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Temperature, Humidity and CO_2 Information Estimation of Indoor Sports Hall Environment by Using Artificial Neural Nets

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Abstract

In hot weather, humidity content affects adversely the human body. It causes body fatigue and slowness in metabolism by excessive sweating and increased body temperature. If the relative humidity rate is 100% , there won't be sweating and the body temperature will rise. The rise in body temperature can lead people to death. Moreover, high amounts of CO_2 in the air accelerate fatigue. Reach of indoor area temperature, humidity and CO_2 amounts to hazard level leads to very serious problems. In this study, totally seven features as the highest and lowest temperature of the day, the highest and lowest humidity content of the day, number of spectators, direction of wind, weather events on the day of match are obtained. During the match, a data pool is generated by taking temperature, humidity and CO_2 information of the environment. Humidity and temperature values of indoor environment are taken by DHT11 temperature and humidity sensor and CO_2 sensor, then they are transferred to Arduino Mega 2560. With the help of Arduino Mega 2560 card, humidity, temperature and CO_2 values have been measured in real time. Using this obtained data pool and artificial neural nets, an expert system has been designed. In this expert system; these ten obtained features have been used as input data, and temperature, humidity and CO_2 data have been used as output data. Through this system, temperature, humidity and CO_2 information of the environment during the match to be held have been estimated at very close value. In addition, using this system, adverse conditions that may occur in indoor sports hall can be estimated and necessary measures can be taken.

Keywords: Estimation of temperature and humidity, artificial neural nets, expert systems, arduino, sensors

Introduction

Factors that create temperature are air temperature, relative humidity and wind speed. Incase air temperature is higher than 20 C^o,; fatigue, tiredness, irascibility, carelessness, increase in errors, muscle diseases may arise. Therefore, the temperature of the indoor sports halls must be kept at desired level.

Our body generates heat with the power spent at sports trainings and competition. Moreover, environmental factors also affect the body temperature. An adult human body temperature is 36,5 C^o. Extreme heat and cold affect human body adversely. In order to maintain normal body temperature, it is required to get rid of undesired heat in the body. Body temperature should be required to be reduced. For this, sweating may turn body back to normal body temperature with the removal of excessive heat through respiration. Good performance and health of our body is necessary for life and it can be reached by keeping body temperature at normal level (Fridlund, L. 1987).

In case of low temperature, it causes shivering and loss at tactile sensation (Hayta, A. B. 2007).

During sports activities and CO_2 consumption increases by increased number of people at indoor area, CO_2 forming increases in connection with this. When CO_2 amount created by people in indoor areas is above 1000 ppm in accordance with ASHRAE standard, headache, dizziness, visual disturbances may occur (Volkov, O. 2014; Daisey, J. M et al., 2003).

When assessing air conditions at indoor sports halls, it must be assessed by measuring air temperature, relative humidity rate in the air, radiation temperature, air flow rate, number of spectators and CO_2. For this, values taken from Amasya Provincial Directorate of Meteorology and Indoor Sports Hall are used. When measured values and found values were compared, quiet good results were obtained found results may have positive benefits for the health and performance of athletes.

Materials and Methods

Materials

Meteorological data used in the study have been taken from Amasya Provincial Directorate of Meteorology. These data include the highest and lowest temperature of the day, the highest and lowest humidity rate of the day, direction of the wind and weather events. Number of spectators attended to activities held in indoor sports hall was taken from Provincial Directorate of Youth and Sports. Information of temperature, humidity and carbon dioxide amounts for indoor sports hall were obtained by establishing measurement system. In this way, for 94 different time, 94x10 size property set including the highest and lowest temperature of the day, the highest and lowest humidity rate of the day, direction of wind, weather events, number of spectators, temperature of the hall, humidity of the hall and amount of carbon dioxide were created. Some examples of property set are given at Table 1.

Table 1. Example test training information to be used in ANN

No	Min. Temperature	Max. Temperature	Wind Direction	Min. Humidity	Max. Humidity	Event	Number of Spectator	Temperature of the Hall	Humidity of the Hall	CO_2 amount
1	2	5,5	4	32	92	0	75	4,8	43	1612
2	4,6	11,1	4	32	82	1	80	6,8	43,6	1620
3	-0,6	14,2	7	32	84	0	140	7,6	43,9	2340
4	1,1	16,7	7	35	85	0	130	8,3	43,7	2310
5	0,7	17,7	7	21	78	0	157	8,4	47	2286
6	7,9	8,9	4	34	86	1	45	8	43,2	1683
7	1,5	3,7	4	46	70	2	103	3,6	47,1	1823
8	-1,1	9,2	4	37	85	1	189	10	44,6	2310
9	-1,7	11,5	3	35	87	0	50	10,2	43,2	1845
10	-2	12,6	6	27	85	0	34	10,3	43,3	1780

Temperature and Humidity Measurement

In this study, temperature and humidity measurement were conducted by using DHT11 sensor. DHT11 is an advanced sensor which is calibrated and gives digital signal output. It has high reliability and is balanced at long-term studies. This sensor, including 8-bit microprocessor, offers fast and quality response. This sensor, which can measure temperature with 2 C^o error margin between 0 and 50 C^o, can make humidity measurement with 5% RH error margin between 20-90% RH (http://www.robotistan.com/dht11-isi-ve-nem-sensoru-kart 05 May ,2016).

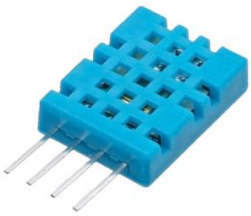

Figure 1. DHT11 sensor

Carbon dioxide Measurement

For carbon dioxide measurement, MG-811 CO_2 sensor card was used. This sensor card, which works highly sensitive, is affected very little from alcohol and CO gas. It can be used for air quality control, fermentation process, indoor air monitoring applications. It can be used successfully in air quality control, fermentation process, indoor air monitoring applications. Output voltage of MG-811 CO_2 module is reduced by the increase in CO_2 amount. Analog and digital output signal can be given (http://sandboxelectronics.com/?product=mg-811-co2-gas-sensor-module (05 May, 2016).

Figure 2. MG-811 CO2 sensor

Signals from sensors are applied to inputs of Arduino Mega 2560 controller. The obtained measurement results are transferred to LCD screen. Block of measuring assembly is shown in Figure 3.

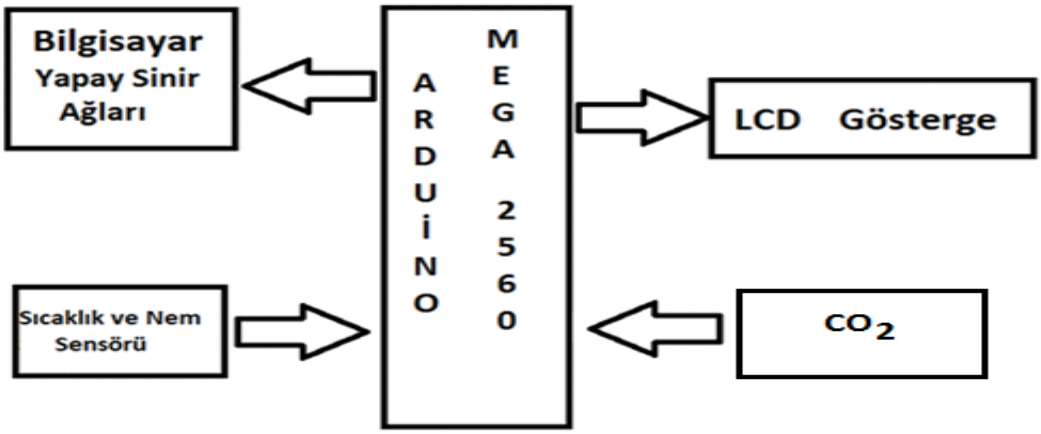

Figure 3. Block Image of Measuring Assembly

Artificial Neural Nets (ANN) based Weather Forecast

Artificial Neural Nets (ANN)

Artificial Neural Nets (ANN) are defined as a system which are developed by imitating human nerve cells, are connected to each other through weighted connections, can perform complex functions related to learn of digital computer (Keleşoğlu et al., 2006 ;Çuhadar et al., 2005;. Terzi ,2006).

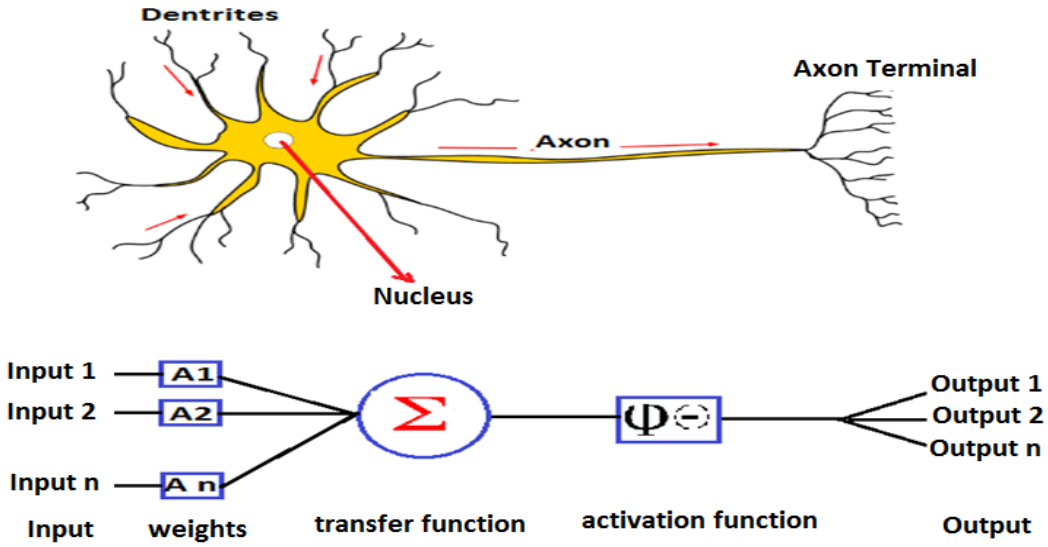

Figure 4. Artificial Neural Nets Model (http://dca.iupr.com/lectures/lecture08-classification-with-neural-networks 05 May,2016)

By Artificial Neural Nets (ANN), by imitating function of basic biological nerve cells and making modeling, a functionality feature similar to human brain is brought (Keleşoğlu at al (2006). The imitated nerve cells include neurons and these neurons form network by connecting each other in various ways. By using complex system information, Neural Nets can bring solution to problem by revealing the relation between learning, storing and data (Karaatlı et al ,2012).

Structures of Artificial Neural Nets

Structures of Artificial Neural Nets can be classified differently. There are a wide variety of Artificial Neural Nets (ANN). In this study, only feed-forward or feed-backward neural networks are mentioned.

Feed-forward Artificial Neural Nets

In feed-forward artificial neural nets (ANN), there is a network structure in which data are given forward to input layer, intermediate layer and finally output layer respectively. Data given to input layer are given to intermediate layer without being modified. It is in the structure in which data are modified according to their weights in intermediate layer and then are advanced to output layer (Kaya et al. ,2011;Yavuz et al.,2012).

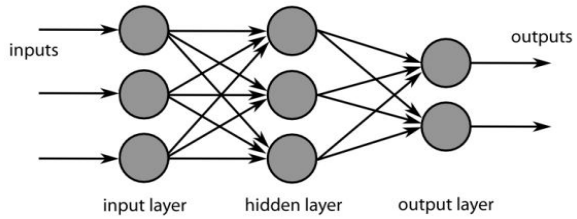

Figure 5. Forward artificial neural nets

Feed-backward Artificial Neural Nets

Feed-backward artificial neural network firstly was introduced in 1974 by Werbos. Feed-backward ANN showed its availability with the help of computer experiments by Rumelhart, Hinton and Williams in 1986 (Akyürek, H. A. (2013).

Typical back propagation network has an input layer, an output layer and at least one hidden layer. It doesn't have any theoretical limit on the number of hidden layer but in general there are only one or two. Some studies showed that number of layers required to solve any complex problem is five (an input layer, three hidden layers and an output layer). Each layers are connected to completely successful layer (http://www.solver.com/xlminer/help/neural-networks-classification-intro,01 May,2016).

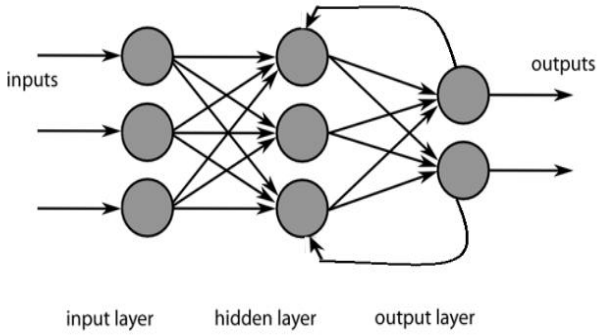

Figure 6. Feed-backward artificial neural nets

Cross verification method

In cross verification method, data set must be separated into two groups. While model parameters taking part in the first group are used for training, parameters taking part in the second group are used for the purpose of testing (Narin et al., 2014).

K-Layered Cross Verification Method

K-layered cross verification method is a technique used widely for estimating the performance of a system. K-layered cross verification will be tone K times. At each stage, one layer takes set verification role while other remaining parts (K-1) training sets.

At k-layered cross verification method, at first a k value is selected. Test pieces are trained with k-1 parts and remained part is used for the purpose of testing (Kırlıoğlu et al., 2014).

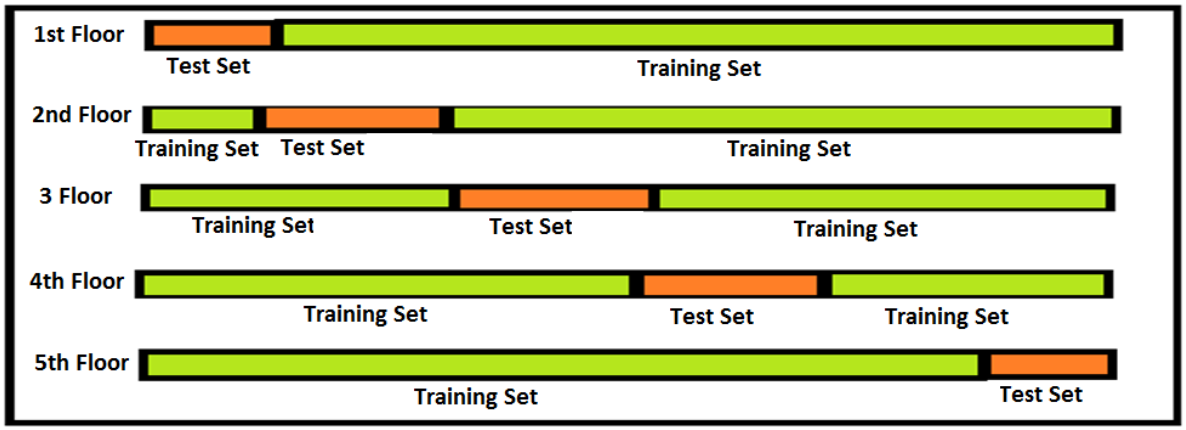

Figure 7. 5-layer cross verification model (Mitchell, T. M. (1997).

Layered Cross Verification Method

In this study, 5 layered cross verification was used to assess the performance of artificial neural network based on weather estimation. By separating 94x10 dimension property set into five parts, training and testing data were determined. 80% data were used for training and 20 % data was used for testing. Bu using each part for training and testing respectively, success of the system was calculated and sample results of success rates are given in Table 2.

Table 2.

Calculated Hall Temperature	Calculated Hall Humidity	Calculated CO2 amount	Measured Hall Temperature	Calculated Hall Humidity	Calculated CO2 amount
0,0794896	0,377339	0,122688	0,048387097	0,411764706	0,1605042
0,292974	0,406373	0,201763	0,129032258	0,422794118	0,16386555
0,174029	0,441189	0,549277	0,258064516	0,441176471	0,45378151
0,613077	0,581434	0,227384	0,552419355	0,431985294	0,28151261
0,618442	0,857307	0,276251	0,536290323	0,944852941	0,2605042
0,872832	0,487712	0,669256	0,766129032	0,422794118	0,68613445

Experimental Results

Artificial Neural Network based on forecast results and the actual values are given in the tables below. By examining Indoor Sports Hall temperature graphics obtained by 5 layered cross verification method, it was recognized that actual and calculated temperature values had been calculated with 92,3% success. Actual and calculated temperature graphic of Indoor Sports Hall is given at Figure 8.

Examining the actual and calculated Humidity graphic of Indoor Sports Hall given at Figure 9, desired humidity data at 93,57% rate was approached. According to this success rate, the system has calculated the humidity rate quite correctly.

Examining actual and calculated CO_2 graphic of Indoor Sports Hall given at Figure 10, it was seen that CO_2 amount at 92,80% rate had been calculated at a rate close to the real time.

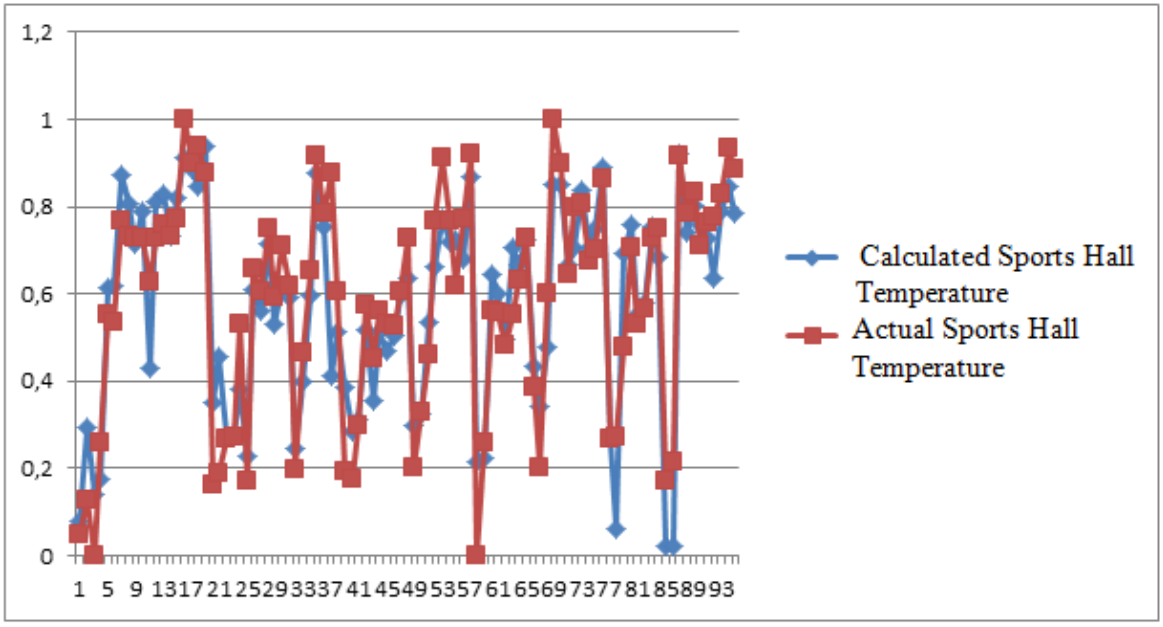

Figure 8. Comparison of Amasya Indoor Sports Hall's actual and calculated temperature values

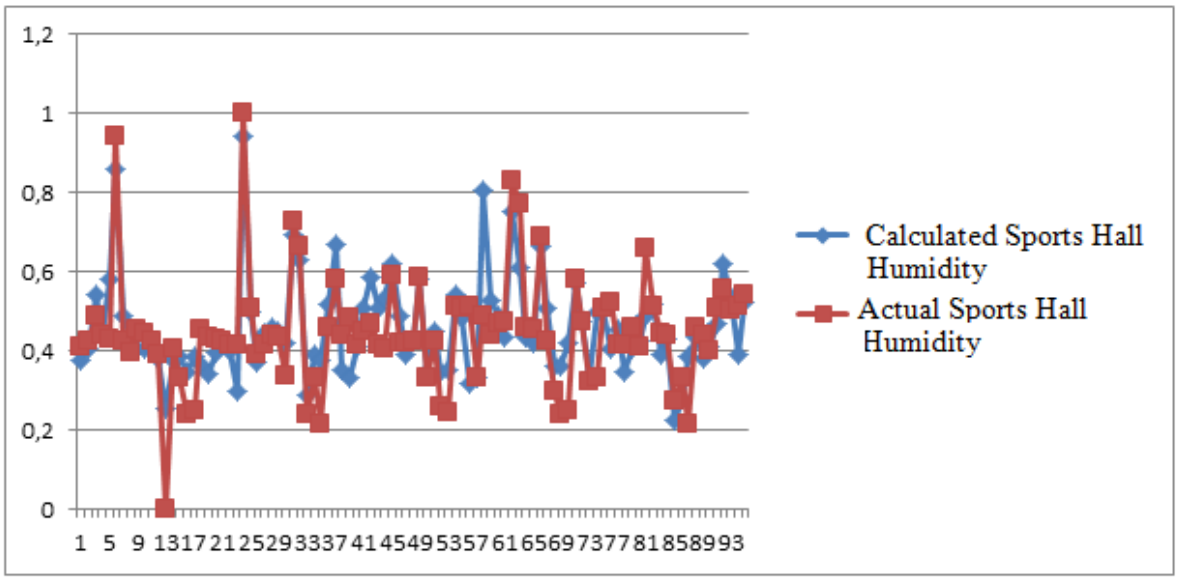

Figure 9. Comparison of Amasya Indoor Sports Hall's actual and calculated humidity values

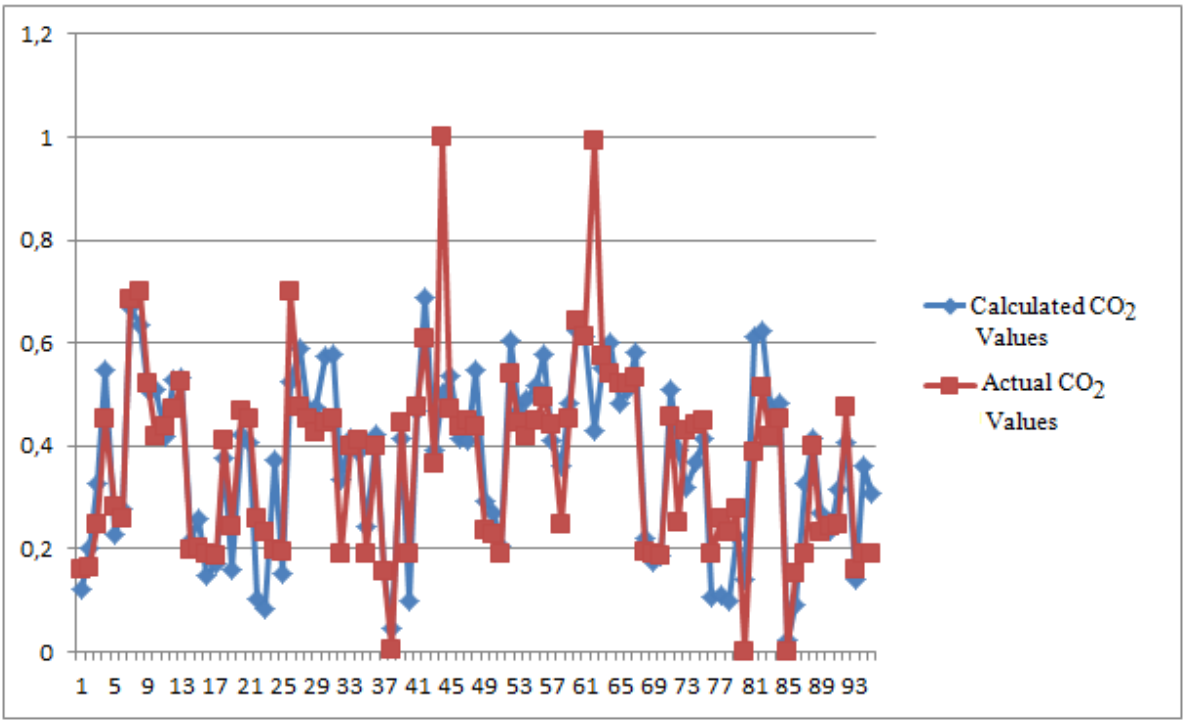

Figure 10. Comparison of Indoor Sports Hall's actual and calculated CO_2 values

Results

This study is preliminary for the estimation of temperature, humidity and CO_2 values in Indoor Sports Hall by using artificial neural nets. Temperature value was measured by 92,3% fault, humidity value was measured by 93,57% fault and CO_2 value was measured by 92,80% fault. Found temperature, humidity and CO_2 values were found close to their actual values, the system made by us worked successfully. According to the results of this study, it has been found that temperature; humidity and CO_2 values at Indoor Sports Hall can be estimated successfully with the use of estimated Artificial Neural Nets.

It is suggested that, estimating the temputure, humidity and CO_2 values in door environments, arranging the working hours and the air conditions including heating and cooling, it is possible to save money.

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