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Context-Aware Smart Lighting Control for Better Mood Creation

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Abstract: Recently, the smart lighting system has been attracting attention as one of the methods to improve the quality of life (QoL). Lighting has a great impact on people's mood, bad lighting will make people feel depressed and work inefficiently. Our research is mainly to develop a smart lighting system to dynamically change the lighting color to make people live more comfortably and make them work more efficiently. For this purpose, our system estimates the people's mood from the mental-state-related data (ECG, facial expressions, speaking sound, etc.) that can be obtained from various sensors such as the wearable device, camera, and microphone, and then changes to the appropriate lighting color according to the estimation result. We build a deep learning model to analyze the data and obtain human's mood. We developed a prototype system which sends a command to the smart bulb by WiFi so that the lighting color will be changed to the target color. The ultimate goal of this system is automatically adjusting the lighting for users based on their emotional feedback. To this goal, we plan to build a reinforcement learning model which automatically learns the best lighting for each mood.

Keywords: lighting control, mood recognition, quality of life (QoL), smart home

1. Introduction

Technology always comes from human nature, and improving Quality of Life (QoL) in a smart home becomes an important challenge. Mood has a great part of human's health. Therefore, how to make people a better mood becomes one of the most popular research topics. Modern people are busy with works and dealing with heavy pressure. If they can relax in a comfortable environment after returning home from work [7], it will help releasing stress and restoring strength. Light has a great impact on human life [4], and it also affects mood [1]. Some studies have pointed out that natural light makes people feel happy and might alleviate depression symptoms. Therefore, we conduct the research on the automatic home lighting system. The goal of our research is to provide a comfortable environment for people by automatically adjusting the home lighting [6], so that people can fully relax and have a good time when they go back home after hard work.

Most lighting control systems were built to save energy. These systems often use activity recognition and adjust the brightness to serve the enough brightness to reduce the lighting waste, or using external lighting (e.g., sunshine) to serve the required lighting. This kind of research is focusing on the environmental protection.

In this paper, we propose to introduce the factor of mood which has not been considered for the automatic lighting system. Fig. 1 shows the concept of this work. Several features will be considered to judge people's mood. Microphone, smart watch, and camera will be used to detect people's voice (speaking sound), heart rate, ECG (electrocardiography) and facial expression, and so on. Besides, Raspberry Pi will be used as a data collector for this work because it has advantage of low price and many open resources available for this research. In our system, we plan to use CNN (Convolution Neural Network) model in order to perform the classification of people's mood.

The ultimate goal is to serve more personal lighting for users, since suitable lighting for each person and his/her mood is not identical. Therefore, we plan to add Reinforcement learning model in our system to collect the feedback forms from users, then adjust the optimized lighting for each person. This is the most distinct point of our research. Since the lighting impacts human's mood a lot, if the system provides a bad lighting to a user, it leads to worse mood of people. This is an important point of lighting control system, but few studies tried to make such a

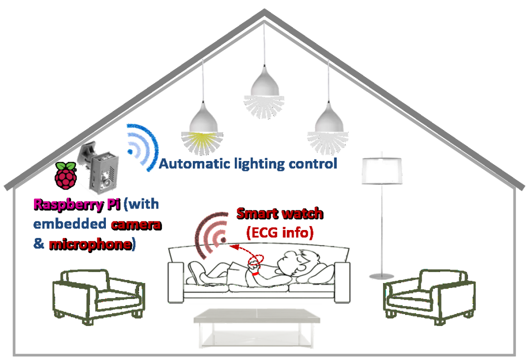

Fig. 1 Concept Diagram

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smart lighting control system.

2. Related Work

Many researches about lighting control focus on the energy saving, such as methods to prevent energy wasting. For example, there is a research which combines the external lighting and the bulb's lighting concentrating to a target, which can reduce the output power of the bulbs [2]. In this work, users can set the lighting depending on their desire by their android smartphones, then a command from smartphone will be sent to Raspberry Pi which sequentially sends a command to control the Arduino with RGB LEDs. The lighting sensor embedded in mobile phone is used to detect the daylight. This system uses the daylight harvesting to composite the target lighting by user's setup.

Also, there are a couple of researches focusing on mood-lighting association. In [3], Cupkova et al. use facial emotional recognition to detect people's mood. The main controller is Raspberry Pi, and they use ESP8266 chip which has a embedded WiFi module and RGB LEDs strips to build the smart bulbs for serving the smart lighting. The camera catches face information first, then the Raspberry Pi performs mood recognition for classification. Afterwards, it sends the command to ESP8266 module, then the ESP8266 will serve the target lighting depending on the result of the mood recognition. They also make a mobile application to provide a manual interface for users to adjust the lighting by themselves, if they do not prefer the preset lighting.

The existing studies described above look perfectly work for our purpose, however they have some defects. First, the accuracy of mood recognition is around 60 percent, which can be enough to be a prototype, but still need to be improved for daily using. Second, the optimal lighting for each user is not same, so to provide a personal lighting for different people is an important functionality. The existing research makes an application for people to manually adjust the lighting system, but this intervenes the user, resulting in the system's inconvenience. If the system can automatically serve the personal lighting depending on the feedback from users, we can realize an adaptive smart lighting system.

3. Proposed System

In this section, we propose a system which dynamically adjusts the lighting color depending on the human's mood. We use some sensors to get the information of several body expressions. For example, cameras are used for catching the face expression and microphones are placed to record speaking sound of people. Also, wearable devices to detect heart-beat and drawing of the ECG are attached to the users. Lastly, a Raspberry Pi processes the collected data and analyze them by using a deep learning model.

Figure 2 shows the flow of our system. This system can be roughly separated into two parts. First is a recognition phase for precise detection of human's mood. We choose three factors to recognize it, those are speaking sound, heart rate/ ECG [8] and face expressions [10]. We plan to use a convolution neural network (CNN) to classify moods of people. There are four types of moods, "sad," "angry," "happy" and "neutral" which will be used in our system.

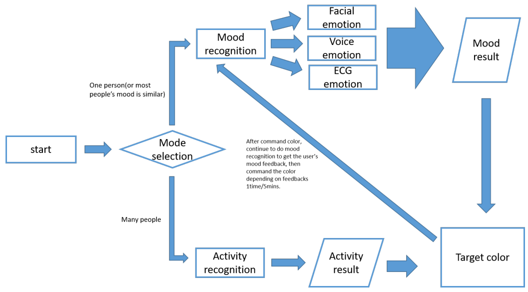

Fig. 2 System Flow Chart

Second, for lighting control, we use Yeelight smart bulbs[*1] to serve the lighting. Yeelight is a smart bulb made by Xiaomi Corp., which can be controlled by wireless LAN. We use Raspberry Pi to control its brightness and lighting color. Depending on the result of mood recognition, Raspberry Pi will send commands to adjust the lighting through wireless LAN.

So far, we addressed about a single person scenario. Therefore, multiple people scenario would not be suitable to decide the lighting color depending on only mood, because mood of each person might not be the same. Lighting can affect people's mood strongly, so unsuitable lighting will cause people's depression. Therefore, if someone does not satisfy a certain lighting way, even if it is suitable for other people, that way could be worst way for a certain person. To avoid this situation, we choose another method in this case. The activity recognition will be applied in multi-user mode by adjusting the lighting according to the ongoing activity of users, as shown in [9].

The optimal lighting of each mood for each person is not identical. To overcome this problem, the ultimate goal of our system is to serve a personal lighting for each and every user. To reach this goal, we plan to use Reinforcement learning model which can adjust model itself depending on the users' feedback. While the system serves users a lighting, the sensors continue to detect their mood in order to respond to mood changing for the worse, by adjusting the lighting with more suitable color for the users.

4. Evaluation Experiment

In our system, we use a Raspberry Pi as main controller and the Yeelight smart bulbs to serve the lighting for users. A camera and a microphone, connected to Raspberry Pi, are used to catch facial expression [11] and record speaking sound of people. Also, users need to wear a wearable device which has ECG detection function. After these sensors collected the context and transmit it back to the Raspberry Pi, Raspberry Pi will perform mood classification [12] to recognize the mood of users. Afterwards, the Raspberry Pi will send the command to Yeelight through Wireless LAN. Consequently, the Yeelight's lighting color will be turned into the target color. Since users may feel annoying if the lighting color changes too often, the Raspberry Pi will not readjust the color during five minutes after sending a command to Yeelight.

We plan to make a questionnaire for the experiment participants, with four questions. Each question's score is 1 to 5 from lowest to highest. The first question is about whether this system makes user's mood better or not, so the score of 3 means "keep

[*1] `https://www.yeelight.com/`

you in original status”, score of under 3 means ”make you more worse”, score over 3 means ”make you better”. Second is regarding to the frequency of the lighting change. Score 3 is normally good, score under 3 means too late or loose and score over 3 means too quick or intrusive. Third question is about how much the user wants this system. Lastly, forth question is related to overall satisfaction, this system operates smoothly, without disturbing, and vice versa.

5. Conclusion

In this paper, we proposed a smart lighting control system which can make human’s mood better. We designed a lighting control system that can adjust the lighting automatically depending on the result of mood recognition. We plan to leverage deep learning and reinforcement learning as our classification methods for contexts, facial emotion, speaking sound and ECG. Also, the optimal lighting color for each person is not identical, therefore we designed the system to be able to provide the personal lighting for each user. In this work, we suppose that the system also receives the emotional feedback from the mood contexts of target users. If the feedback shows user’s mood does not become better or is kept in a good status, the system will adjust the lighting automatically. We expect our system can be fused with human relaxing and become a base for improving QoL (Quality of Life) of people by our user-oriented smart lighting system.

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