Intelligent Architecture for Illumination Control in LED Lighting System

M. Rahasudha, S Vinothini, M. Mathankumar

Abstract: ***Nowadays energy consumption in buildings largely depends on the lighting system. To get light naturally Sun is the source but it is not available all the time. Hence we are always in need of an artificial source to produce light. This artificial source should contribute in energy consumption. Therefore, the selection of luminaries should be better in the working environment. In this paper, Light Emitting Diode (LED) based lighting system is implemented. The illumination control is not based on sensors for LED lightings which are networked. In order to model all nonlinear and linear relationship, a scheme is introduced which has Multiple Inputs Multiple Outputs (MIMO) and closed loop neural network. Since the scheme does not depend on lighting simulation software, microcontrollers are used in the hardware setup for easy implementation and flexibility. Light sensors are not used in control loops for energy saving. Hence, the installation will be easy and accuracy will also be high. The closed loop neural network system has faster response. In addition with this, buzzer circuit is included for safety measures within the buildings.***

Keywords:IlluminationControl,Energysaving,LEDLightingSystem,Feedbackcontrol,MIMO,PIC,Skinrange

I. INTRODUCTION

In today's environment energy conservation becomes a major topic for researchers, due to increase in demand of energy for various domestic and industrial purposes. Among all energy, electrical energy is more needed and particularly light energy consumption is more. For energy conservation the first thing to be noted is the light energy because it consumes 20 to 35 % of total energy. Sun is the natural source of light. But it is not that we get all energy from sun for lighting system. Therefore we have artificial lighting system to supply light. More than the domestic purpose, the main need for lighting is in the working environment. For this we should also consider the configuration of the working environment where daylight effect will takes place and the luminance on one table will affect the other [1] [2].

The source of artificial light that is being selected should also be noted. Nowadays LED's are used widely which comes under solid state lighting technology. LED's are considered here because they have much advantage over the other lighting system. By analyzing an optical system that constitutes LED, it is known that LED can be simulated easily.

It can be modeled as directed and extended source. High accuracy can be obtained using an extended source [3]. The other advantage of using LED is that they can work under three working conditions and they are near, mid, and far-field [4]. To control the luminance of LED, a network is formed. Light sensors are placed to sense the amount of light that is emitted. When office configuration is very large it is difficult to group sensors with luminaries and hence optimal control is not efficient. Hence sensorless technique for illumination control is used here. A feed forward system is used to adjust the illumination. There exist a relationship between table luminance and dimming level of luminaries.

Hence to map the relationship among them neural network is used. A computing system, which response dynamically to external inputs is known as neural network. The system has simple and highly interconnected processing elements by which the information is processed in a very fast manner. Neural network will consider the whole office configuration as a black box and hence there is no need that the configuration of the office should be known for its working. This is an advantage and hence it can be applied to any configuration [5] [6] [7] [8].

These can all be done in software part. To execute the same in real time some hardware integrated board is needed. Here microcontroller acts as a heart of the system, Zigbee for both transmitting and receiving data, driver circuit to supply proper voltage to the component connected with the personal computer (PC). It acts as an interface between hardware and software, for safety measure we use buzzer to alert the users [9].

II. RELATED WORK

R.KalaRanjani et al [10] explained about the technique used to control the illumination of LEDs without any sensors. No sensors were placed to measure the luminance instead of that cameras are used to capture the image which is given to neural network for analyzing. The purpose of using neural network here is that there is no need to know the configuration of any environment. It will consider the whole office configuration as a black box. The illumination control is done by using pulse width modulation (PWM) technique. Another advantage of using neural network is depends upon the application and the number of layers can be increased to store the input value and from that the output can be obtained.

D.Caicedo et al [11] deals with the problem of local sensing and actuation capabilities of luminaries. To attain

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daylight integrated spatial illumination, distributed illumination control is considered. The target illumination at the light sensor is given by the mapped value of the illumination in the respective zone. The dimming level is determined by the neighboring controller's co-ordination and sensing information. The algorithm used here is DCA (Distributed Control Algorithm). For achieving the sensor values of target and light, many conditions are given sufficiently for the working of algorithm. This advancement in sensor technology will help in minimizing detection error and the obtained illumination is nearly equal to the desired level.

M.S.Shur et al [12] proposed an alternative to electrical lighting, which generates white light from the source. At first pyro luminescence and torches were used. Peculiarities in semiconductor are made to glow LED in narrow band spectra, but they are colored and so the technology requires white light. Two approaches are used. First, one is the replacement of florescent lamp with cheap single chip device. Second, one is revolution technology i.e. dynamic control of colors.

Z.Z.Wang et al [13] implemented a system where dimming levels of luminaries are related to the power it consumes. A mapping is required to relate the dimming level of luminaries and table luminance. A test bed is taken where all the luminaries are DALI (Digital Addressable Lighting Interface) controlled. The tables are not highly partitioned and hence the effect of one luminary can affect other tables. A technique called Functional Approximation from Neural Network is used to know the relationship between luminaire dimming value and table luminance. The data has to be trained and divided into three subsets as Training, Validation and Test set. For meeting various illumination preference and maximize the energy conservation the system is considered as a whole.

III. PROPOSED DESIGN

The training of neural network with input images are done in the personal computer. All possible configurations of the environment is captured and given to the neural network input node for training them. The images are processed and a command is defined for each images. For illumination control the office configuration is monitored using the camera. At equal interval of time, the camera will capture images and send it to the personal computer.

The Fig.1 shows the system block diagram. The images are compared with the data set and the corresponding command is transferred to the PIC microcontroller using RS232 and Zigbee. Zigbee will act as both transmitter and receiver. With PC, the Zigbee will act as transmitter. Along with microcontroller it will act as receiver. For the working of microcontroller power supply is given. Pulse Width Modulation and LED driver are used to adjust the illumination of LED connected. Here PWM acts as a Digital-Analog converter and the illumination will be adjusted. LED drivers are used to supply a constant output voltage for LED. To display the amount of power consumed, LCD is used here. Thus without using sensors luminance of the system is controlled. In addition to this, it can also be used for security purpose.

While training the neural network images with fire occurrence is also given which will be useful when the image is detected with fire. Now the microcontroller will set the buzzer ON indicating that the fire has occurred. For proper supply of power to the buzzer driver circuit is connected across it.

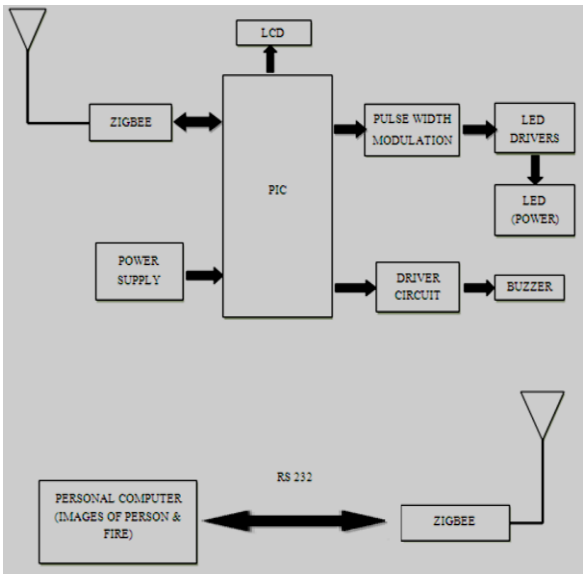

Fig.1. System Block Diagram

IV. SYSTEM ARCHITECTURE

A. Zigbee

Zigbee is a wireless communication transceiver employed to transmit and receive the information between a numbers of nodes. It operates on IEEE 802.15.4 standard and implements direct sequence spread spectrum technique to achieve secure data communication and minimize the consumption of power. This system uses Zigbee technology, due to its automatic end-to-end acknowledgement property. It augments reliability and battery life through mesh networking and multicasting. Zigbee network includes a coordinator node and number of client nodes/end devices.

B. PWM (Pulse Width Modulation)

It is nothing but a modulation technique which is used to control the supplied power to the electrical device by adjusting the width of the pulse. This is done by turning the switch between supply and load ON and OFF at a fast pace. Thus the average value of voltage which is given as an input to the load is controlled. The power supplied to the load depends on the switch ON time.

PWM is considered to be an alternative to DAC, because the signal from the processor to the digital system remains digital. PWM is a best and efficient technique which is used for controlling analog circuits with the digital output that we get from microprocessor. Noise is reduced as a result of keeping the signal digital.

C. PIC Microcontroller

Here the PIC16F877A microcontroller is used to control the process. It operates 8 bit data and follows RISC architecture which makes the system design less complex. This version is most commonly used because of its cost effectiveness and reliability. The microcontroller has program memory of 14.3 KB, an inbuilt ADC and Watchdog timer. For this system the USART port in the controller is enabled for serial communication with Zigbee.

V. SIMULATION RESULTS

The project coding is done in MATLAB and the illumination is controlled using hardware. Fig.2 shows a sample coding screen shot. In simulation, the number of persons present will be counted which is used to control luminance. To calculate the number of persons present we have to calculate the skin range, which is the summation of bounding box value, area and holes value of the image.

The images are collected to form a database for luminance control. The images that are used can be of any number to train the neural network. Then the accuracy in the output will be increased. Fig.3 shows a sample image used to train the neural network. When the image is processed in MATLAB first the color image is converted into gray scale and then to DWT (Discrete Wavelet Transform). From this the skin range is calculated. Fig.4 represents skin range and counting of individual persons in a room using MATLAB.

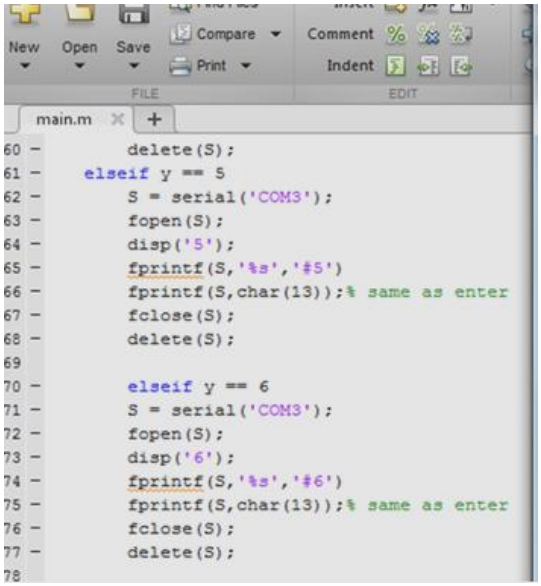

Fig.2. Screen Shot of Sample Program

Fig.3. Input Image to neural network

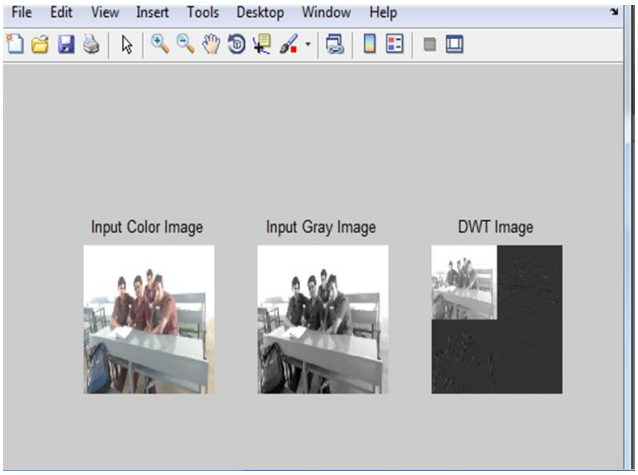

Fig.4. Screen Shot of Processed Image

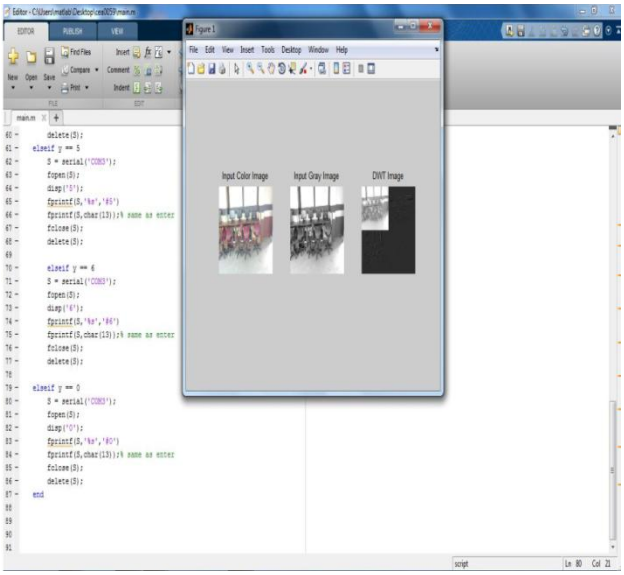

Fig.5. Simulation output without human occupancy

Fig.5 shows the simulation output for a room without human occupancy and Fig.6 shows the output when fire occurs.

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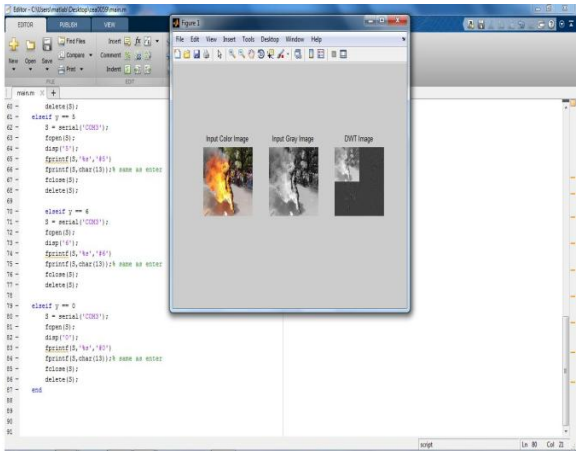

Fig.6. Simulation output when fire occurs

VI. HARDWARE IMPLEMENTATION

This approach is very easy to implement on personal computer with common programming software like MATLAB. Hardware is built using the PIC microcontroller with additional Flash memory and EEPROM. Fig.7 gives the hardware module for the system. The purpose of using these two memories is to store the updated data for the neural network. Program code is simulated in MATLAB version7.8.0 (R2009a). Using MPLAB software PIC programming is done. Then the number of persons present in the given image can be obtained. Using that information, the illumination can be controlled. Here the LEDs are grouped together using power line communication protocol.

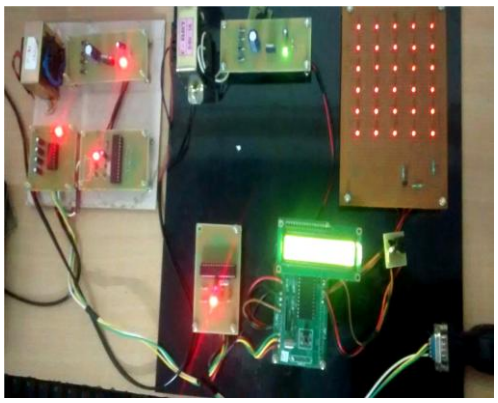

Fig.7. Hardware Module

VII. CONCLUSION

In all previous systems, the illumination is controlled using some light sensors, so the illumination control is not accurate. The selection of luminaries is also considered for power consumption and efficiency. This paper gives an illumination control approach in a sensor-less way for the LED lighting system, which is networked. The illumination control is done in variety of configurations, but no fixed configuration is used. The proposed system adopts a feed forward neural network approach to tackle the non-linearity characteristics of the lighting system. Along with the illumination control, a fire alarm is placed which provides safety for the office. Therefore, it has a merit of low cost, flexibility, easy installation, fast response and high accuracy. Hence the energy saving is done at a large scale.

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