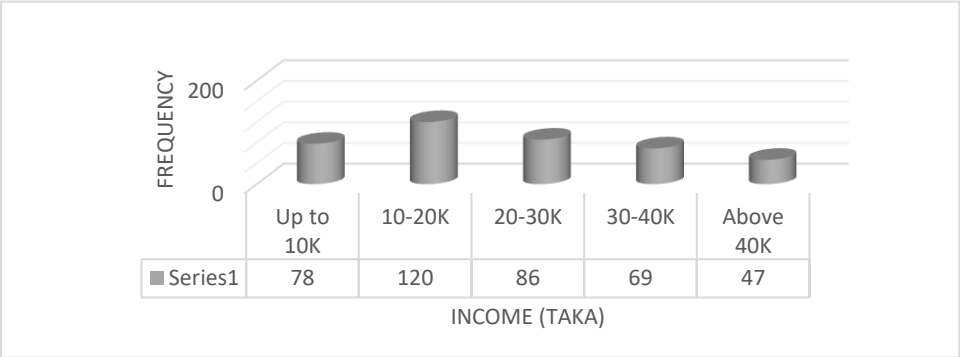


Figure 2: Income of Passenger

### 3.2 Age of Passenger

After analyzing, nearly 68% passengers were between 20 to 50 years old and most of them were involved in different professions, although few of them were student at the graduate level.

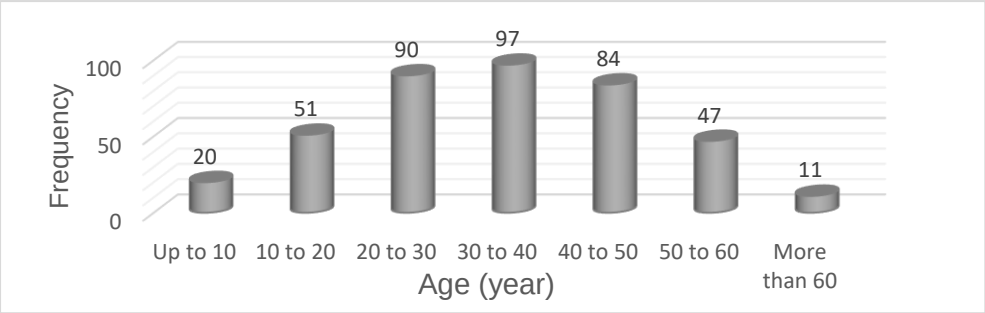


Figure 3: Age of Passenger

Bus users above 50 years old about 14%, were former professionals and few of them still continuing the jobs. Passenger below 20 years approximately 17%, most of them was student at various level and new professionals. But below 10 years, few of them involved with laborious works.

### 3.3 Attributes Ranking

Table 1 show that Punctuality and Reliability secure the rank 1 in both ranking method over 22 attributes due to the least R value and the largest RMSE according to ANFIS model. Passengers don't want to kill their valuable time on roads because of traffic congestion. On the other hand, Route information has largest R and lowest RMSE value, so rank 22 according to ANFIS model. On-time performance, Seat availability, On-board security, Structural condition bustook in top five places respectively. Bus users thought bus service providers would follow strict timetable to operate their service.

Table 1: Attributes Status Assessment

| | | ANFIS | | | Public opinion | |
|---|---|---|---|---|---|---|
| **Sl. no** | **Attributes** | **R** | **RMSE** | **Rank** | **Service Quality(Sq)** | **Rank** |
| 1 | Proximity from home | 0.52692 | 0.57287 | 15 | 0.3612 | 19 |
| 2 | Proximity from workplace | 0.54052 | 0.55614 | 16 | 0.3204 | 22 |
| 3 | Commuting frequency | 0.47286 | 0.63752 | 11 | 0.4428 | 14 |
| 4 | Service frequency | 0.59759 | 0.42874 | 10 | 0.3508 | 8 |
| 5 | Commuting period (weekdays) | 0.38181 | 0.7691 | 12 | 0.5092 | 9 |
| 6 | Commuting period (weekends) | 0.23647 | 0.94953 | 9 | 0.5563 | 18 |
| 7 | Ticketing system | 0.49695 | 0.60834 | 13 | 0.4948 | 11 |
| 8 | Fare expenditure (daily) | 0.58301 | 0.48127 | 19 | 0.5100 | 20 |
| 9 | Punctuality and reliability | 0.20411 | 0.99111 | 1 | 0.5712 | 1 |
| 10 | Seat availability | 0.48898 | 0.62079 | 3 | 0.4108 | 2 |
| 11 | Seat comfort | 0.43883 | 0.7132 | 8 | 0.5012 | 10 |
| 12 | Accessibility to/from bus | 0.24422 | 0.91816 | 17 | 0.5124 | 12 |
| 13 | Ventilation system | 0.26622 | 0.90859 | 6 | 0.5536 | 5 |
| 14 | On-board security | 0.23952 | 0.93708 | 4 | 0.5561 | 3 |
| 15 | Female harassment | 0.55862 | 0.53717 | 18 | 0.3356 | 21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | On-time performance | 0.22850 | 0.98314 | 2 | 0.5556 | 4 |
| 17 | Bus staff courtesy | 0.36821 | 0.78351 | 21 | 0.4788 | 17 |
| 18 | Structural condition | 0.54502 | 0.55158 | 5 | 0.4940 | 7 |
| 19 | Interior cleanliness | 0.36160 | 0.88269 | 7 | 0.5172 | 6 |
| 20 | Noise level | 0.50492 | 0.59877 | 14 | 0.4676 | 15 |
| 21 | Commuting experience | 0.58962 | 0.46235 | 20 | 0.4876 | 13 |
| 22 | Route information | 0.69297 | 0.35306 | 22 | 0.4624 | 16 |

According to public opinion, Seat availability, On-board security, On-time performance, Ventilation system secured top five positions respectively. However, Proximity from workplace marked as lowest according to passenger discerning. Now people prefer private cars over public transports because of poor bus services. Consequently, traffic tail log is a common scenario in Gazipur and its surrounding areas. Better public transport could plummet not only the traffic congestion but also increase the standard of city living to enticing mass users toward it. The outcome of this study will convey some valuable suggestions to the service providers, operators, policymakers and transportation authorities about how to amend the bus SQ in view of attracting more passengers. However, due to inadequacies in resources of developing countries like Bangladesh, it is merely impossible to improve all the SQ attributes at once. This study delivers a platform for staged improvement with the most significant attributes to start with.

### 3.4 Bus Service Quality

Figure 4 shows overall service quality was not at satisfactory level. Based on passengers' thinking, only 3% were highly satisfied with current service quality, 27% thought service was good. But 64% passenger thought the service quality was poor to attract new users toward bus as a mode of transport. Also, 6% users claimed the service quality was very poor to use, they preferred another option for moving one place to another.


Figure 4: Bus Service Quality

## 4. CONCLUSIONS

This study focused on predicting the bus level of service of a newly growing city using fuzzy inference system to helps transport specialists to make the better decision on future transportation system to increase the quality of service, mobility, reduce pollution and provide vigorous city life. Punctuality and reliability found to be the most significant attributes in Gazipur city based on users' perception. However, present service quality was not at the satisfactory level, 64% passenger thought the service quality was poor to attract new users toward bus as a mode of transport. But 27% user accepts the present service quality because of their income level. Alarming thing is that a large number of people prefer private cars and other small vehicles over bus because of poor service quality. So better service of

public transport could fascinate mass users toward it over others mode of transport to reduce congestion and improve mobility.

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