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Indoor Surveillance Camera based Human Centric Lighting Control for Smart Building Lighting Management

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Abstract

The human centric lighting (HCL) control is a major focus point of the smart lighting system design to provide energy efficient and people mood rhythmic motivation lighting in smart buildings. This paper proposes the HCL control using indoor surveillance camera to improve the human motivation and well-beings in the indoor environments like residential and industrial buildings. In this proposed approach, the indoor surveillance camera video streams are used to predict the day lights and occupancy, occupancy specific emotional features predictions using the advanced computer vision techniques, and this human centric features are transmitted to the smart building light management system. The smart building light management system connected with internet of things (IoT) featured lighting devices and controls the light illumination of the objective human specific lighting devices. The proposed concept experimental model implemented using RGB LED lighting devices connected with IoT features open-source controller in the network along with networked video surveillance solution. The experiment results are verified with custom made automatic lighting control demon application integrated with OpenCV framework based computer vision methods to predict the human centric features and based on the estimated features the lighting illumination level and colors are controlled automatically. The experiment results received from the demon system are analyzed and used for the real-time development of a lighting system control strategy.

Keywords: *Human Centric Lighting, IoT, Building Automation, Intelligent Video Surveillance, Smart Building.*

1. Introduction

Recent days building facilities have the basic components include walls, doors, windows, furniture or storage space, video surveillance, ventilation, air conditioning, and lighting fixtures, etc. The every area or room of the building facility has not only the electrical network, but also from the lighting infrastructure and the lighting is a “hot spot” for the sensors in the smart buildings. The building infrastructure developers must

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need to think from what people really want it in the building infrastructure and create strategic to cover up the people pleasing point inside the building infrastructure.

The air quality and humidity level inside the building facility is an ideal parameter to sense for building automation, which not only saves energy but also improves system efficiency, which directly enables active lighting control to create optimal working conditions [1]. The optimal lighting directly influences the people, increasing people feel or employee working efficiency and motivation every individual during inside the building facility. On this point, there are many building management regulations, such as energy star and various international standards, the concept of intelligent sensors and controls is becoming increasingly important to provide efficient light illumination, air quality and humidity in the building facility [2, 3, 4, 5].

Implementing intelligent sensor technology will increase the bill of material (BOM) of lighting devices in the building facility if the building facility developers look for the features like the detection of volatile organic compounds (VOCs) in the air, early warning systems for fire detection, and multiple human centric lighting (HCL), etc. This paper propose the indoor surveillance camera based HCL control for smart building lighting management without installing addition intelligent sensor network inside the building facility. The proposed solution removes increasing BOM of lighting device as well as give more effective HCL solutions to save energy and provide pleasing moments inside the building infrastructure.

The section 2 describes the human centric lighting control basics and advantages. In the section 3, this paper describes the proposed indoor surveillance camera based human centric lighting control. The following section 4 presents the experimental results and analysis of the proposed solution. Finally, the Conclusions are drawn based on the analysis in the section 5.

2. Human Centric Lighting Control

Light color wavelength and temperature has the greatest effect on human emotions and motivations. The light intensity and colors stimulate us, and directly influences our moods swings and activity levels. The reason is human physiological system always response to observed light depends on the light ray characteristics such as light colour spectrum, light intensity and observed timing. The characteristics of the generated artificial light in our living areas have the significance effect if indoors lights are observed by individuals. The nature light simulation model is illustrated in Figure 1.

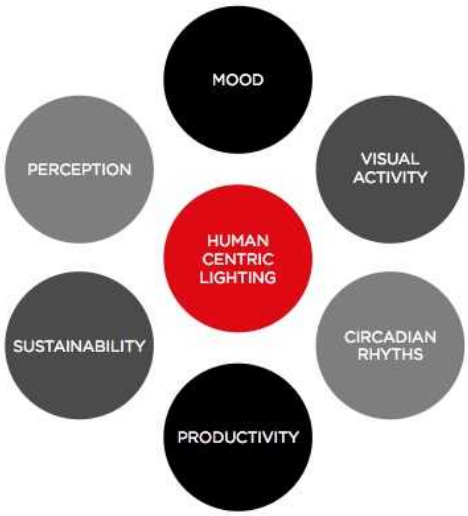

Figure 1. Natural Light Simulation

The human centric lighting (HCL) solutions basically can support visual light quality, improve the human circadian rhythm, enhance concentration, prevent sleeping disorders, perception and performance productivity and improve our overall well-being. HCL bring up to a lighting system beneficial to humans and when utilize

the lighting system wisely. The light can enhance our biological functions, emotions and health, etc. Nowadays, every one spend maximum time under artificial lighting system. That means that the lighting system not only help us see the brightness at darken time, but also affects human spirits, health and emotions. The following section describes the surveillance camera based HCL control in the indoor building facility.

3. Proposed Indoor Surveillance Camera based Human Centric Lighting Control

The human always expects to have pleasant emotions with good health and everyone works towards on the target. The maximum time, everyone spent in the indoor environment with artificial lights sources and light source can able to control our emotions, productivity, etc. So smart buildings must have the intelligent feature to sense the environment conditions and illuminate the lights according to the specific conditions which are called as HCL. The HCL control of color temperature value for day light time to have controlled human spirits, health and emotions is shown in Figure 2.

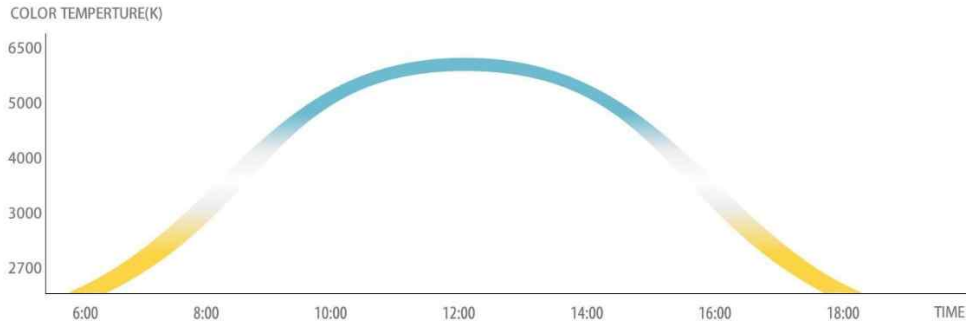

Figure 2. HCL Color Temperature Model on Day Lights

The HCL control can be implemented using sensor technology but that increase the cost in building facility infrastructure development and need to update every when need to change the infrastructure. On this paper study, we found that every building facility default install the indoor surveillance for safety and security. So this proposed the indoor video surveillance based HCL light control. To do that indoor video surveillance monitoring system must add video analytic features to predict the crowd depth, human occupancy level, and human emotions feature [6, 7] to control the color temperature of the location specific LED light sources connected in the building light management system. The proposed indoor surveillance base HCL control model is illustrated in Figure 3.

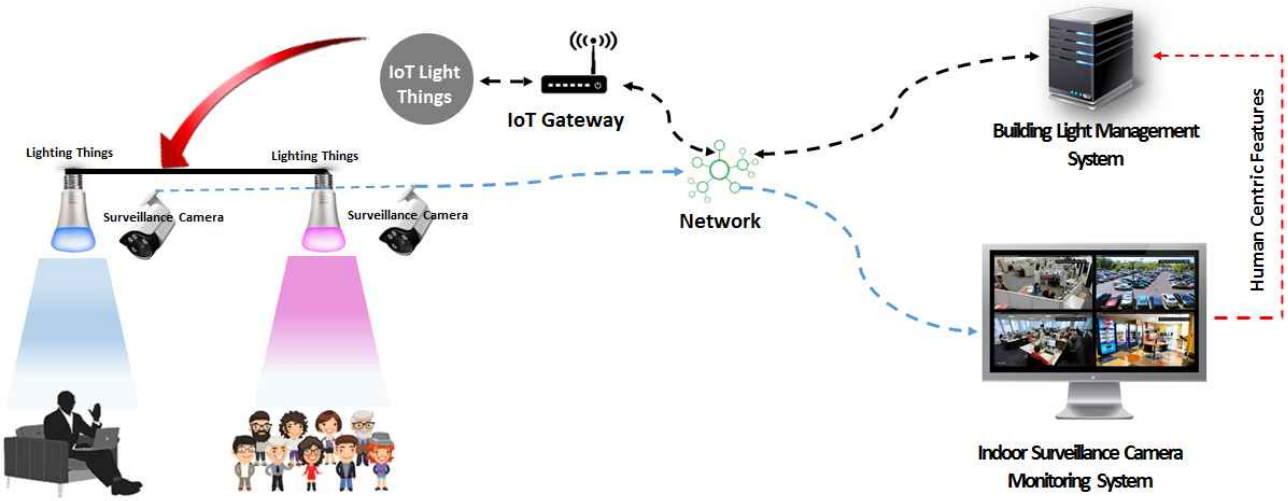

Figure 3. Proposed System Model

Figure 4 explain the human emotion based color temperature mapping to control HCL in real-time in the building facility.

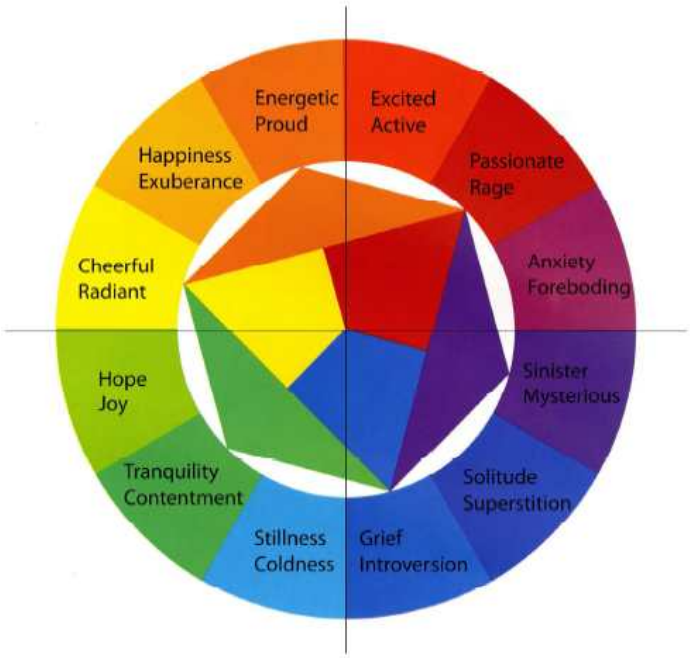

Figure 4. Human Emotion Mapped Color Temperature Circle

This paper proposed the surveillance camera based human emotion detection technique to calculate the human emotions. In this paper study analyse the proposed solution with four emotions such as angry, happy, sad, and neutral mood emotion based Arousal Valance (AV) model. The Figure 5 illustrate the video emotion analytical model proposed part of the proposed HCL control using surveillance system.

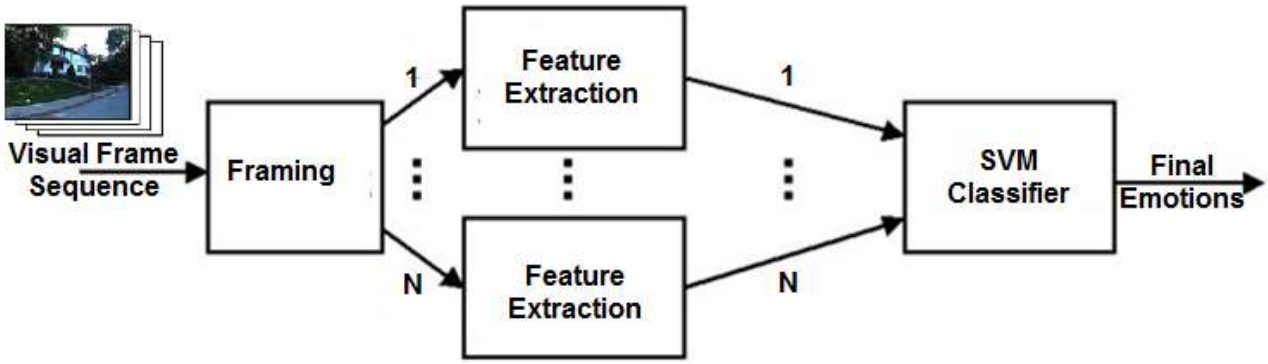

Figure 5. Video Emotion Analytical Model

4. Experimental Result and Analysis

To evaluate the proposed indoor video surveillance camera based HCL control and VLC based automatic door lock access control solution, IoT open-source LED controller based light source designed using Arduino

Mega open-source hardware platform with ESP8266 Wi-Fi controller as shown in Figure 6. The Xiaomi smart home 1080P HD intelligent security Wi-Fi camera installed for indoor video surveillance and surveillance camera capture the video with 130^{O} field of view (FoV) and stream the audio/visual stream using real-time streaming protocol (RTSP) to the monitoring server.

The proposed human emotions and environmental features detections are implemented on Visual Studio 2013 on Intel i7 Core with Windows 7 platform using OpenCV3.0 with SVM classified. As discussed before this implementation used to detect four emotions such as angry, happy, sad, and neutral mood using Arousal Valance (AV) model.

Figure 6. IoT Light Source Controller

The video surveillance monitoring server application built-in with IoT based lighting control protocol using MQTT protocol for HCL control in real-time. The proposed HCL control implemented with four defined emotions to measure and analyse the proposed solution. The OpenCV based custom emotion detection algorithm uses facial features and provide the 90% accuracy to detect the emotional features. The IoT light source control the human emotional feature specific area light color temperature and intensity is controlled using MQTT IoT protocol interface. The average IoT light source control response time is 800 milliseconds. This evaluation result confirms that the prosed HCL control using indoor video surveillance solution have high efficiency and cost effectively to implement in the building infrastructures. The performance of the proposed solution can be improved using artificial intelligent (AI) methods in human emotion detection.

6. Conclusion

This paper discussed the proposed indoor video surveillance camera based human centric lighting control using open-source hardware based IoT light controller and OpenCV based human emotion detection method by facial features with SVM classifier. The experimental result and analysis confirm that the proposed solution possible to implement without installing the additional sensor and does not increase any installation cost for implementation. This paper discussed only four emotion features such as angry, happy, sad, neutral, and this can be extended to any number of emotional features. The additional emotional features implementation only cost computation cost in the video surveillance server side and does not required any additional cost to realize the solution in real-time. This paper achieved the 90% emotional features detection accuracy and can be improved by implementing with deep learning and other AI methods.

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References

[1] C. Branas, F.J. Azcondo, J.M. Alonso, "Solid state lighting: a system review," IEEE Industrial Electronics Magazine, Vol.7, No.4, pp.6-14, 2013.

[2] C. Atici, T. Ozcelebi, J. Lukkien, "Exploring user-centered intelligent road lighting design: a road map and future research directions," IEEE Transactions on Consumer Electronics, Vol.57, No.2, pp.788-793, 2011.

[3] Y.K. Tan, T.P. Huynh, Z. Wang, "Smart personal sensor network control for energy saving in dc grid powered led lighting system," IEEE Transactions on Smart Grid, Vol.4, No.2, pp.669-676, 2013.

[4] J. Cooley, D. Vickery, et al., "Solid-state lamp with integral occupancy sensor," In Proceedings of the Twenty-Fifth Annual IEEE Applied Power Electronics Conference and Exposition (APEC), pp. 2305– 2313, 2010.

[5] Aderemi A. Atayero, Victor Ademu-Eteh , et al.,"Occupancy Controlled Lighting System for Smart Buildings," In Proceedings of the World Congress on Engineering and Computer Science, vol.II, pp. 1-5, 2017.

[6] Caiyan Yu, Xiaoshi Zheng, Yanling Zhao, Guangqi Liu, Na Li, "Review of intelligent video surveillance technology research," In Proceedings of the International Conference on Electronic & Mechanical Engineering and Information Technology, pp.230-233, 2006.

[7] Hyeon-Jung Lee, Kwang-Seok Hong, " A study on emotion recognition method and its application using face image," In Proceedings of the International Conference on Information and Communication Technology Convergence (ICTC), 2017.