An Intelligent LED Affective Lighting System: A Platform Design for the Realization of a User-centric Affective Life based on ISO/IEC 11179 in Ubiquitous Environments

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Abstract: - Recently, from device-centered automatic solutions, human emotion considered as an intelligent solution has been investigated. According to this idea, the importance of emotional technology has been raised. However, for investigating human emotion accurately, a technique that is able to recognize data comprehensively, including various and complex user context data, the condition of the user space, and changes to this space, are in demand. Additionally, research on sensors that can recognize various environments and studies of reasoning algorithms are necessary. In particular, research related to standard platforms and storage techniques for the recognition, reasoning, expression, and similar areas is necessary for extracting different personal attributes of variables such as gender, age, birth area, and race. Thus, the paper outlines the design of an intelligent LED affective lighting system that can determine the emotional condition of a user and supply light adequate to it after adaptively recognizing a user’s physiological response as well as the space in which a user is active.

Key-Words: - Intelligent LED, Affective lighting system, User-centric, ISO/IEC 11197, Ubiquitous Environments

1 Introduction
In ubiquitous circumstances, emotion technology can greatly draw out its ability through emotional reasoning by providing a pleasant movie or prosaic music when people feel depressed. Moreover, when people are driving, the technology helps by controlling the indoor environment of the vehicle. Thus, research on various sensing techniques related to reason human emotion using various sign with which humans can express elements of their feelings such as their countenance, voice intonation, and gestures is currently active. Furthermore, emotion reasoning algorithms and emotion expressing mechanisms that provides a user with intelligent IT services according to emotion is progressing. However, it is difficult to reason human emotion accurately owing to the various and complex types of user context data, such as gestures, voice, implicative expressions, and changes of countenance. By applying the factors presented above in an emotional system, the invention of various future services is possible. Particularly, it can be put to practical use in future medical treatments as a form of an emotion light service leading to psychological changes using the light and its wavelength as well as the color of the light to cure diseases. ITS (Interactive Therapy System) is the first multi-function five-sense stimulus therapy system in the world that treats illnesses through stimulation of the human five senses in a unified therapy system of Aroma Therapy, Color Therapy, and Video Therapy integrated into emotion technology and unorthodox medicine. In this therapy system, treating human physical responses can be activated through the color or the light. In this method, temperature and brightness of light colors flowing out of a light device applied in conjunction with a human psychology state and physiological rhythm can make a person comfortable in conversation and maximize effect of the rest the person receives. The invention of an emotion light platform creating a human-centered space with various emotions is required; this can be the start of a supply of a convenient, pleasant, healthful, and safe future life combining emotion and technology.

2 Related Works
To supply a user with an intelligent affective lighting service, a system that can recognize user emotions precisely and that can provide adequate light according to the recognized emotion should be developed. To do this,
it is necessary to define and classify emotion data that are
demanded in service and to measure user emotions
accurately through an emotion reasoning algorithm
according to an emotion data classification system.
Simultaneously, analysis of a standard means of
collecting and storing personalized emotion data as well
as earlier research concerning affective lighting systems
is required.

First, “ISO/IEC 11179 - Metadata Registry” was enacted
by the International Standards Organization ISO/IEC
JTC1/SC32 Data Management and Interchange to
propose a framework for the standardized of data, phrases,
and expressions. By maintaining and managing standard
metadata through this framework, it is possible to share
the details and significance of metadata.

The ISO/IEC 11179 - Metadata Registry is composed of
four spheres, as shown in Figure 1. They are largely
divided into a conceptual level and a representational
level [1].

Emotional data can be expressed as shown in Table 1.

<table>
<thead>
<tr>
<th>ISO/IEC 11179</th>
<th>Emotional data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Domain</td>
<td>Vocal Emotion</td>
</tr>
<tr>
<td>Data Element Concept</td>
<td>Vocal Emotion Measurement Method</td>
</tr>
<tr>
<td>Data Element</td>
<td>Vocal Emotion Expression Word</td>
</tr>
<tr>
<td>Value Domain</td>
<td>Emotion Expression Words</td>
</tr>
</tbody>
</table>

Secondly, the research tendency is as follows:
Picard et al. showed pictures eliciting happiness, sadness,
anger, fear, disgust, surprise, neutrality, platonic love,
and romantic love. The physiological signals measured
were GSR, heartbeat, respiration, and electrocardiogram.
The algorithms used to analyze the data were Sequential
Forward Floating Selection (SFFS), Fisher Projection,
and a hybrid of these two. The best classification
achievement was gained by the hybrid method, which
resulted in 81% overall accuracy [2].

Nasoz fully qualified the measured data, stored them in
three-dimensional arrays, and measured the emotion
condition using the following three algorithms:
1) k-Nearest Neighbor Algorithm (KNN) [3]
2) Discriminate Function Analysis (DFA) [4]
3) Marquardt Back Propagation (MBP) [5]

The DFA algorithm was superior to the KNN algorithm
in terms of sadness, anger, surprise, and amusement. On
the other hand, KNN performed better for frustration and
fear. The MBP algorithm performed better than both
DFA and KNN for all emotion classes except surprise [6].
All of these studies succeeded in finding a pattern of
physiological signals for each of the emotions elicited.
In summary, the results of these studies suggest that
physiological patterns can successfully be identified
using statistical procedures [6].

Finally, The Life Therapy system by Feelux using SIH
(Sun In House) is a type of psychological treatment. It is a
highly advanced lighting technique that can apply color,
temperature and brightness according to different
psychological states to change the space. The Life
Therapy system is an affective lighting technique
scientifically applied to a light device. It can present sun
light changes indoors such as a sunrise, sunset, and
day-time changes, and can freely control the
characteristics of the light in the range of 2,400K~7,000K .
Additionally, it uses affective light in
an arbitrary zone of inner space and gives warm and
comfort so as to create a healthy mind and body by
producing different light in every zone. Related to this
technology, many studies have been done to understand
human emotion, yet the results have not reached the point
at which human emotion can be understood accurately
because recognition factors that are able to recognize
human response are not various and reasoning algorithms
are specialized to a certain target emotion. To solve these
problems, measuring various recognition factors
according to human responses and the development of a
new reasoning algorithm that can recognize recognition
factors adaptively is essential. The present study develops
an affective lighting system from this viewpoint and a
system that is able to supply light to a user after
measuring the emotion of the user accurately.

3 A System Architecture

3.1 Scheme of the Affective Metadata Registry
This paper proposes collecting and storing an affective database using ISO/IEC 11179 rules that stipulate how various affective data area maintained and managed, and that is intended to support affective reasoning research and be a base for additional types of accurate reasoning. The context defines whether the condition is human, place, or reciprocal action, while context-awareness is meant as the awareness of the user context in which the optimum service is supplied to the user [7, 8, 9]. In addition, devices or/and systems are equipped with environmental adaptation sensors to recognize the present location. The devices exist in a circumstance in which user can use them.

Here, the design and embodiment of context-aware technology is necessary. First, the embodiment of a context-aware engine is needed. A model of such an engine can be divided into three classes: raw context, general context including general data, and an application-specific context that is serviced in the relevant application. As the third element is considered an upper class, it is defined in a more systemized context and is utilized as significant data [10].

The model classifies the data using the attribute value of the category data first. There are numerous algorithms, such as those of the Decision Tree, Bayesian Classification, Bayesian Trust Network, Nerve Network, k-nearest neighbor classifiers, case-based reasoning, Gene Algorithm, and Fuzzy Logical Technology. Though the data that an affective reasoning algorithm can collect is various, context data of the assumption space could be as follows in Table 2.

<table>
<thead>
<tr>
<th>Context type</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical context</td>
<td>Pulse, blood pressure, body temperature, voice, countenance, brain waves, acts</td>
</tr>
<tr>
<td>Spatial context</td>
<td>Position, direction, speed, force</td>
</tr>
<tr>
<td>Time context</td>
<td>Year, month, hour, season, holiday, daily schedule, business trip schedule</td>
</tr>
<tr>
<td>Environmental context</td>
<td>Temperature, humidity, intensity of illumination, noise, quantity of oxygen, quantity of ozone</td>
</tr>
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</table>

At present, techniques for recognizing affective data mainly analyze the context using such attributes as the physical context (shown in Table 1) and determine affective data through the analyzed results. However, not only through individual personal attributes such as voice, countenance, and acts but also through the factors of space, time, and environment, emotion can be determined. For example, emotion can be changed depending on whether it is the weekend or a weekday. Moreover, the temperature or humidity in the home can influence emotion.

Therefore, for affective predictions that are more accurate, additional types and quantities of data can be advantageous; techniques that can store them effectively are also needed.

The total flow of the emotional database in establishing the emotional database using the emotional data and ISO/IEC11179 is shown in Figure 2.

First, a Metadata Registry that registers emotional data as Metadata in the base of ISO/IEC 11179 should be established. The emotional data collected by sensors, such as the pulse and face image should then be classified to data factors and permissible values and meanings through the Metadata Registry. This classified data should be stored in the emotional database. The stored emotional data should be applied after a determination stage in middleware. In the emotional database model, the following research has to be considered.

![Figure 2. The emotional data and ISO/IEC 11179](image-url)
Secondly, in reasoning emotion, database having a large scale of data will require a considerable amount of time to process the data. This could be indicated as a shortcoming of the application part in terms of how it expresses the result in real time.

3.2 A System Structure
The LED affective lighting system can be moved by intelligent LED affective lighting control middleware. This middleware consists of four distinct parts as Figure 3:

Figure 3. A System Structure

A Sensing Interface Component recognizes the user’s emotion condition data and space condition data pertaining to where the user is located. It then transfers this data to the system. To abstract various recognition factors, this study consists of three recognition domains of the image/voice recognition domain, the biologic reaction recognition domain, and the circumstance and condition recognition domain. Each recognition domain can sense emotion condition data through a dedicated sensor. Sensed data in this manner are transferred to an affective metadata extracting component. The affective metadata extracting component transfers the data to the Metadata abstract routine that is able to perceive abnormal signs when a critical value over a set limit is transferred by any sensor according to the user’s emotions accumulated earlier. In other cases, it lessens the amount of transferred data to decrease the process overload and manage the available data. In this way, it embodies a real-time service for the user. Data that have been sent to the metadata abstract routine classifying signs for emotion reasoning are transferred to the middleware system. A multi-level reasoning algorithm determines the abstracted user semantic affective data and generates a lighting control command according to the emotional condition of the user. Through the circumstance condition recognition data, it perceives the position, type, and data pertaining to the light and matches it to the command. A command generated in this way is transferred to a wireless LED lighting controller and supplies the personalized affective lighting service according to user emotions.

An operational test using a test-bed of the intelligent LED affective lighting system supporting the Affective Lighting service according to the emotional condition of the user in a test home server consisting of the aforementioned sub-components designed in this paper was done. In this test, the system recognized the emotion condition using four typical previously known emotion classification factors: pleasant-unpleasant and awake-relaxed. By building a sensor network in a home, this study was able to measure the position of the user as well as various spatial factors such as the temperature and humidity of the environment. In addition, the system transferred the information to the home server. The home server determines the emotional condition of the user on the basis of the extracted data and transfers a command for affective light that matches the emotional condition of the user to the wireless LED lighting controller.

4 Conclusion
This paper suggests adaptively recognizing the physiological responses and life space of a user during activity. The study designs an intelligent LED affective lighting system that determines the emotional condition of a user on the basis of recognized data and supplies light according to the psychological situation of the user. The data used in the emotion determination step includes the space, time, and circumstances as well as the physical attributes through the development of sensor techniques. An emotion database through ISO/IEC 11179 – MDR was set up to manage this data effectively. Moreover, the middleware for a personalized emotion determination of a user and the middleware for control and management of the LED affective lighting system were designed.

References: