SMART WORK SPACE USING PIR SENSORS

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Abstract

Smart work space is a reasonable scenario for evaluation of the smart spaces paradigm maturity. In this paper, we come across how to sense the number of occupants in the work space with the help of PIR sensors and automatically switch the lights ON/ OFF based on occupancy. We can be able to analyze the usage of the work space, number of persons present in the work space, the time for which lights are on and the power consumed. Using this sensing information, we propose a implementation module which is used to adapt the dimming levels of the light such that the desired lighting levels are achieved at the work space level.

1.INTRODUCTION

A major portion of electrical energy consumption in commercial office buildings is used for artificial lighting. On the system level, the energy consumed in artificial lighting may be reduced by adapting the artificial light output to daylight and presence conditions. In order to obtain this information, PIR sensors can be used. Lighting levels can be monitored using light sensors. In industry practice, light sensors are located at the ceiling. An initial calibration phase with light meters is hence required to map the illuminance values at the work spaces to the ceiling light sensors. A disadvantage of such calibration is that if the environment at the work space changes, the initial calibration becomes invalid and lighting control is ineffective in achieving the desired illuminance values at the work spaces. There are three types of occupancy sensors, passive infrared (PIR), ultrasonic, and dual-technology. [6] The capabilities of each type of sensor will determine its application and may require different installation procedures.

2.RELATED WORK

A number of smart lighting systems have been designed to adjust the lighting condition according to the occupancy in the work space and for the power consumption. For example In 2006, an author proposed a smart building automation solution using a combination of PIR sensors and magnetic reed switch door sensors . Recently, British University developed a lighting control application using networks of PIR sensors. In 2010, there was the problem of how to optimize the dimming levels of LED fixtures based on space occupancy information . A review paper by Georgia university, has comprehensively discussed different sensors that have been used in occupancy-based lighting control systems, including PIR sensors, ultrasonic sensors, audible sound sensors, and pressure sensors where PIR sensors use infrared and ultrasonic sensors. Also, a PIR sensor detects the infrared radiation emitted from an object, so it works well for detecting people and other human beings. The gradient change in the infrared field can be used to detect motions of people, thus enabling applications such as finding the number of occupants in the work space and automatically-activate the lighting systems. Thus, any object that affects the visible light could be detected.

3.SYSTEM ARCHITECTURE

Different system architectures of smart lighting systems that depends on factors such as

(i) the size of the spaces,
(ii) the number of occupancy sensors,
(iii) the communication between controllers and
(iv) the location of light sensors.

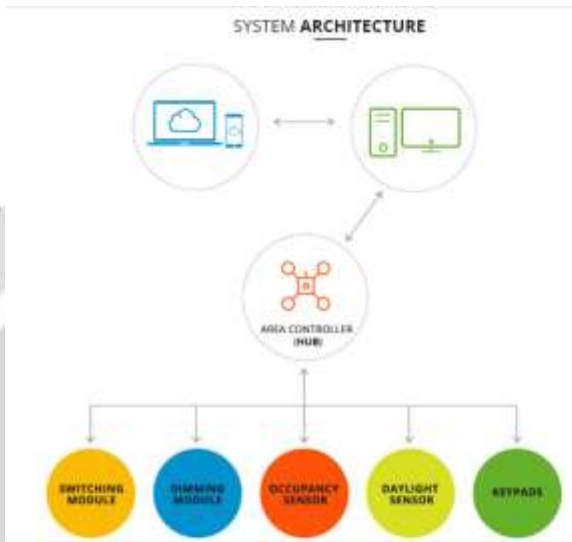

Fig 1: System architecture

The architecture used for smart lighting systems in work space consists of a single control zone, one or multiple LED luminaires, a binary PIR sensor, a single light sensor and a single controller.[1] Here, we present the components of the architecture. The controller, the binary PIR sensor, the light sensor and the luminaire which are depicted by a triangle, diamond, circle and square, respectively. Here, we also show the connection between the controller, light sensor and PIR sensor. [2][4]In the architecture, the occupancy information from the PIR sensor is used by the controller to determine whether the smart lighting system has to be activated or not. If the smart lighting system is activated, the illuminance measurement from the light sensor is used by the controller to adapt the dimming by the LED lights such that the illuminance requirement at the light sensor is achieved.

4.WORKING

The PIR Sensor's Data OUT Pin is connected to Arduino's Digital I/O Pin 8.As shown in fig 2. an LED is connected to pin 13 of Arduino to indicate whether the light is turned ON or OFF. The IN1 pin of the Relay Module is connected to Pin 9 of Arduino. A bulb is connected to mains supply through relay. [5]One terminal of the bulb is connected to one wire of the mains supply. The other terminal of the bulb is connected to the NO (Normally Open) contact of the Relay Module.COM (Common) contact of the Relay is connected to the other wire of the mains supply.

The smart work space uses Arduino and PIR Sensor , where the lights in the room will automatically turn on upon detecting a human motion and turn off as soon as there is no motion in that space. Working of this module is explained very clearly from the fig. 2.

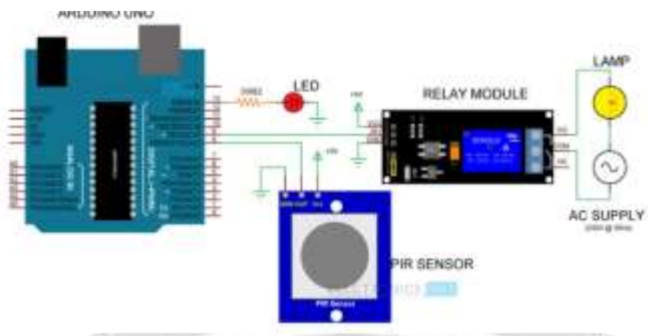

Fig 2: Circuit Diagram

Initially, when there is no human movement, the PIR Sensor doesn't detect any person and its OUT pin stays LOW. As the person enters the room, the change in infrared radiation in the room is detected by the PIR Sensor. As a result, the output of the PIR Sensor becomes HIGH. Since the Data OUT of the PIR Sensor is connected to Digital Pin 8 of Arduino, whenever it becomes HIGH, Arduino will activate the relay by making the relay pin LOW (as the relay module is an active LOW module).This will turn the Light ON. As in fig 3, the light stays turned ON as long as there is movement in front of the sensor. If the person takes a nap or leaves the room, the IR Radiation will become stable (there will be no change) and hence, the Data OUT of the PIR Sensor will become LOW. This in turn will make the Arduino to turn OFF the relay (make the relay pin HIGH) and the room light will be turned OFF.

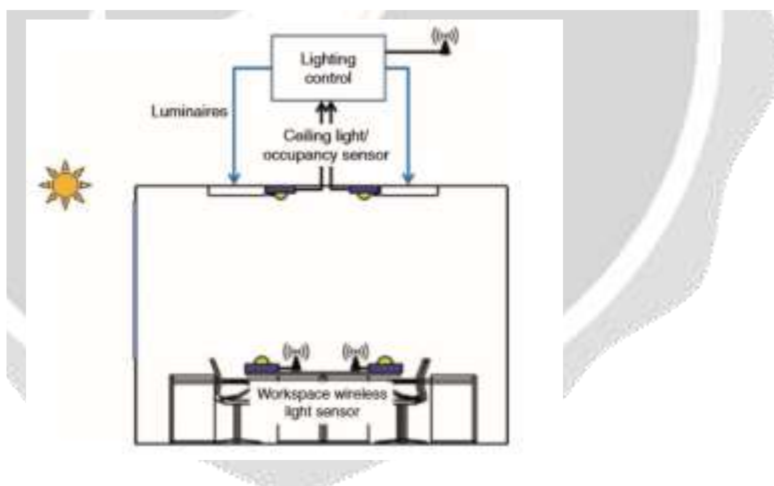

Fig 3:Work space setup

Tested setup:

A related work has been done in the past by the students of Stanford University. The content below describes the whole experiment.

The goal of the system is to achieve occupancy-detection smart lighting. [2]In other words, when the occupancy distribution in the room changes, the system should produce the lighting condition that suits the occupancy scenario to maximize comfort and minimize energy consumption. In most cases, by "occupancy distribution", which means the number of spatial locations for people in the room. For this purpose, there should be a control strategy module and an occupancy sensing module, and they should work in two alternating stages: the sensing stage and the adjustment stage. In the sensing stage, the occupancy sensing module collects the sensor readings to estimate the occupancy distribution; in the adjustment stage, the control strategy module decides what lighting condition should be produced based on the estimated occupancy distribution. Currently our main scope is towards the occupancy sensors.

5. ALOGORITHM:

In many multi-source multi-sensor systems such as sonar, ultrasound, the process of the system follows an affine relationship:

$$y = Ax + b, \quad (1)$$

where vector x is the input signals to all sources, and vector y is the measurements from all sensors. The matrix A can be understood as the coefficients of the process, and vector b is the systematic bias.

Eliminating b. To eliminate the ambient light response from Eq. (1), we proceed as follows. We first set the LED input to a reference level x0, and the output of the sensors is

$$y0 = Ax0 + b. \quad (2)$$

Now if we add a small perturbation δx to the input, the new output becomes

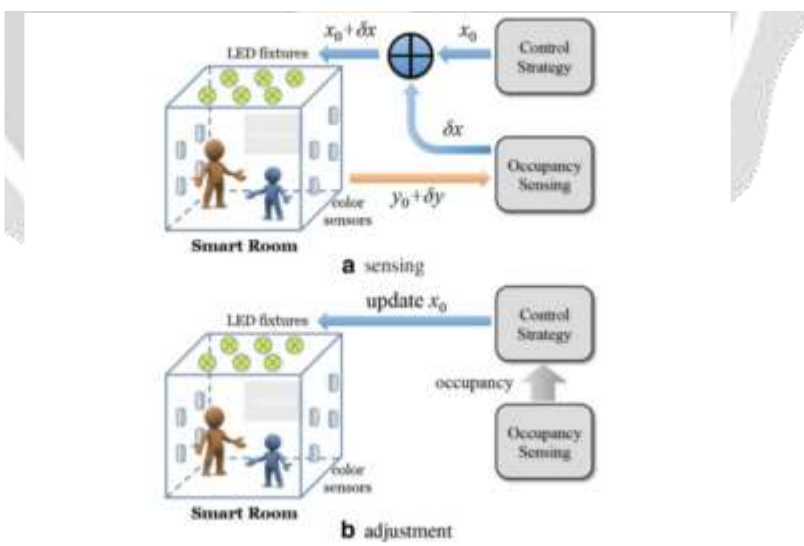

Fig 4: Two stages of the lighting system.(a)In the sensing stage, the occupancy sensing module collects sensor (b)In the adjustment stage ,the control strategy module uses estimated occupancy distribution to determine what base light should be produced.

$$y0 + \delta y = A(x0 + \delta x) + b. \quad (3)$$

y simple subtraction, we can eliminate b, and get : $\delta y = A\delta x$. (4)

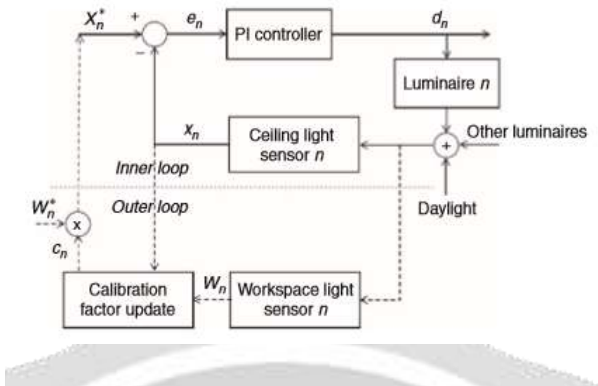

Fig 5:Algorithm structure

In our smart lighting system, we call x0 the base light, which is determined by the control strategy module. We call δx a perturbation ,the term related to occupancy. Depending on the desired lighting conditions and possible changes in the room occupancy, x0 may be adjusted over time — but not during sensing.

Solve for A.

If we can apply different perturbations(disturbance in motion) to the fixtures very fast, and also read the sensor readings very fast, we can make many measurements within a very short time period, during which we can assume both matrix A and vector b do not change. Thus, if we measure y0 once, and measure y0 + δy multiple times with different δx, we get a linear system to solve for A. In other words, we perturb the input to the LED fixtures x0 with different m1-dimensional signals δx1, δx2, ... , δxn, and measure the m2- dimensional changes of the sensor readings δy1, δy2, ... , δyn.

Let X = [δx1, δx2, ... , δxn] and Y = δy1, δy2, ... , δyn , where X ∈ Rm1×n and Y ∈ Rm2×n. Now the problem becomes a linear system Y = AX, which is very similar to the light transport problem in computer graphics. [7]With modern LEDs a we can usually make many measurements in a short time period to ensure n > m1. Thus this can be simply solved by the Moore-Penrose pseudo-inverse:

$$A = YXT^{-1}XXT^{-1} \qquad (5)$$

[6] If under some circumstances n is smaller than m1, then Y = AX is an underdetermined system. Then other methods such as recursive least squares (RLS), low rank approximation, can be used. In our problem, we can always make enough measurements to ensure n > m1 and use the simple pseudo-inverse method. Fig 4,5 :gives overview of the algorithm.

6.FUTURE WORK

The final transformation is really based on the current need on the people. Currently, all benefits that provide work, life and play solutions are idle for 25% - 50% of the time. And it is also it is estimated that cities are responsible for 60%-80% of total energy use worldwide. While individuals work, their homes remain empty,it will be no longer before we witness spaces that could act as work space during the day, change to entertainment zones by evening and sleep zones by night ensuring 100% utilization of the space can be done with zero resting periods during the 24-

hour cycle. Due to these features, the demand for office spaces will be centered around flexible leasing terms. There will be ready solutions for entrepreneurs that can avail offices for trial periods – on a monthly, daily or even hourly basis. Co-working spaces are not only limited to start-ups, bigger companies are also opting to operate within shared working spaces.

7.CONCLUSION:

Thus, we have presented a smart lighting system that adapts to daylight based on inputs from work space light sensors that provide information at high and low update rates, respectively. The performance of the proposed method was evaluated using an experimental testbed and compared to methods that only use information from work space light sensors. We showed that our proposed method

1. improves the achieved lighting efficiency when compared to a control method that only uses inputs from ceiling light sensors .

2. And it is also more robust against temporal blocking of the view of work space light sensors.

The proposed system provides a good balance between energy saving, the amount of lighting offered at the user work space and also keep a count on the number of occupancy. Furthermore, since measurements from the work space light sensors are at a low update rate, such sensors may be potentially operated on harvested energy.

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