Sustainable Energy Management by Optimizing Daylight with Artificial Neural Network

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ABSTRACT:

Construction of a house is the life time dream of every individual. While planning the house there are many parameters such as room sizes, individual choices, requirements, circulation requirements and location of rooms with regard to lighting and air circulation and orientation of the building. Any attempt to provide optimization in planning is to consider all these factors and conceive a plan with building elements to achieve least energy consumption for a given size of the house. A study has been conducted to analyze the inflow of daylight inside the rooms of a typical house building in Coimbatore. 25 dwelling units are chosen for this study. In the study, the building orientation, building level, location of rooms, room sizes, orientation of rooms, openings in the walls of the room, luminous intensity, temperature and relative humidity for different seasons in a year and different times in a day.

The above said parameters are very complex in nature and the analysis requires an efficient tool to predict the required target of luminous intensity for a room for maximum living comfort in the different rooms during the day time. Hence artificial neural network technique is used to solve the above said problem. Artificial Neural Network model (ANN) is developed in MATLAB R2008b software. The ANN software is written in such a way that it can predict the target even for a new set of inputs. The ANN model efficiency is analysed and the co-efficient of relationship for the training and validation process are obtained as 0.22977 and 0.03292 respectively.

1.0 INTRODUTION:

Buildings consume over 50 per cent of energy produced is used for those activities happening inside the buildings. In dwelling houses, energy is consumed for lighting, heating ventilation and air- conditioning, pumping, cooking and so on. In offices, energy is used for lighting, heating, ventilation and air-conditioning, computers and office equipments and so on. In Industries, energy is used for running machineries, lighting, heating, ventilation and air-conditioning and so on. There are over 250 industries which contribute to construction activity including material manufacturers, machinery suppliers etc and almost every industry in this consumes colossal energy. So any country which would like to have a sustainable development must seriously plan and forecast the environment development.

Any attempt to reduce environmental degradation and also to ensure a sustainable development has to take optimization of use of building materials and energy use for non-productive purposes inside the buildings. There are three phases viz, pre-construction, construction and post construction. Out of these, pre-construction phase plays an important role in which the energy optimization is decided to a great extent, because at this stage, the materials to be used, the sizes of rooms, sizes and location of openings, orientation of the building, space around the buildings etc are decided.

It is estimated that 40 to 50 per cent energy can be saved in buildings, if the energy efficiency measures are incorporated at the pre-construction stage, which is otherwise called the design stage. In case of existing buildings about 20 to 25 per cent of energy savings can be achieved by implementing proper measures in improving energy efficiency.

1.1. Energy consumption:

For understanding the energy usage inside a typical house building in India, following are the glimpses which represents the consumption of energy inside residential buildings;

Where Air – Conditioning is not used:

Lighting/Ventilation Fans : 45 per cent

Fridge/Mixie/Geyser etc. : 55 per cent

Where air-conditioning is used:

Lighting Fans : 30 per cent

Ventilation Fans/AC : 30 per cent

Miscellaneous Equipment : 40 per cent

Energy conservation is the practice of decreasing the quantity of energy used. It may be achieved through efficient energy use, or by reduced consumption of energy services. Individuals and organizations that are direct consumers of energy may want to conserve energy to promote cost and economic security. Housing sector consumes significant portion of the energy. So, energy conservation in the non-productive activity like housing should be the prime concern of the policy planners and construction industry professionals, in order to face the challenges of the future with regard to the energy scenario.

This paper aims optimization of day lighting within the house buildings, so that considerable energy can be saved by minimizing the artificial lighting.

2.0 LITERATURE REVIEW:

According to Lee et al., (2009) the drive towards sustainable, low energy buildings has increased. The 'daylight' building meet minimum standards for energy and human comfort performance, and also the current metrics do not account for the temporal and spatial aspects of daylight, nor of occupants comfort or interventions.

Sansoni et al., (2007) developed an innovative system with illumination of internal spaces has studied. Each sunflower includes sunlight concentrators, optical fibres and mechanical and electronic systems for sun tracking.

Rosemann et al., (2008) have developed a system that enables both daylight and electric light to be efficiently delivered to core areas of a building. According to him

daylight is directed into the building by means of a new and cost-effective canopy system which collects sunlight and directs it into the dual-function luminaries.

The objectives of the thesis are as follows:

- 'to create a tool to predict the prevailing luminance inside the building so as to plan the building units which require less energy for the comfort dwelling.'
- 'to determine the factors affecting the luminous intensity inside the building and to reduce the contribution of artificial lighting in order to reduce the power consumption.

3.0 MATERIALS AND METHODOLOGY

The main aim of this work is to reduce the power consumption in the residential areas so as to have the energy efficient mechanism within the building. The data are location of the study area, size of the build up area, orientation of the building, room size, location of the room within the building, function of the room, openings in the room including doors, windows ventilators and other opening in long wall as well as short walls, season in which data is being taken, time in which taken, the value of luminous intensity, humidity and temperature.

For measuring the luminous intensity, lux meter of model MS 6610 of make MASTEK is used. The temperature inside the room is also very important factor which induces the energy requirement the high temperature inside. The temperature is measured by digital thermometer of model CT-138A. This device has the measuring range of 1º to 120º C with an accuracy of ±1ºC.

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3.1 Artificial Neural Network (ANN):

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system.

It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANN is also like people, they

learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process.

3.2 Architecture of Artificial Neural Networks

The basic structure of an Artificial Neural Network consists of the following:

- Input layer
- hidden layer
- output layer

Input layer is the layer where the data is feed into the network, only from this layer the data can be feed into the network, this can be used both while training and validation. Hidden layer is the most important layer where the weights are calculated, adjusted and other process takes place. During the training process the network calculates each weight for each node. Output layer consists of a set of targeted out calculated during the training purposes, if a new input is given after passing through the hidden layer it will look for the closely associated output. The Data base is converted into soft copy mode using Micro Soft excel 2003. Even though neural network tool is available in MatlabR2007b software, software program is written in MATLAB R2007b.

The buildings in various locations in Coimbatore city were chosen, for the study of flow of light waves inside the rooms. The luminance inside the rooms of the buildings, were monitored. The built-up size of the structure was also noted down. Using builder's compass the orientation of the building was determined. If the longest size of the building is oriented towards North- South direction, then the orientation is represented by 1 and if it oriented towards East -West direction, then the orientation of the building is represented by 2.

Using lux meter, Thermo meter and psychrometer, the lux value, temperature and humidity at the centre of each room is noted along with season and time. A software programme was written in MATLABR2007b, the program was written in such a way that it takes the feed data directly from feeddata.xls.

4.0 RESULTS AND DISCUSSIONS

The data collected from the site is fed in ANN model and the following results were obtained. The ANN model shows the plot between the measured quantity (taken at site) verses predicted target by ANN for both training data set as well as validation data set. The co efficient of relationship between the above said two variables is significant for validation dataset than training dataset since the model is trained as well as validated with the known target. The coefficient of relationship for the plot shown in figure 4.1(after training) is 0.22977, where as for figure 4.2 (after validation) is 0.03292.

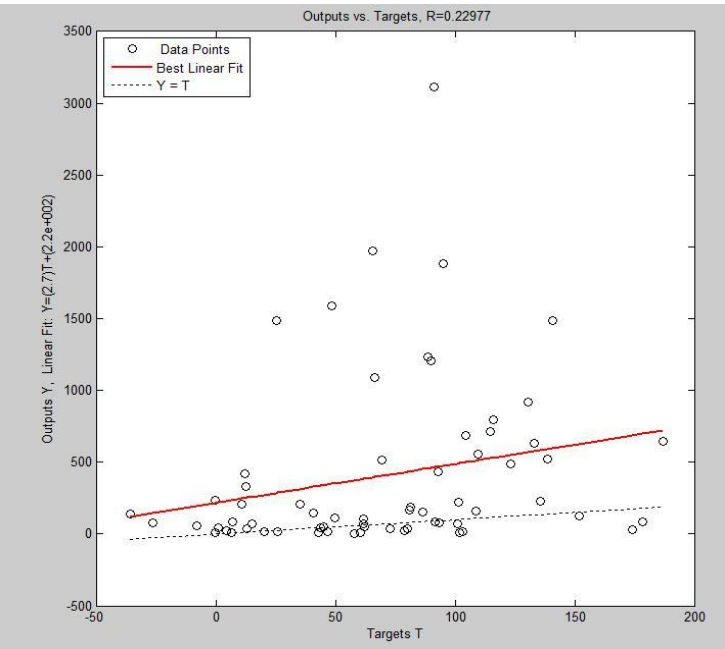

Figure 4.1 – The plot between measured output and target predicted by ANN for the training data set.

The linear relationship between the target and measured output is given as

$$Y = (2.7)T + (2.2e+002) \text{ ------- } \mathbf{(4.1)}$$

Where Y = Measured output and T = Target

The shape of the plotting points are in the shape of even triangle and the most of the points fall linearly and hence best fit line is almost a flat slope line.

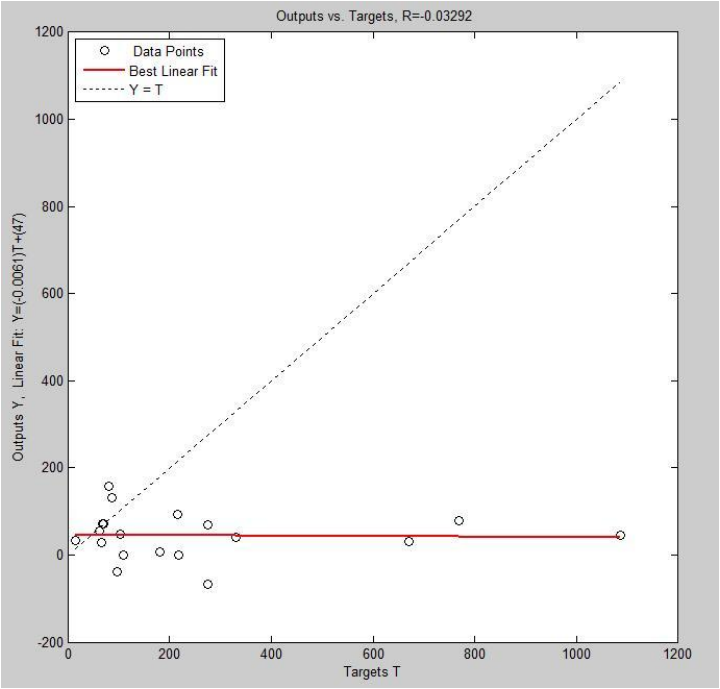

Figure 4.2 – The plot between measured output and target predicted by ANN for the validation set.

Figure 4.2 shows that the points are spread in a liner strip, and the relationship between target with measured output is

Y = (-0.0061) T + (47) ----- **(4.2)**

Where Y = Measured output and T = Target

The low value of co efficient of relationship for both the cases may be due to less number of dataset recorded, in other words if the number of dataset is more the coefficient of relationship might have been improved.

4.1. Prediction by ANN model for new set of input:

The ANN model gives necessary plots and becomes 'ready-to-use' model for predicting the target for new set of data. The ANN model delivers the input box (shown in figure 4.3) in which the new set of inputs can be entered so that the ANN model can predict the target and delivers the output in the output box (shown in figure4.4) .

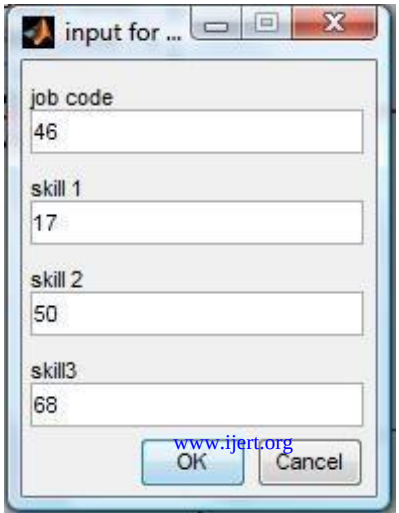

Figure 4.3 Input box

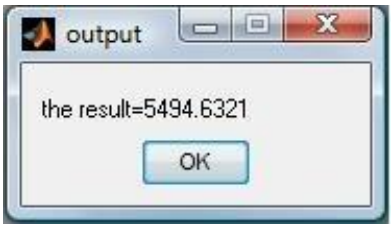

Figure 4.4 Output box

The correlation matrix reveals that the luminous intensity that is the output has the positive correlation with the independent variables.

6.0 CONCLUSIONS FROM ANN MODELLING:

The following conclusions are made from the ANN model,

- The ANN model can predict the target for any set of new inputs very near to the probable output.
- Based on the accuracy of prediction the ANN model is found to be best suited model for prediction of target for new projects.
- The ANN model, even though not explaining the relationship of input variables with the output variables, is the better tool for the accurate prediction of targets.

Openings

No	Flr	House facing	Orntn	Rm. Postn 8dir	L Ft	B Ft	Area Sft	W in L-Sft	W in B-sft	Tot W Sft	D in L Sft	D in B Sft	Tot D Sft	W/A L - %	W/A B-%	D/A L-%	D/A B-%	W+ L-s
1	1	1	1	2	20	16	320	18	42	60	119	0	119	5.63	13.1	37	0	137
2	1	1	3	8	11	11	121	20	0	20	21	0	21	16.5	0	17	0	41
3	1	1	2	6	11	5	55	18	0	18	21	17	38	32.7	0	38	31	39
4	1	1	2	4	11	8	88	55	0	55	21	42	63	62.5	0	24	48	76
5	1	1	1	4	16	8	128	18	0	18	21	21	42	14.1	0	16	16	39
6	1	1	1	5	16	11	176	26	20	46	21	0	21	14.8	11.4	12	0	47
7	1	1	2	1	11	5	55	60	24	84	0	0	0	109	43.6	0	0	60
8	2	1	2	3	20	8	160	36	12	48	0	63	63	22.5	7.5	0	39	36
9	2	1	2	6	11	10	110	0	16	16	0	21	21	0	14.5	0	19	0
10	2	1	1	1	11	10	110	16	0	16	0	21	21	14.5	0	0	19	16
11	2	2	1	8	10	8	80	15	0	15	21	0	21	18.8	0	26	0	36
12	2	2	2	3	20	10	200	30	12	42	21	42	63	15	6	11	21	51
13	2	2	1	5	11	10	110	0	16	16	0	21	21	0	14.5	0	19	0
14	2	2	1	5	11	10	110	16	16	32	0	21	21	14.5	14.5	0	19	16
15	2	2	1	4	10	8	80	15	0	15	21	0	21	18.8	0	26	0	36
16	1	2	1	1	10	6	60	20	20	40	21	0	21	33.3	33.3	35	0	41
17	1	2	2	1	16	10	160	45	0	45	88	42	130	28.1	0	55	26	133
18	1	2	1	4	10	8	80	12	0	12	21	0	21	15	0	26	0	33
19	1	2	2	5	10	8	80	22	0	22	0	42	42	27.5	0	0	53	22
20	1	2	3	8	10	10	100	22	0	22	21	0	21	22	0	21	0	43
21	1	2	1	5	11	10	110	14	22	36	21	0	21	12.7	20	19	0	35
22	1	3	2	4	16	8	128	96	18	114	56	0	56	75	14.1	44	0	152

23	1	3	2	3	16	11	176	112	0	112	84	28	112	63.6	0	48	16	196
24	1	3	3	4	11	11	121	0	42	42	0	28	28	0	34.7	0	23	0
25	1	2	1	4	14	11	154	0	54	54	0	28	28	0	35.1	0	18	0
26	1	3	1	7	16	11	176	40	0	40	28	0	28	22.7	0	16	0	68
27	1	3	2	3	16	11	176	0	36	36	56	28	84	0	20.5	32	16	56
28	1	3	3	4	11	11	121	21	0	21	28	0	28	17.4	0	23	0	49
29	1	3	2	2	11	10	110	15	0	15	0	25	25	13.6	0	0	23	15
30	2	3	2	4	16	11	176	5	0	5	28	56	84	2.84	0	16	32	33
31	2	3	2	5	11	8	88	45	0	45	28	0	28	51.1	0	32	0	73
32	2	3	1	4	14	11	154	9	54	63	0	28	28	5.84	35.1	0	18	9
33	2	3	1	6	20	11	220	30	0	30	56	0	56	13.6	0	25	0	86
34	2	3	1	8	16	11	176	15	17.5	32.5	21	21	42	8.52	9.94	12	12	36
35	2	3	2	2	10	8	80	0	17.5	17.5	25	25	50	0	21.9	31	31	25
36	2	3	1	1	16	11	176	17.5	17.5	35	28	0	28	9.94	9.94	16	0	45.
37	1	3	2	5	26	6	156	100	0	100	22	0	22	64.1	0	14	0	122
38	1	3	1	4	12	14	168	0	0	0	18	18	36	0	0	11	11	18
39	1	3	1	4	12	14	168	0	9	9	18	18	36	0	5.36	11	11	18
40	1	3	2	7	11	6	66	24	0	24	18	0	18	36.4	0	27	0	42
41	1	3	1	6	12	14	168	21	0	21	23	0	23	12.5	0	14	0	44
42	1	3	2	1	11	6	66	0	0	0	21	0	21	0	0	32	0	21
43	1	3	2	1	6	5	30	0	0	0	0	42	42	0	0	0	140	0
44	1	1	2	2	30	6	180	100	0	100	21	0	21	55.6	0	12	0	121
45	1	1	1	2	12	14	168	0	6	6	0	42	42	0	3.57	0	25	0
46	1	1	1	2	12	14	168	0	12	12	21	0	21	0	7.14	13	0	21
47	1	1	1	5	11	6	66	7.5	0	7.5	36	18	54	11.4	0	55	27	43.
48	1	1	1	4	11	6	66	7.5	0	7.5	0	18	18	11.4	0	0	27	7.5

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