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PREDICTION OF ROAD TRAFFIC NOISE LEVELS BY USING REGRESSION ANALYSIS AND ARTIFICIAL NEURAL NETWORK IN TIRUPATI TOWN

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Abstract*:* Traffic Noise pollution is an interfering air-pollutant which possesses both auditory and a host of non-auditory effects on the exposed population. Since there is no medicine to cure hearing loss, prevention to over exposure is the only alternative left. Noise pollution not only effects the human beings but also the animals. Hypertension, sleeplessness, mental stress, etc. are the implications of noise pollution. Due to this adverse effect of noise level, it is essential to assess the impact of traffic noise on residents and road users.

The present study measures traffic volume and noise levels during the peak traffic flow in the selected areas of Tirupati town. The traffic volume studies are carried out by means of manual methods prescribed by Indian Standards and noise levels are measured following standard procedure using Sound Pressure Level Meter. The obtaining results are used to validate the developed model by using regression analysis and artificial neural networks for the prediction of road noise levels of Tirupati town.

Keywords: Traffic noise pollution, Traffic volume, octave band analyzer, regression analysis , Neural networks

I. INTRODUCTION

Fast growing vehicle population in town in the recent years, has resulted in considerable increase in traffic on roads causing alarming noise pollution and air pollution. Transportation operators are major contributors to noise in modern urban areas. Noise is generated by the engine and exhaust system of vehicles by aerodynamic friction and by interaction between the vehicle and its supporting system (Example: tyre pavements and rail wheel interaction). Noise diminishes with distance from the source. The vehicle by virtue of the movement are not only polluting the atmosphere by emission of poisonous gases but also grabbing off peace from mankind by generating high noise levels that are annoying of irritating to the inhabitants to such an extent that noise pollution caused by the highway traffic has to be studied at great depth, analyzed and has to be controlled. Noise levels increases with traffic volume in an exponential manner. In India like many other developing countries traffic noise is major continents of environmental pollution and now it has become a permanent part of urban and sub-urban life. It is very harmful to human beings. In the new millennium, for protection environmental degradation it is imperative to pay greater attention towards measuring noise pollution, enforcing regulation for noise emission limits, elimination and control noise pollution. Taking a step in this direction, Noise pollution level was measured in Tirupati town.

II. METHODOLOGY

The traffic volume study was conducted in Tirupati town at different Junctions. To measure the potential effects of traffic noise at different Junction, data on traffic volume, including types of vehicles were measured and roadside sound levels, are measured and

interpreted using various models. Sound level meters, a manual hand counter, and portable measurement instruments were used to obtain the required data. Data analysis was conducted using Microsoft Excel and SLM(Sound Level Meter).Traffic volume (composition and flow) and traffic noise were measured at three time periods per day at different Junctions. These time periods were the morning peak hour (08:00–10:00 AM), the daytime peak hour (02:00–03:00 PM), and the evening peak hour (05:00–07:00 PM). The volume and composition of traffic were measured for 60 min during each peak period. Traffic composition was determined on the basis of the presence of two wheelers, three wheelers, four wheelers and Heavy vehicles (Buses, Lorries).

Data on the geometric dimensions of road sections, as well as the number of lanes and their widths, were also measured. Sound level measurements were performed using a sound level meter (Real Time Octave Band Analyzer Model No: 407790). Traffic noise was measured using Sound Level Meter in1/3 Octave- band mode index with an A-weighted scale expressed as Leq, in decibel units at an interval of 3 seconds throughout the peak period.

III. MEASUREMENT PROCEDURE:

Volume studies have been undertaken in this junction at different hours i.e., morning 8 am to 10 am, afternoon 2:00 pm to 3:00 pm and in the evening at 5:00 to 7:00 pm. For traffic volume studies manual method is being used. In this process enumerators count the number of vehicles moving over that section during the peak hours. The vehicles are categorized in to Two Wheelers (2W), Three Wheelers (3W), Four Wheelers (4W) including cars and school buses, and Heavy Vehicles (HV) including buses and lorries as the prediction of traffic noise levels at the intersection total number of vehicles per hour data is required. Since the intersection consist of three roads, the traffic volume is carried out on each side for a time interval of 20mins such that the total intersection is covered in one hour of time.

The sound level meter was placed closest to the noise source, and the microphone was positioned 70 m from the traffic light, at a height of 1.2 m above the ground level corresponding to the ear level of an individual of average height (Onnu, 2000) and 70 m was adopted with the assumption that most vehicles in the traffic stream had already reached steady speed (Burgess, 1997). Measurements were taken at a time interval of 3seconds for about 20mins on each side of the three road intersection in 1/3 octave band frequency mode and L_{eq} values also measured.

IV. REGRESSION ANALYSIS

Excel's regression analysis tool performs linear regression analysis, which fits a line through a set of observations using the "least squares" method. Regression is used in a wide variety of applications in finance and accounting to analyze how the value of a single dependent variable is affected by the values of one or more independent variables. You can then use the regression results to predict the value of the dependent variable based on values of the independent variable(s).

The standard formula for multiple regression with two independent variables is :

$$Y = a + b1X1 + b2X2$$

Y = Predicted value of the dependent variable

a = Y-intercept

b1 = Coefficient of Weight of Materials (first independent variable)

X1 = Any value of Weight of Materials (first independent variable)

b2 = Coefficient of the second independent variable

X2 = Any value of Dollar Value of Materials (second independent variable)

As noted previously, the Y-intercept can be found in cell B17, the coefficient b1 of X1 can be found in cell B18, and the coefficient b2 of X2 can be found in cell B19.

Thus, using Excel terminology, the regression formula in this example could be written as:

=B17+B18*X1 +B19*X2

$$Leq = 83.3711-0.28435(Q)-0.64327(P)+0.285084(Nc)+0.000245(Nm)-0.01837(Nb)$$

Where

Leq =Equivalent Continuous Noise Level (dBA),

P =Percentage of heavy vehicles (%),

Q = Total number of vehicles per hour,

Nc = Number of light vehicles per hour,

Nm = Number of motorcycles per hour,

Nb =Number of buses per hour

Table 1 : Traffic Parameters

Balaji Colony

DATE	Time	Q	P	N_c	N_m	N_{hv}	N_b
DAY-1							
18/02/15	8 to 9am	4039	0.297103	4027	2820	12	55
18/02/15	9 to 10am	4150	0.216867	4141	3029	9	66
18/02/15	2 to 3pm	3693	0.324939	3681	2572	12	46
18/02/15	5 to 6pm	4067	0.245881	4057	2927	10	60
18/02/15	6 to 7pm	4081	0.269542	4070	2804	11	66
DAY-2							
19/02/15	8 to 9am	4122	0.291121	4110	2990	12	74
19/02/15	9 to 10am	4126	0.15	4120	2967	6	75
19/02/15	2 to 3pm	3685	0.35	3672	2560	13	48
19/02/15	5 to 6pm	4164	0.17	4157	2989	7	65
19/02/15	6 to 7pm	3984	0.28	3973	2769	11	71
DAY-3							
21/02/15	8 to 9am	4173	0.19	4165	2981	8	81
21/02/15	9 to 10am	4372	0.21	4363	3101	9	76
21/02/15	2 to 3pm	3175	0.28	3166	2110	9	49
21/02/15	5 to 6pm	4323	0.16	4316	3134	7	77
21/02/15	6 to 7pm	4363	0.16	4356	3169	7	87
DAY-4							
22/02/15	8 to 9am	2522	0.317209	2514	1618	8	61
22/02/15	9 to 10am	2847	0.175623	2842	1821	5	77
22/02/15	2 to 3pm	2712	0.184366	2707	1898	5	61
22/02/15	5 to 6pm	4243	0.141409	4237	3075	6	75
22/02/15	6 to 7pm	3765	0.185923	3758	2767	7	76

Table 2 : Traffic Parameters

Annamayya Circle

No.Days	Date	Time	Q	P	N_c	N_m	N_{hv}	N_b
DAY-1								
	23/02/15	8 to 9 AM	3163	0.189693	3157	1804	6	48
	23/02/15	9 to10AM	3530	0.1983	3523	2258	7	60
	23/02/15	2 to 3 PM	2680	0.223881	2674	1540	6	13
	23/02/15	5 to 6 PM	3015	0.099502	3012	2055	3	35
	23/02/15	6 to 7 PM	4092	0.146628	4086	2747	6	38
DAY-2								
	24/02/15	8 to 9 AM	3066	0.163079	3061	1714	5	52
	24/02/15	9 to10AM	3419	0.116993	3415	2124	4	43
	24/02/15	2 to 3 PM	2599	0.153905	2595	1489	4	10
	24/02/15	5 to 6 PM	2909	0.068752	2907	1984	2	31
	24/02/15	6 to 7 PM	4170	0.143885	4164	2712	6	57
DAY-3								
	07/03/15	8 to 9 AM	3368	0.356295	3356	1816	12	59
	07/03/15	9 to10AM	4584	0.283595	4571	2411	13	83
	07/03/15	2 to 3 PM	2840	0.56338	2824	1601	16	17
	07/03/15	5 to 6 PM	3276	0.3663	3264	2194	12	43
	07/03/15	6 to 7 PM	4252	0.211665	4243	2844	9	41
DAY-4								
	08/03/15	8 to 9 AM	2160	0.32	2153	989	7	28
	08/03/15	9 to10AM	2858	0.17	2853	1727	5	21
	08/03/15	2 to 3 PM	2530	0.32	2522	1379	8	20
	08/03/15	5 to 6 PM	2565	0.19	2560	1702	5	21
	08/03/15	6 to 7 PM	3867	0.13	3862	2619	5	18

Table 3: Traffic Parameters

Bliss Circle

No.Days	Date	Time	Q	P	N_c	N_m	N_{hv}	N_b
DAY1	9/3/2015	8 to 9 AM	5919	0.135158	5911	3790	8	256
	9/3/2015	9 to 10AM	6010	0.366057	5988	3608	22	251
	9/3/2015	2 to 3 PM	4540	0.528634	4516	2543	24	266
	9/3/2015	5 to 6 PM	5620	0.24911	5606	3351	14	258
	9/3/2015	6 to 7 PM	6083	0.21371	6070	3832	13	295
DAY-2								
	10/3/2015	8 to 9 AM	5711	0.262651	5696	3428	15	268
	10/3/2015	9 to 10AM	5750	0.365217	5729	3425	21	297
	10/3/2015	2 to 3 PM	4850	0.391753	4831	2711	19	296
	10/3/2015	5 to 6 PM	5654	0.371418	5633	3207	21	278
	10/3/2015	6 to 7 PM	6083	0.21371	6070	3832	13	295
DAY-3								
	14/03/2015	8 to 9 AM	5103	0.293945	5088	3022	15	288
	14/03/2015	9 to 10AM	5226	0.267891	5212	2923	14	299
	14/03/2015	2 to 3 PM	4400	0.568182	4375	2382	25	268
	14/03/2015	5 to 6 PM	5594	0.375402	5573	3387	21	259
	14/03/2015	6 to 7 PM	6257	0.287678	6239	3894	18	316
DAY-4	15/03/2015	8 to 9 AM	3716	0.32	3704	2051	12	246
	15/03/2015	9 to 10AM	4060	0.39	4044	2228	16	289
	15/03/2015	2 to 3 PM	3465	0.61	3444	1681	21	291
	15/03/2015	5 to 6 PM	5212	0.21	5201	3073	11	269
	15/03/2015	6 to 7 PM	5353	0.28	5338	3172	15	288

Table 4: Traffic Parameters

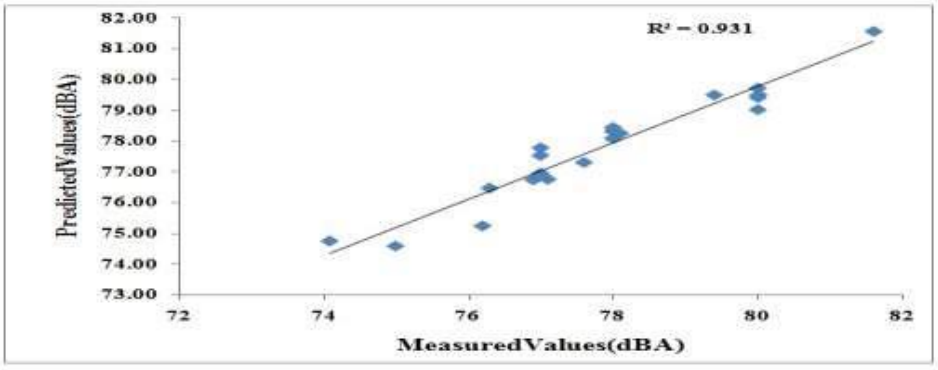
Leelamahal Junction

No.DAYS	DATE	TIME	Q	P	N_c	N_m	N_{hv}	N_b
DAY-1								
	17/03/15	8 to 9 AM	4420	0.135747	4414	2896	6	143
	17/03/15	9 to 10AM	4320	0.115741	4315	2846	5	137
	17/03/15	2 to 3 PM	3151	0	3151	1933	0	152
	17/03/15	5 to 6 PM	3706	0.269833	3696	2236	10	180
	17/03/15	6 to 7 PM	2583	0.038715	2582	1610	1	71
DAY-2								
	18/03/15	8 to 9 AM	4000	0	4000	2509	0	169
	18/03/15	9 to 10AM	3618	0	3618	2216	0	144
	18/03/15	2 to 3 PM	2832	0	2832	1607	0	173
	18/03/15	5 to 6 PM	3351	0.268577	3342	2006	9	183
	18/03/15	6 to 7 PM	2583	0.038715	2582	1610	1	71
DAY-3								
	21/03/15	8 to 9 AM	4142	0.12	4137	2696	5	124
	21/03/15	9 to 10AM	3995	0.10	3991	2557	4	145
	21/03/15	2 to 3 PM	2807	0.04	2806	1607	1	159
	21/03/15	5 to 6 PM	3411	0.21	3404	1949	7	175
	21/03/15	6 to 7 PM	4428	0.07	4425	2887	3	165
DAY-4								
	22/03/15	8 to 9 AM	2821	0.248139	2814	1573	7	140
	22/03/15	9 to 10AM	2931	0.102354	2928	1643	3	140
	22/03/15	2 to 3 PM	2511	0	2511	1345	0	147
	22/03/15	5 to 6 PM	2901	0.241296	2894	1544	7	192
	22/03/15	6 to 7 PM	3829	0.026116	3828	2310	1	169

Statistical Performance Measure Of Regression Analysis

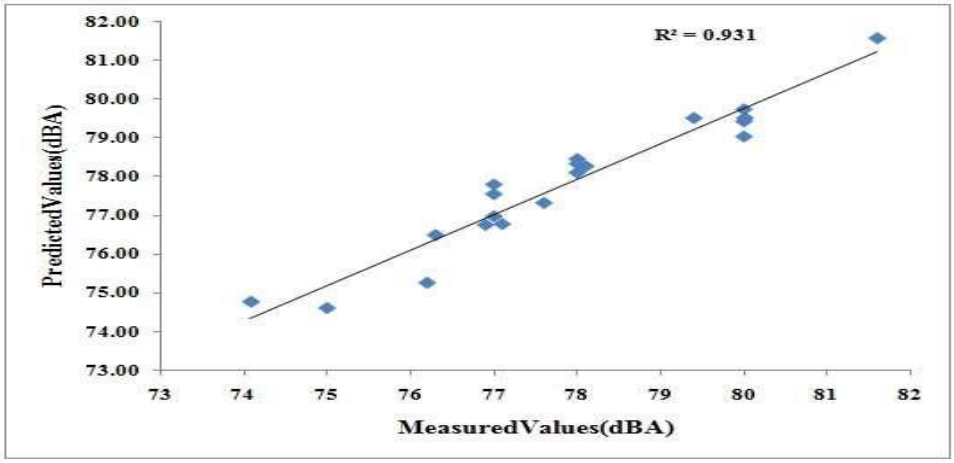
BALAJI COLONY

Predicted	Measured
82.40	82
83.24	82.7
82.23	82.35
82.96	82.5
82.53	82.1
82.16	82.17
83.94	84.18
81.88	81
83.86	83.65
82.35	81.65
83.27	82.98
83.24	83.45
82.57	82.19
83.79	83.67
83.65	83.4
82.01	81.44
82.95	82.31
83.16	82.98
84.05	84.01
83.30	83.05



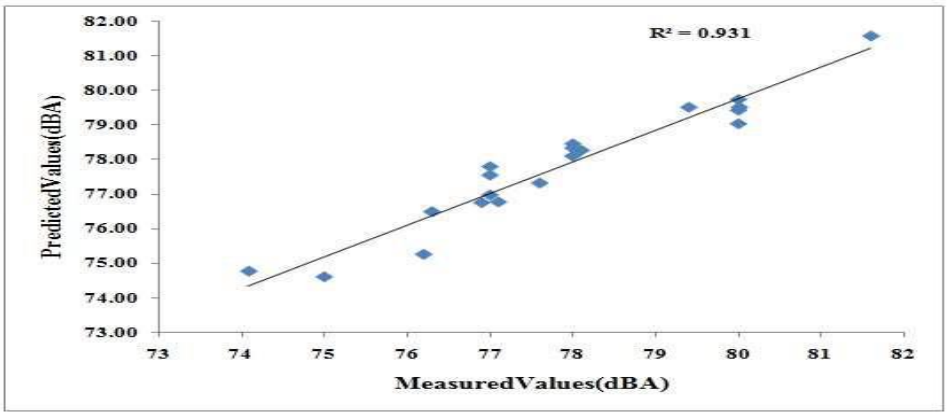
ANNAMAYA CIRCLE

Measured	Predicted
81.6	81.5668
78.1	77.54096
76.2	75.25269
80.1	79.41958
80.1	79.50496
81.01	79.02765
77	76.74635
76.3	76.48344
77	76.96756
80.1	79.50496
79.3	78.09522
79	78.26086
75.1	74.7634
77.6	77.31416
78.3	77.78891
79	78.44911
78.7	76.7686
77	74.60009
80	79.73022
79	78.32398



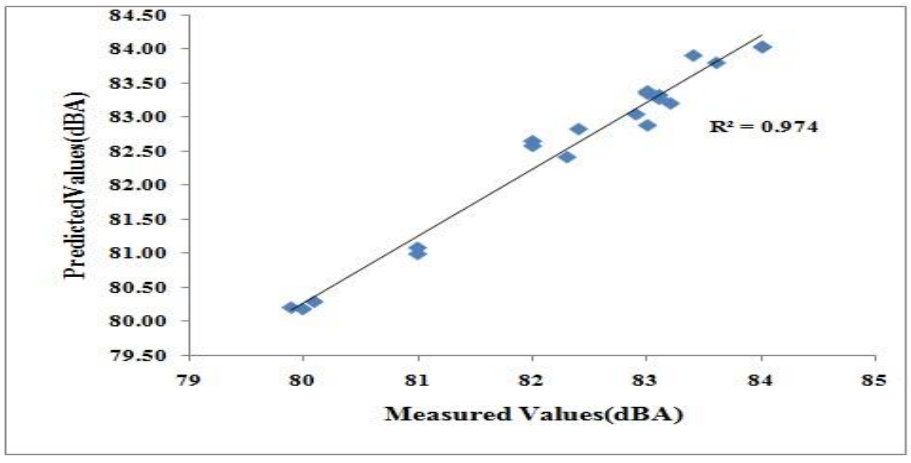
BLISS CIRCLE

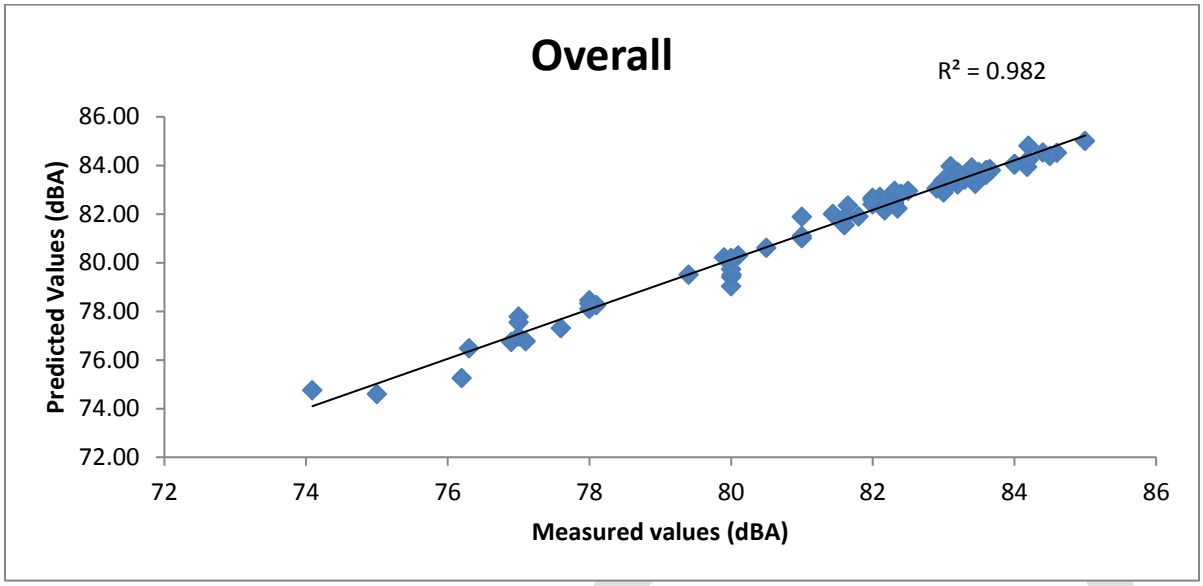
Measured	Predicted
81.6	81.5668
78.1	77.54096
76.2	75.25269
80.1	79.41958
80.1	79.50496
81.01	79.02765
77	76.74635
76.3	76.48344
77	76.96756
80.1	79.50496
79.3	78.09522
79	78.26086
75.1	74.7634
77.6	77.31416
78.3	77.78891
79	78.44911
78.7	76.7686
77	74.60009
80	79.73022
79	78.32398



LEELA MAHAL JUNCTION

Measured	Predicted
83	82.89477
83.2	83.21742
83	83.36154
80.1	80.30371
84	84.04402
83.6	83.81248
83.4	83.91998
82	82.66221
79.9	80.21804
84	84.04402
83.1	83.28582
83.06	83.05666
82	82.59304
81	81.00589
83.01	83.39334
81	81.09673
82.3	82.42859
82.4	82.84036
80.09	80.19752
83.1	83.33653





IV Neural Network

An artificial neural network is a computational tool inspired by biological neural systems. It is a massively parallel distributed processor with the ability to learn and generalize, i.e. ability to model complex relationships between inputs and outputs or find patterns in data. The proposed ANN model is developed using "Graphical User Interface(GUI)" using NN tool in MATLAB software. In this a neural network will be developed with different number of inputs, outputs, hidden layers and hidden neurons

The whole dataset was divided in to three parts:

Data points for training

Data points for validation

Data points for testing

Neural networks predict equivalent sound level (Leq) according to the input data set which contains a number of two wheelers, three wheelers, four vehicles, buses and heavy vehicles. A network has been developed by taking the traffic volume studies as input and the Leq values are taken as output value. Eighty data sets were used for training, testing and validation of the neural Network. Data sets are collected by systematic noise measurement in urban areas of Tirupati. The training set is used to adjust the values of the connections weights, the validation set to prevent over fitting problem and the test set to evaluate the performance of the developed neural network.

In neural networks, mainly four types of networks are used:

Feed- Forward Neural Network

Radial Basis Function (RBF) Network

Kohonen Self – Organizing Network.

Feed- Forward Back propagation.

A few applications of ANN are: Aerospace ,Financial, Automotive Manufacturing, Defense, Medical, Electronics, Oil and Gas ,Engineering etc.,

Development of a ANN model with Feed- Forward Back Propagation:

Normalize the inputs and outputs with respect to their maximum values.

Normalization can be done by using the formula:

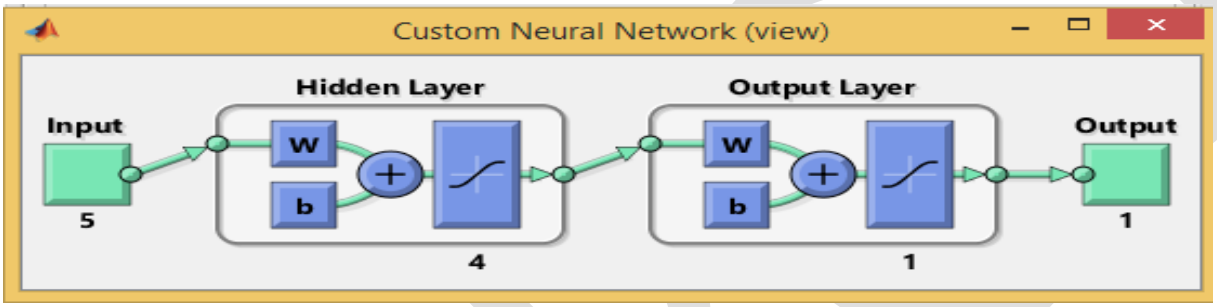
$$X=0.1+0.8*(x_i / x_{max})$$

where

X= Normalized Value

Choose a neural network, configure its architecture and set its parameters. The network will choose randomly the training data and will train the network with the training-set data. The network itself evaluate its performance by using the validation-set data. Repeat steps 2 and 3 with different architectures and training parameters. Select the best network by identifying the smallest error found with validation set.

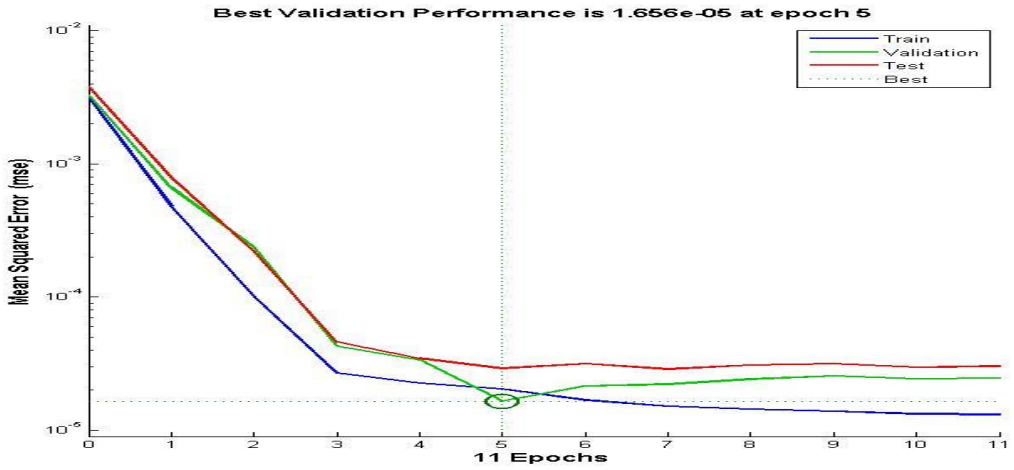
In this study an architecture have been developed for the prediction of Leq values at the four junctions by taking traffic volumes studies of the study area under consideration.. The no. of neurons assumed for the present study are 1 to 5. It is based on trial and error basis.

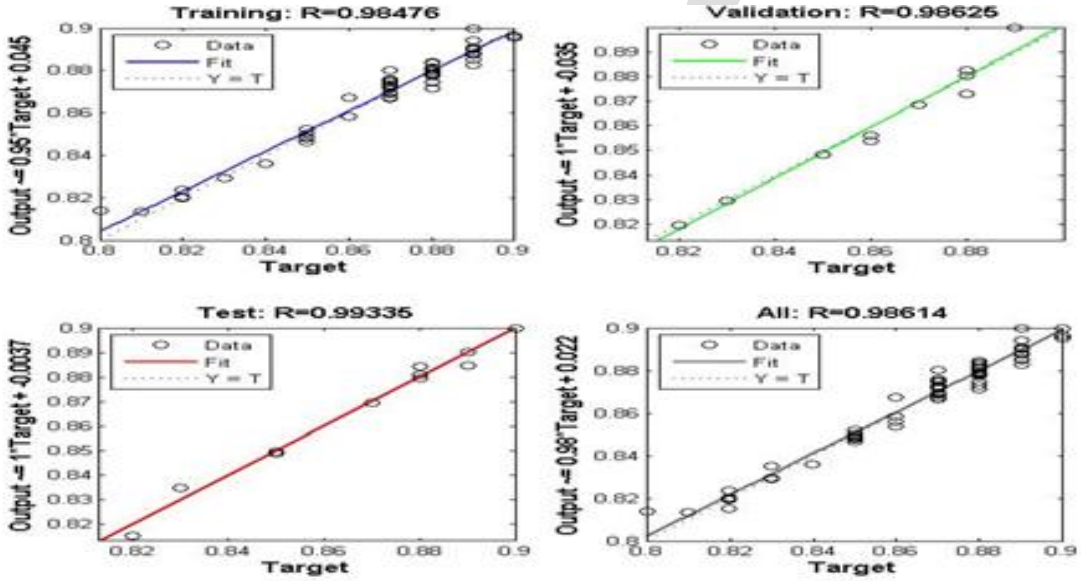


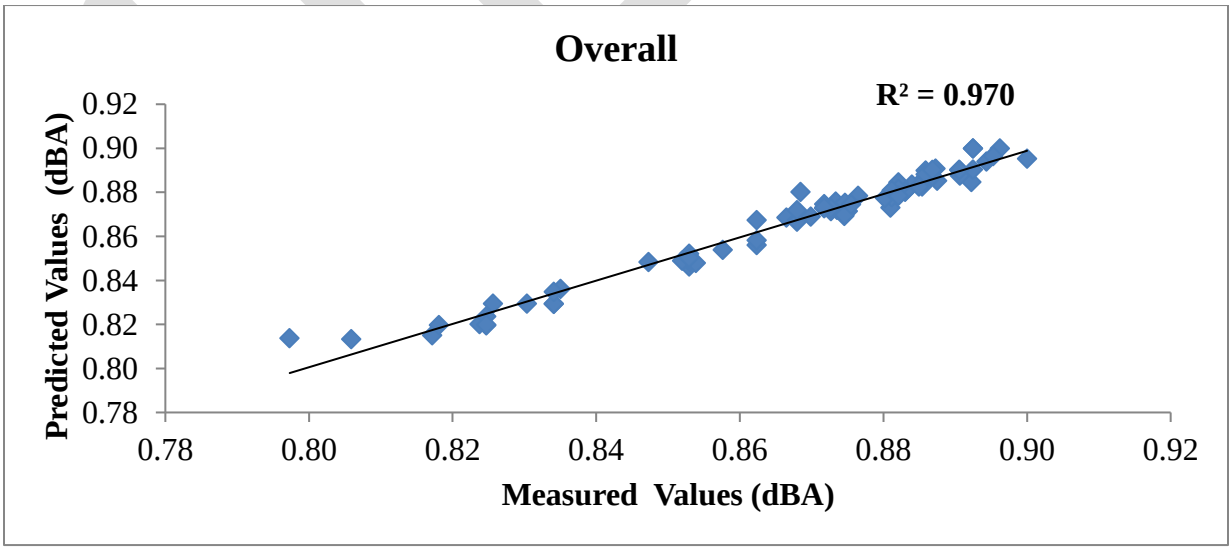
Architecture for the prediction of Leq values by using traffic volume studies as inputs

S.No	Network	No. of Hidden Neurons	R(CORRELATION)			
			Training	Validation	Testing	Overall
1	5-1-1	1	0.981	0.955	0.969	0.977
2	5-2-1	2	0.983	0.980	0.982	0.982
3	5-3-1	3	0.981	0.986	0.981	0.981
4	**5-4-1**	**4**	**0.984**	**0.986**	**0.993**	**0.986**
5	5-5-1	5	0.973	0.979	0.987	0.975

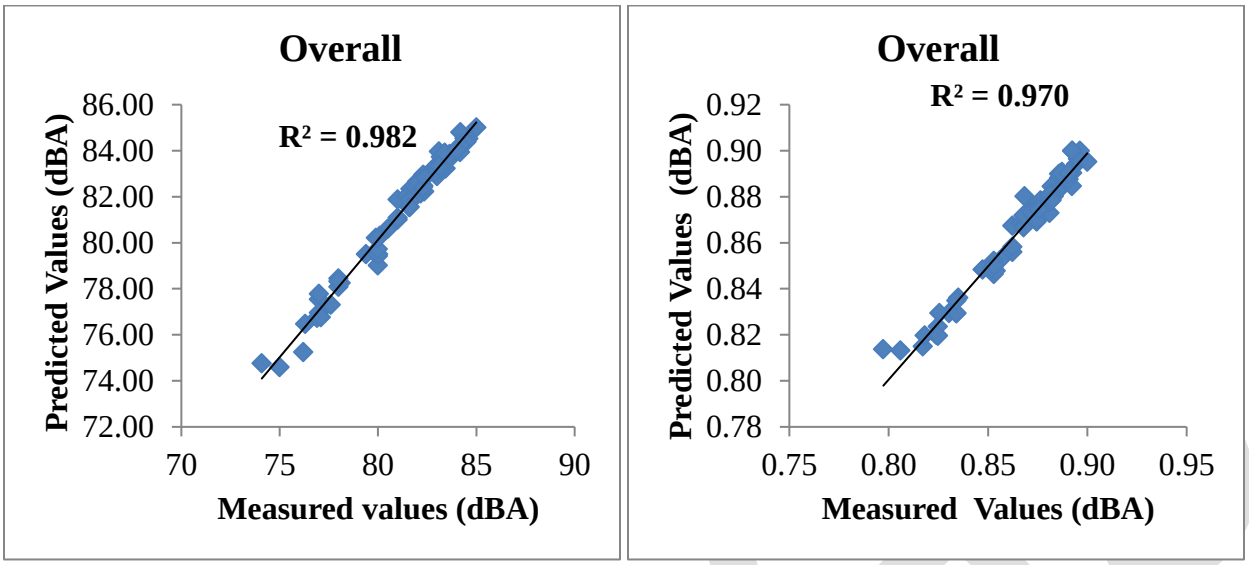
Performance statistics of a Neural network models for the prediction of Leq values


Best Validation Performance is 1.656e-05 at epoch 5
Train
Validation
Test
Best
Mean Squared Error (mse)
11 Epochs


Training: R=0.98476
Validation: R=0.98625
Test: R=0.99335
All: R=0.98614
Data
Fit
Y = T
Target


Overall
R² = 0.970
Predicted Values (dBA)
Measured Values (dBA)

Overall regression for Developed mathematical equation	Overall regression for Artificial Neural Network (NN tool)



Comparison of regression values between developed Mathematical equation and Artificial neural network (NN tool) .

CONCLUSION

The traffic flow and volume were high during the peak periods, and the highest volume was recorded during both morning and evening timings. The measured noise level in Leq for the studied locations varied between 74 and 85 dB(A), which exceeds Indian guidelines of Noise Pollution Act (1972) of range 70 dB(A). A slight decrease was observed during the early afternoons followed by a gradual increase during the evening times from 4 PM due to increase in the traffic flow. It was observed that the highest and lowest sound pressure levels witnessed in an octave band analysis in the present study were25 Hz and 3150 Hz, respectively. It was observed from the spectral analysis, the lowest Sound Pressure Level recorded was in the range of 17.5 dBA at 25 Hz during the afternoon due to decrease in the traffic volume and the highest value recorded was in the range of 78.1dBA at 3.15 KHz due to the more number of traffic volume during the evening timings and at the same time more or less almost equal sound pressure level was recorded during the morning time also.

From the spectral analysis, it was observed that for all the study period the maximum Sound Pressure Level was recorded at 3.15 KHz frequency which was beyond the permissible limits for the human being which is usually 1 KHz. An equation has been developed by using regression analysis for the prediction of Leq values at the four junctions by taking traffic volumes studies of the study area under consideration. The predicted values from the developed mathematical model was then compared with the measured values to know the validity of the model.

From the graphs it was observed that the R^2 value between the measured values and predicted values at all the four junctions is > 0.9. A neural network had also developed for the prediction of noise levels L_{eq} and the best network 5-4-1 had been proposed. The Regression(R^2) values for Developed Mathematical equation and for Artificial neural network are 0.982 and 0.970. Among the two models (i.e., developed Mathematical equation and Artificial neural network) the developed Mathematical equation given accurate predicted Noise levels. Finally it can be concluded that the suggested Two models could nicely predict the road traffic noise in Tirupati town.

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