Malaysian
Journal Of Civil
Engineering

Full Paper

IDENTIFYING KEY FACTORS OF COMMUTER TRAIN SERVICE QUALITY:AN EMPIRICAL ANALYSIS FOR DHAKA CITY

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Article history
Received
25 March 2019
Received in revised form
05 June 2019
Accepted
06 June 2019
Published online
31 July 2019

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Abstract

Commuter train is a viable alternative to road transport to ease the traffic congestion which requires appropriate planning by concerned authorities. The research is aimed to assess passengers' perception about commuter train service running in areas near Dhaka city. An Adaptive Neuro Fuzzy Inference System (ANFIS) model has been developed to evaluate service quality (SQ) of commuter train. Field survey data has been conducted among 802 respondents who were the regular user of commuter train and 12 attributes have been selected for model development. ANFIS was developed by the training and then tested by 80% and 20% of the total sample respectively. After that, model performance has been evaluated by (i) Confusion Matrix (ii) Root Mean Square Error (RMSE) and attributes are ranked based on their relative importance. The proposed ANFIS model has 61.50% accuracy in training and 47.80% accuracy in testing. From the results, it is found that 'Bogie condition', 'Cleanliness', 'Female harassment', 'Behavior of staff' and 'Toilet facility' are the most significant attributes. This indicates that some necessary measures should be taken immediately to recover the effects of these attributes to improve the SQ of commuter train.

Keywords: Commuter train, ANFIS, Service Quality, Passenger perception, Questionnaire survey

1.0 INTRODUCTION

While there is a debate over whether local or sitting public bus service, which is more beneficial to commuters in Dhaka city, a passenger can take commuter train every day to travel from his home to office for work and return to home—in avoiding hours of traffic congestion which is an inevitable part of bus journey. Commuter train provides scheduled service on fixed short distance routes (i.e. local and regional travel between central business district and adjacent suburbs) to passengers along the conventional railway tracks. Travelling public bus takes more time and higher fare price comparing to commuter train—especially, during morning peak and evening rush hours. The condition of public bus in Dhaka is exaggerated depending on road traffic, sometimes it is difficult to manage seat during rush hours and need to hang onto door for long hour even in hot weather. Commuter train is a better choice for regular commuter—workers, professionals and students— who used to commute from outside of the city to central business district (CBD) of Dhaka daily for work, as it is cost saving and less likely to accident prone than public bus. Commuter train service is regarded as the cheapest and most effective means of transportation in areas near to Dhaka and it has become popular among the low and middle-income classes day by day. Perhaps, concerned authorities have not been able to keep up with the growing demand and maintain adequate service quality (SQ) for commuters of all social groups.

According to Bangladesh railway (BR), there are four trips of DEMU train (Diesel Electric Multiple Unit) provided by Bangladesh railway (BR) for regular commuters of Kamalapur-Joydebpur route along with privately owned Turag Express. Passengers from Joydebpur, Dhirsom, tongi, Airport, Cantonment, Banani and Tejgaon can avail these commuter trains. On the other hand, fifty up-down trips run daily through Dhaka-Rajshahi and Dhaka-Mymensingh railway route via Joydebpur junction, where standing tickets are sold for commuters. In addition, for the passengers of Gandaria, Pagla, Fatullah, Chashara and Narayanganj—there are six DEMU trains along with thirty-two up-down commuter trips, from Kamalapur to Narayanganj every day. Approximately 40,000 passengers are carried to and from Dhaka by commuter rail services on daily basis. If theses passengers used the bus service, the city would need at least 800 additional buses, which would exaggerate traffic jam in roads of Dhaka city. Dhaka-Narayanganj commuter rail service is the most popular amongst all these services with approximately 12,000 daily passengers (Wang et al., 2014a). In this context, commuter train service is a viable alternative to road transport, such as, public bus and attract more commuters and it requires more attention for further development.

As mentioned earlier, commuter trains reduce the pressure on roadway and hence lessen congestion in the traffic. Thus, the service quality (SQ) is the main concerning issue in this regard and ensuring desire SQ for the commuter of all groups is the major challenge for this sector. Identifying influences of the attributes affecting SQ of commuter train service through Adaptive Neuro Fuzzy Interface System (ANFIS), is the main objective of this research. ANFIS was introduced by Jang (1993), is a hybrid of fuzzy if-then rules with appropriate membership functions implemented in the framework of feedforward neural network with supervised learning capability. This adaptive artificial neural network (ANN) based on Takagi-Sugeno fuzzy interface system is widely adopted as approximating large-scale nonlinear functions, estimating parameters and optimizing errors. Service Quality (SQ) of several public transport modes have been studied utilizing ANFIS, for example, Islam et al. (2016) assessed SQ of public bus, Ahmed et al. (2017) evaluated SQ of paratransit and Ghius (2017) investigated SQ of public train. Researchers performed ANFIS to estimate weightage and rank attributes of SQ models. Usually, large numbers of datasets were collected through stated preference (SP) questionnaire survey (QS) from field. Later, dataset was trained for modelling and tested correspondingly to validate it.

2.0 LITERATURE REVIEW

Since commuter train is an effective alternative mass transportation mode for short distance trips and ease traffic congestion, several researchers have been devoted on various aspects to improve the SQ of commuter rail service and hence enhance ridership. Nelson and O'Neil (2000) assessed reliability of travel time of commuter train and identified the causes of delay and on-time performance. They evaluated track maintenance schedule, weather, engineering and mechanical malfunction of equipment, transportation of crew and passenger related issues. Chakour and Eluru (2014) studied commuter train users' behavior considering Level of service (LOS) parameters, socio-demographic factors, trip characteristics, land-use, station characteristics and built environment factors. They found that travel time has negative impact and presence of parking, increasing train frequency has positive effect on station choice. St-Louis et al. (2014) conducted travel survey to compare commuter satisfaction of different modes along with commuter train service. Their extensive research developed ordinary least square regression models of trip satisfaction for each mode including travel characteristics, personal characteristics, mode preferences etc. as independent variables. Wang et al. (2014b) evaluated economic feasibility of various improvement polices for commuter train service in Dhaka city. They used net present value and cost benefit ratio to identify long-term and short-term policies, which can make commuter train ridership more attractive. Chan and Farber (2019) explored that population density, proportion of residential land, low auto ownership and median income were positively related with the access to commuter rail stations. They utilized binomial logit model to investigate influence of land-use and socio-economic variables on commuter train service in the context of Toronto and Hamilton area, Canada. Ibrahim et al. (2019) studied service quality (SQ) of commuter train service in Kuala Lumpur, Malaysia and suggested that ticket price, timely arrival and departure of train, train counter are the most important service items, which should be improved urgently. They performed gap analysis between passenger's expectation and perception scores and important preference analysis to identify most preferred service items. Halse et al. (2019) studied commuter train service in Norway and found that improving travel time reliability by reducing delay had little effect on demand and did not alone lead to massive increase in ridership.

Various techniques have been adopted to model relationship among attributes and SQ of public transport. Basu and Hunt (2012) modelled passengers' attractiveness to suburban train service using multinomial logit (MNL) and mixed logit (ML). They incorporated influence of headway time, ride time, crowd level and estimated willingness-to-pay values. However, MNL and ML are inapplicable for continuous data, those cannot incorporate multiple observations of the same individuals in the model and have a tendency of over-fitting. Nugraha (2019) used binary logit model to identify the potentiality of new commuter train service over private car in Malaysia. He found that comfort, safety and fare are the key attributes of choosing commuter train service. Rahman et al. (2019) developed grouped order logit model to assess impact of new commuter train service over the existing public bus in Orlando, Florida. The model included land use, demographic and socio-economic variables along with transit infrastructure, stop level attributes and built environment as factors. Chou et al. (2014) formulated Structural equation model (SEM) to explore unobserved latent variables and investigated SQ factors affecting customers' satisfaction of high-speed train service in Taiwan. Shortcoming of SEM are—it requires multivariate normality, needs to specify a full model and all relationships in prior for testing. Moreover, SEM only uses first order relationship between variables and need time consuming power transformation in case of quadratic variables. De Oña et al. (2014) focused on decision tree classification technique to estimate factors affecting SQ of railway in Italy. They found that courtesy and competence in station, workability of windows and doors, regularity of train frequency are more important attributes. The drawbacks of decision tree classification are overfitting in case of noise data, unstable with small variance and have low bias, which makes it difficult to fit new data into the model. Aydin et al. (2015) adopted combined fuzzy hierarchy method to evaluate customer satisfaction levels of rail transit. The limitations of the method are—it takes much more computation time when number of levels in hierarchy increase and consider only triangular fuzzy number. Cui et al. (2016) estimated delays to evaluate the SQ of commuter train. They used reinforcement learning to calibrate delays to ensure consistency between simulated and actual train operations. Farajpour et al. (2017) combined KANO customer satisfaction model with SERVQUAL model to explore factors affecting SQ of commuter train in Iran. They identified travel pass, presence of modern equipment inside the train, staff's willingness to help passenger and on-time train service are important factors. Heyns and Luke (2018) adapted SERVQUAL model to identify the gap between passengers' perception and their expectations regarding commuter train service in South Africa.

ANFIS is widely used to solve various transportation engineering problems. For instance, Park (2002) estimated freeway traffic volume, Prˇibyl and Goulias (2003) studied travel behavior, Andrade et al. (2006) developed choice model, Musci et al. (2011) estimated queue length at signalized intersection and Hadiuzzaman et al. (2018) calibrated speed-density model using ANFIS. Since ANFIS combines the ANN and fuzzy-set theory, it provides the advantages and overcome the disadvantages of both techniques. Training of ANFIS utilizes fuzzy logic model and have the ability of ANN to classify and identify patterns. ANFIS has less memorization errors and more transparent to user than ANN along with quick learning capacity, capture nonlinearity easily and better adaptation capability. Prior studies found that ANFIS models are suitable for SQ evaluation of various modes of public transport. In this research, ANFIS model was deployed to explore the relationship among passengers' attributes and SQ of commuter train. The SP survey datasets obtained from passengers were trained and tested under ANN framework to validate the fitness of the Fuzzy interface system. After that, the parameters were estimated for the attributes of the service quality (SQ) of commuter train. ANFIS can model relationship among observed variables, hidden layers and output variables effectively in this regard.

3.0 ARCHITECTURE OF ANFIS FRAMEWORK

ANFIS combines neural network learning algorithm to Fuzzy-Logic Inference System (FIS). The ANFIS tool in MATLAB 12 is used in this research to predict commuter train's SQ. The Sugeno-type model (compact and computationally efficient) in FIS is utilized to capture the non-linear relationship between commuter train SQ and its attributes. The weights for a specific set of input and output variables are optimized by the objective function of ANN training. After that, the output variables are calculated by the network and compared with the corresponding training data. The randomly set parameters are adjusted iteratively in order to reduce the errors of the output variables. The error optimization ends when it reaches as expected value. A combination of least-squares and back propagation gradient descent method are adopted in ANFIS structure to calibrate the parameters.

The numbers of rules adopted in an ANFIS model depend on the number of membership functions (MF) and input variables. Rule outputs have different strengths. Subsequently, the rule outputs are combined to provide a single output. The questionnaire survey data are provided to perform the calculations required by the ANFIS. ANFIS modifies the input and output MF parameters with the objective of minimizing the error during the learning process. The error is the sum of the squared differences between the observed and modeled values. The structure of ANFIS comprises of five-layers as shown in Figure 1(a). Each of these layers is connected by links and nodes. Nodes are process units which consist of adaptive and fixed parameters. Adaptive parameters can be altered and the membership functions are reformed by setting learning rules.

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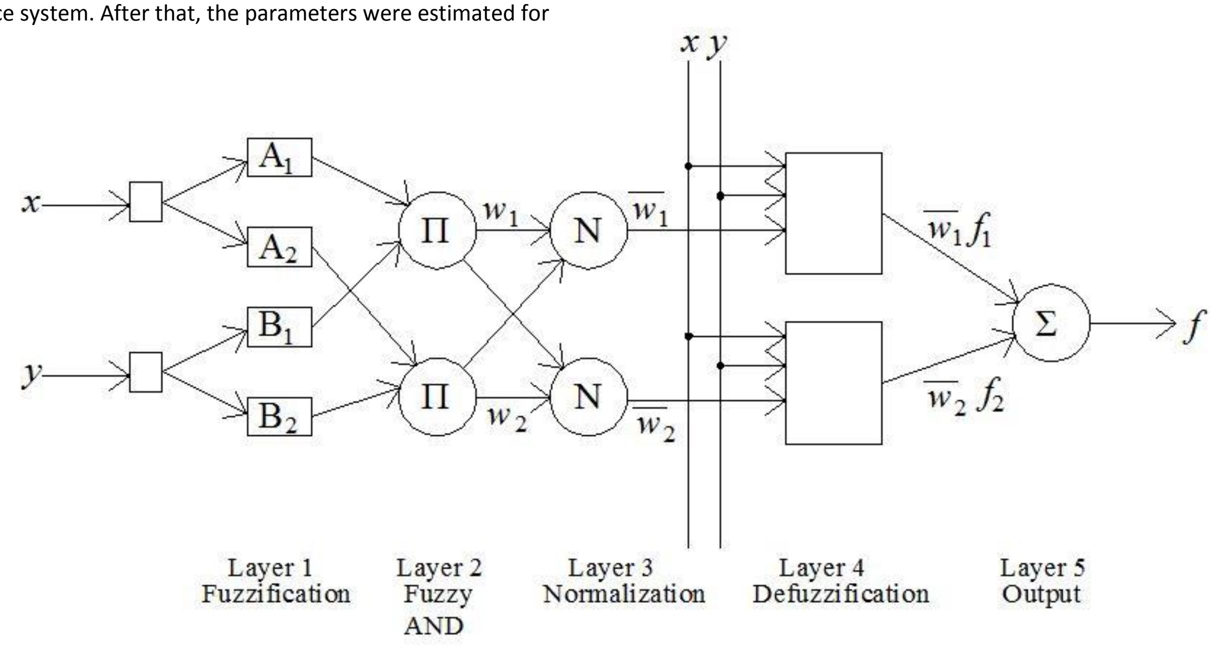

Figure 1 ANFIS structures: two input variables used for mathematical illustration

In Figure 1(a), two input variables (x, y) and one output (f) are considered for simplified mathematical illustration of ANFIS. Equation (1) to equation (4) are written for first-order Sugeno fuzzy model and typical if-then fuzzy rules. In these equations, a and b are the coefficients of input variables and c is the constant term. These parameters are referred as consequent parameters and are optimized through the least square method. The details of SQ attributes are described in the next 'Study case' section.

Assume, there are two rules in the ANFIS framework, which are as follows:

Rule 1: If *x* is A_1 and *y* is B_1, then $f_1 = a_1 x + b_1 y + c_1$ (1)

Rule 2: If *x* is A_1, and *y* is B_1, then $f_2 = a_2 x + b_2 y + c_2$ (2)

Layer 1: All nodes in first layer are adaptive and it is input layer. This layer is known as fuzzification. It assigns input crisp variables to fuzzy sets i.e. transformed into linguistic variables and establishes mapping of crisp input to fuzzy set (Jang, 1993). The relationships between the output and input membership functions (MF) of this layer are:

$$O_i^1 = \mu_{A_i}(x); i = 1, 2 \tag{3}$$

$$O_j^1 = \mu_{B_j}(y); j = 1, 2 \tag{4}$$

Here, x and y are the input of nodes Ai and Bj respectively. Ai and Bj are the linguistic labels. μ_(A_i) and μ_(B_j) can take any membership function. The Gaussian shaped membership function is considered for μ_(A_i) as per Equation (5),

$$\mu_{A_i}(x) = exp\left[-\left(\frac{x-u_i}{v_i}\right)^2\right], i = 1, 2 \tag{5}$$

Where, u_i and v_i are the parameters of the membership function. The parameters are known as premise parameters. Similar, Gaussian membership function is considered for μ_(B_j) as well.

Layer 2: The second layer is fuzzy AND layer and is labeled as Π. The layer is input membership function (MF). All nodes are fixed in this layer and perform as simple multiplier. T-norm operators which perform generalized AND are used as node function of this layer. The outputs of this layer have firing strengths represented by:

$$O_i^2 = w_i = \mu_{A_i}(x) \times \mu_{B_j}(y); \quad i \text{ and } j = 1, 2 \tag{6}$$

Layer 3: The third one is normalization layer and is labeled as N. This layer works as a normalizer to the firing strengths received from the previous layer. Weighted average method is used for normalizing the sub-normal membership function. The outputs of this layer are normalized firing strengths and given as:

$$O_i^3 = \overline{w}_i = \frac{w_i}{\sum w_i}; i = 1, 2 \tag{7}$$

Layer 4: All nodes are adaptive in the fourth layer, which is known as defuzzification layer. The layer is output MF. It maps a fuzzy set to a crisp set. This layer converts fuzzy sets and corresponding MF to produce a quantifiable result in crisp value. The output of each node in this layer is the product of the normalized firing strength and a first order polynomial. The outputs of the layer are expressed by:

$$O_i^4 = \overline{w}_i f_m = \overline{w}_i(a_i x + b_i y + c_i); i = 1, 2 \tag{8}$$

Layer 5: The fifth layer is output layer. Only one single fixed node performs the summation of all incoming signals in this layer and it is labeled as Σ. Therefore, the overall output of the model in the fifth layer represented as:

$$O_i^5 = \sum_{i=1}^{2} \overline{w}_i f_i = \frac{\sum_{i=1}^{2} w_i f_i}{\sum_{i=1}^{2} w_i}; i = 1,2 \tag{9}$$

4.0 STUDY CASE

4.1 Survey

The stated preference (SP) questionnaire survey was conducted among around 802 users of commuter train of different age, gender, occupation type and different purpose of using commuter train. The questionnaire survey was constructed into two sections (a) to collect information about the socioeconomic characteristics of the users (gender, age, occupation, purpose of travelling) and (b) to collect service quality attributes about the commuter train (e.g. fitness of train, seat comfort, service availability, movement flexibility, safety, journey end connectivity and security). The question format of demographic and general characteristics of respondents are prepared which are resemble to the Transit Cooperative Research Program (TCRP) Report 41 (1999a). The survey was carried out in both weekdays and weekends and also in different hours (peak and off-peak hours) in a day. At last the respondents were asked to rank the overall service quality of the commuter train service in Dhaka and also the most important attribute which should be improved immediately. These attributes are in a close ended arrangement with relevant multiple choices. The respondents were asked to assess the present situation of the service by marking the checkboxes from their point of view against each attribute. Like five level Likert scale, the multiple-choice check boxes are numbered by 1 to 5 where "5" corresponds to excellent quality and "1" corresponds to very poor quality. Data was collected for the selected 24 attributes in the questionnaire survey but for the best performance of model 12 attributes were finally selected. The attributes were—ticket cost, cleanliness, comfort level, ease of entry-exit, security of passengers, ventilation system, facility of waiting room, noise level, toilet facility, female harassment and behavior of staff and bogie condition.

4.2 Selection of Attributes

The attributes were selected based on—(i) Literature review of prior SQ analysis of train, (ii) Interview of train passengers and (iii) Collecting opinion from the expert transportation planners and engineers. The attributes with their explanation and references are presented in the Table 1.

Table 1 Explanation of attributes used ANFIS models.

Attributes	Explanation	References
Ticket cost	Train fare influences its attractiveness than other modes of transportation.	Eboli and Mazzulla (2012) Studied fare/service ratio, Redman et al. (2013) considered fare price as an attribute to enhance ridership of public transport over private cars.) and TCRP Report 41 (1999b) remarked cost effectiveness, affordability, and value, Fairness/consistency of fare structure as factors of SQ.
Cleanliness	Commuters prefer clean and hygiene environment inside train	Natahanail et. al. (2008), Agunloye and Oduwaye (2011), Chou et al. (2014) mentioned cleanliness as important factors for SQ evaluation.
Comfort level	Comfortable journey is desirable and it influence ridership potentiality.	Natahanail et. al. (2008) considered comfort level of train service and Islam et al. (2018) highlighted comfort level in terms of seat condition.
Ease of entry-exit	Easy accessibility to enter into public transit is expected. Only captive riders prefer overcrowded train.	TCRP Report 41 (1999b) marked ease of opening doors when getting on/off train as a criterion of SQ measurement.
Security of passengers	Safe journey is a common desirable expectation from passengers' point of view	Nandan (2010), Irfan et al. (2012) and Islam et al. (2018) highlighted passenger security.
Ventilation system	Commuter feel exhausted, suffocated and discomfort, if the train has inadequate ventilation.	De Oña et al. (2014) and Irfan et al. (2012) revealed influence of inside train ventilation as a performance measure.
Facility of waiting room	Commuter expect convenience and spacious waiting room at platform	Balakrishnan (2012) marked waiting arrangement at platform for assessing SQ of train service.
Noise level	Passenger perceive annoying from the extreme harsh sound of train	Irfan et al. (2012) considered noise level of train and TCRP Report 41 (1999b) marked quietness of train service and its system as a part of Transit quality measures
Toilet facility	Clean and adequate water availability in the toilets of train are preferable	Eboli and Mazzulla (2012), Islam et al. (2018) revealed importance of toilet condition for the evaluation of SQ of train service
Female harassment	Women are less interested and feel unsafe to access public transport facilities in this regard.	Irfan et al. (2012), Hsu (2011), Harrison (2012) mentioned that female harassment on public transport creates negative impact on ridership
Behavior of staff	Empathy and responsiveness of railway staff toward passenger	Balakrishnan (2012), Rahman and Rahman (2009) highlighted that behavior of employee of railways are also a factor for service quality. SERVQUAL model of public transport by Mikhaylov et al. (2015) considered empathy and responsiveness of employees for the performance evaluation of a service.
Bogie condition	Physical appearance and fitness of bogie are a tangible measure for performance evaluation	De Oña et al. (2014) and Irfan et. al. (2012) mentioned bogie condition of train as an attribute of SQ.

4.3 Characteristics of Commuters

For this research purpose, the number of total respondents was around 867. From them 802 respondents were selected for analysis. Information provided by some respondents were incomplete, which were discarded for further evaluation. The commuter train users were usually office going person who used commuter train almost in an everyday basis. But some other passengers also used commuter train service for travelling. Table 2 illustrates the general characteristics of the respondents collected from the questionnaire survey.

Table 2 General characteristics of the commuter train users

Characteristics	Statistics	No. of Respondents	Percentage
Gender	Male	569	71.13%
	Female	231	28.87%
Age	11 ~ 20 Years old	71	8.87 %
	21 ~ 30 Years old	410	51.25 %
	31 ~ 40 Years old	169	21.12 %
	41 ~ 50 Years old	82	10.25 %
	51 ~ 60 Years old	44	5.50 %
	> 60 Years old	19	2.37 %
Occupation	Service Holder	226	28.25 %
	Business	92	11.50 %
	Student	349	43.62 %
	Worker	86	10.75 %
	Housewife	47	5.87%
Motivation of Choosing Commuter Train	Captive Rider	48	6%

Characteristics	Statistics	No. of Respondents	Percentage
	Economical	87	10.87%
	Comfortable	217	27.12%
	Safer	426	53.25%
	Other	22	2.75%

4.4 Commuters Responses And Satisfaction Level

Respondent's perception about the service quality of commuter train that had been surveyed as questionnaire survey have been presented in tabular form in Table 3.

Table 3 Summary of Users' Perception about Commuter Train Service

	Attribute	Excellent	Very Good	Good/Satisfactory	Poor	Very Poor
01	Ticket Cost	1 %	10 %	55 %	28 %	6 %
02	Comfort Level	4%	18 %	24 %	31%	23%
03	Ease of Entry-Exit	7%	41 %	22 %	17 %	13 %
04	Security of Passenger	8%	26 %	38 %	18 %	10 %
05	Ventilation System	5%	33 %	40 %	18 %	4 %
06	Waiting Room Facility	4 %	14%	35 %	24 %	23 %
07	Toilet Facility	5 %	11 %	26 %	29 %	29 %
08	Female harassment	8 %	26 %	28 %	18 %	20 %
09	Behavior of Staff	7 %	25 %	50 %	10 %	8 %
10	Bogie Condition	6%	15%	46%	24%	9%
11	Cleanliness	2%	16%	42%	28%	12%
12	Noise Level	3%	11%	21%	46%	19%
	Overall	4%	20%	61%	10%	5%

From the Table 3, it has been observed that about 46% passengers rate bogie condition as satisfactory and total 33% rate this poor and very poor. Again, for cleanliness 42% passengers rate this satisfactory and 40% rate this poor and very poor. Moreover, respondents were also opined about the exiting overall quality of the commuter train. About 61% of the total respondents rate the overall quality of commuter train as good or satisfactory. On the other hand, about 20% rate this poor. Maximum respondents are satisfied with the overall service provided for commuter train users. About 5% are very happy with the service provided as they rate this 5**.**

5.0 MODEL DEVELOPMENT AND EVALUATION

5.1 Model Development

ANFIS combines comprehensibility of fuzzy rules, adaptability and self-learning algorithms of artificial neural networks. The accuracy of the prediction model is tested by comparing its predicted outputs with corresponding observed targets. Accordingly, the data samples were divided into two sub-samples: a training sample (80% of the total data sample set) and forecasting sample (20% of the total data sample set). MATLAB 12 was used for development of the models. The attributes of the model were randomly altered by trial and error technique to get the best performance. The attributes of ANFIS model is shown in Table 4.

Table 4 Attributes of ANFIS for Commuter Train SQ Prediction

ANFIS	
Number of input variables	12
Number of layers	5
Number of membership function	181
MF type	Gaussian
Transfer function of hidden layer	Tansigmoid
Scaling method	Normalization
Transfer function of output layer	Linear
Training algorithm	Back-propagation
Training cycles, epochs	10
Training goal	0.01

5.2 Model Evaluation

The model performance had been evaluated by (i) Confusion Matrix (ii) Root Mean Square Error (RMSE). Confusion matrix checked the one-to-one matching between output classes of predicted Service Quality (SQ) and target classes of actual SQ and RMSE values estimated the correlation and error between actual SQ and predicted SQ of commuter train. After that, ranking of attributes was calculated by ANFIS and compare with public opinion for validation.

5.3 Confusion Matrix

A confusion matrix comprises information about actual and predicted classifications done by a classification system. Performance of such systems is commonly evaluated using the data in the matrix. Confusion matrix is used to check the one-to-one matching between output classes (1 to 5) and target classes (1 to 5). The diagonal green boxes in Figure 2 illustrate the amounts and percentages that are identical in both output and corresponding target classes. The red boxes (non-diagonal elements) illustrate the amounts of misclassifications. The right-bottom blue box (right most bottom diagonal element) represents the total correct classifications (bold) and misclassifications (plain) in percent (%).

In prediction of Service Quality (SQ), ANFIS had 61.50% accuracy in training period which was about 395 of total 641 predictions. In testing, the accuracy was 47.80% which was about 77 out of 161 predictions.

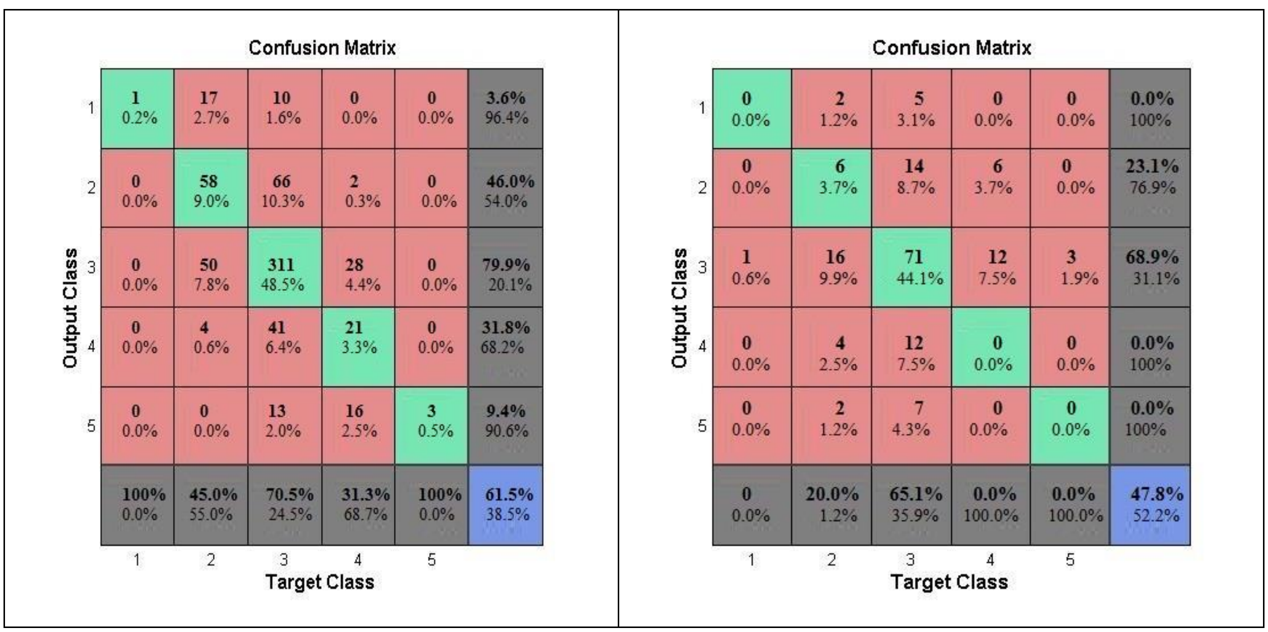

Figure 2 Confusion matrices for ANFIS of (a) training model (b) testing model

Some of the statistical tools for attributes rankings are—cross-correlation, principal component analysis (PCA) stepwise approach and connection weightage. This study follows stepwise approach to rank the commuter train service quality attributes. In stepwise approach a single attribute was considered to develop models in ANFIS to find out the significant attribute and the output of every developed network by a single attribute was then compared with the actual SQ of the test sample. This comparison was performed by evaluating RMSE.

Table 5 shows the RMSE values and ranking of the attributes using ANFIS model. The ranking of attributes by RMSE value indicates the significance of the individual attribute under different cases. It is found that 'Bogie Condition' has got the lowest RMSE value using ANFIS model and ranked as first significant attribute to be considered. Practically, it is seen that bogies of the train are not very clean and also the seat arrangement and other service for the passengers are not properly provided in the study area. Comparing the practical scenario and model analysis the results are quite similar is this case. Considering the second ranking 'Cleanliness' has got second lowest RMSE value using both ANFIS and public opinion. Bogie cleanliness is one of the major factors that may rise some effect on the overall quality. Sometimes passengers face some behavioral problems by the staffs of commuter train which affects the overall SQ provided by the Bangladesh Railway (BR). From table it is found that 'Ease of entry-exit', 'Ticket cost' and 'Air ventilation' have got highest RMSE value which indicates the better quality of service provided for passengers. Therefore, these are not very significant attributes for taking immediate action.

In the questionnaire survey respondents were asked to give their opinion about 12 most significant attribute that should immediately be treated for better SQ of commuter train. From their perception a ranking of the attributes has been made in ascending order to understand the performance of the model and respondents' response. It should be noted that respondents were independent to give their valuable opinion in this section. From Table 5, it is found that about top 4th attributes match to the public opinion. From 5th to 8th attribute there is dissimilarity in the sequence. Last four attributes were randomly matched to the public opinion.

Public opinion data (obtained from fourth section of the questionnaire) are not the same of the data used for ANFIS model development (obtained from second section of the questionnaire). The respondents were very much precise in answering questions of different sections of the designed questionnaire showing the data accuracy and validity.

Table 5 Attributes ranking comparison among ANFIS and Public Opinion

Attributes	ANFIS model		
	RMSE	RANK	Public opinion
Bogie Condition	0.807079	1	1
Cleanliness	0.807573	2	2
Female Harassment	0.811409	3	3
Behavior of Staff	0.837773	4	4
Noise Level	0.838738	5	8
Toilet Facility	0.949011	6	7
Ventilation System	1.009274	7	5
Waiting Room Facility	1.036597	8	6
Ease of Entry-Exit	1.042572	9	9
Comfort Level	1.045547	10	12
Overall Security	1.048513	11	10
Ticket Cost	1.05147	12	11

6.0 CONCLUDING REMARKS

The stated preference (SP) questionnaire survey in this study has depicted the potentiality in modeling satisfaction level of commuter train passengers. Passengers' perceptions towards the existing service of commuter train were analyzed and evaluated the influence of different attributes on existing service quality (SQ). Furthermore, the research identified the influencing attributes of service quality of commuter train for prioritize and improvement purpose. Planners and policy makers can utilize passengers' preference to make sustainable decision. They will have specific suggestions for allocating finance and resources to prepare better investment plans. Thus, SQ of commuter train can be improved at expected level with optimized cost reduction.

Several researchers analyzed rail transit SQ based on commuters' perceptions in terms of satisfaction judgments. Some of them adopt ANFIS methodology, however, no study was focused on the commuter rail services in context of Dhaka city, Bangladesh. Precisely, in this research a commuter rail service was analyzed and relevant number of service attributes was investigated. ANFIS executed ANN algorithm into FIS which was implemented to estimate SQ of commuter train based on twelve attributes. The research focused on assessment of commuter train SQ attributes according to their importance. The proposed ANFIS model have 61.50% accuracy in training and 47.80% accuracy in testing. The calibrated model is an advanced hybrid technique, it is faster and better in predicting heterogeneous type data. The obtained outcomes can be utilized for development program for other commuter rail services as well. On contrary, the effects of each service attribute may significantly vary from one transit service to another, from one country to another, or even from one region to another. The proposed framework in this study can be generalized for analyzing any types of transit service and a tool for better improvement planning.

The ANFIS model incorporated step-wise approach to prioritize the twelve SQ attributes. Considering the RMSE values, it was found that the most significant problem of exiting commuter train service is the existing bogie condition of the train. Public opinion and the model results both gives the same output about the existing condition of bogies of the train. Passengers found that the inside space of the train is old and dilapidate condition and do not have good appearance. This makes them to avoid commuter train for their movement. Therefore, the first initiative of the authority can be providing a proper repaired and cleaned bogie of the train. In second most important attributes from this research is cleanliness. It is not very satisfactory into the train which also affects the public opinion about to ride in commuter train. Besides, female harassment, behavior of staff, toilet facility, ventilation system, noise level of train and waiting room facilities are some other important attributes. In contrast, ease of entry-exit, comfort level, over all security and ticket cost are less important attributes for commuter train service in this regard. The result of the study will be helpful the decision maker to take initiative for improving the service quality of commuter train.

The SP survey data focused on the perspectives of commuter train passengers of Dhaka. Although the sample size used in this study is adequate, further research performed with a larger dataset will provide better understanding. Besides, research on specific passenger groups, for example, student, female, senior citizens, low income people, and so on may provide other significant findings regarding the commuter train SQ. Heterogeneity among passengers might influence commuter train SQ distinguishably. These attributes are not equally perceived by the different commuters' group. The future plan of the study is to apply ANFIS for investigating the attributes influencing commuter train SQ with a combining dataset of both commuters and non-commuters. This comparative study will reveal the way to attract new commuters. In addition, Probabilistic neural network (PNN) and other neural network models can be investigated along with ANFIS on the same dataset for identifying best estimation tool. The prediction capabilities of ANFIS found in the study will aid transportation planners to implement this technique to rank SQ of other public transportation systems as well.

Acknowledgements

The authors would like to express thanks to the Committee for Advanced Studies and Research (CASR) of Bangladesh University of Engineering and Technology (BUET) for the financial support.

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