A Service Platform Design for Affective Lighting System based on User Emotions

Byounghee Son[1], Youngchoong Park[2], Hyo-Sik Yang[3], and Hagbae Kim[1]

[1]Dept. of Electrical & Electronics Engineering, Yonsei University,
134 Shinchon-dong, Seodaemun-gu, Seoul, Korea
{diana, hbkim}@yonsei.ac.kr
[2]Ubiquitous Technology Research Center, Korea Electronics Technology Institute
8Floor, #1599, Sangam-dong, Mapo-gu, Seoul, Korea
ycpark@keti.re.kr
[3]Dept. of Computer Engineering, Sejong University,
98 Gunja-dong, Gwangjin-gu, Seoul, Korea
hsyang@sejong.ac.kr

Abstract: - The development of IT has changed not only computer techniques, but also human life and the environment. It provides us with more and more chances to interact with computers. While we feel much unease while communicating with computers, from device-centered automatic solutions, human emotion are considered as an intelligent solution has been investigated continuously. Skillfully dealing with emotions is important in realizing more natural communication between computers and human being. According to this idea, the importance of emotional technology has been raised. For investigating human emotion accurately, however 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 which 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 are necessary for extracting different personal attributes of variables such as gender, age, birth area, and race. This paper outlines the service platform design for 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: - Affective lighting system, Intelligent LED (light emitting diode), ISO/IEC 11197, User-centric affective life, Service Platform, Affection, Emotions

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. 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 provide 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 psychological state and rhythm can make a person comfortable in conversation and maximize effect of the rest the person receives. The development 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.
Thus the paper designs a service platform for affective lighting system which can adaptively determine the emotion condition of a user and supply light adequate to users as a basis of data recognition for the physiological response of the user and the space in which the user is active.
The paper is organized as follows. We overview and analyze the related works about affective lighting system in the following section. In section 3, we propose the new system architecture and describe each components of sub system. In section 4, we simulate the proposed system and describe the test-bed set-up. Section 5 concludes the paper.

2 Related Works

Table 1 summarizes the results of previous works investigating the relationship between emotions and physiological arousal using other statistical procedures such as ANOVA and Hidden Markov Models. 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 the physiological patterns can successfully be identified using statistical procedures [6].
Addition to these data, in our society, colors are often used to communicate method; e.g., danger signals, and banners. Colors can give valuable information about pictures [11]. Many systems are generated emotions and knowledge organization using the shape recognition and the color recognition. And many research works in robotics and autonomous systems are focused on getting an agent to learn to do some task such as recognizing an object or reaching a specific place [12]. One more thing, the present work is part of the European project “Principled Hybrid Systems: Theory and Applications”, which aims to develop a theory for the systematic hybridization of Neural Network models (NNs) with systems based on the traditional artificial intelligence methods [13]. The hybrid approach will hopefully lead to models that combine the strengths of both kinds of systems.
To supply a user with an intelligent affective lighting service, a system that can recognize user emotions precisely and that can provide appropriate light according to the recognized emotion should be developed.

Table 1. Previous Research on Recognizing Emotion from Physiological Signals [6]

Author	Emotion Elicitation Method	Emotions Elicited	N	Measures	Data Analyze Technique	Results
Lanzetta, J. T. and Orr, S. P. (1986)	Vocal tone, slide of facial expressions, electric shock	Happiness and fear	60 (23 female, 37 male)	Skin conductance (galvanic skin response)	ANOVA	Fear produced a higher level of tonic arousal and larger phasic skin conductance.
Vrana, S. C., Cuthbert, B. N., and Lang, P. J. (1986)	Imagining and silently repeating fearful and neutral sentences	Neutral and fear	64	Heart rate and self report	ANOVA and Newman-Keuls pair wise comparison	Heart rate acceleration was higher duging fear imagery than neutral imagery or silent repetition of neutral sentences or fearful sentences.
Pecchinenda, A. and Smith, C (1996)	Difficult Problem Solving	Difficult Problem Solving	32 (16 male, 16 female)	Skin conductance self-report, and objective task performance	ANOVA, MANOVA, and Correlation / regression analyses	Within trials, skin conductance increased at the beginning of the trial but decreased by the end of the trials for the most difficult condition.

Sinha, R. and Parsons, O. (1996)	Imagery script development	Neutral, fear, joy, action, sadness, and anger	27 males (ages 21-35)	Heart rate, skin conductance, finger temperature, electro-oculogram, and facial electromyograms	Discriminant Function Analyses and ANOVA	99% correct classification was obtained. This indicates that emotion-specific response pattern for fear and anger is accurately differentiable from each other and from neutral.
Scheirer, J. Fernandez, R. Klein, J. and Picard, R. W. (2002)	A slow computer game interface	Frustration	36	Skin conductivity and blood volume pressure	Hidden Markov Models	Pattern recognition worked significantly better than random guessing while discriminating between regimes of likely frustration from regimes of much less likely frustration.

To do this, it is necessary to define and classify emotional 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 are required. Therefore, this section discusses ISO/IE 11179, research on the tendency of emotion reasoning algorithms and affective lighting system by FEELUX co., ltd.
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 standardization of data, phrases, and expressions. By maintaining and managing standard metadata through this framework, it is possible to share the detail and significance of metadata.

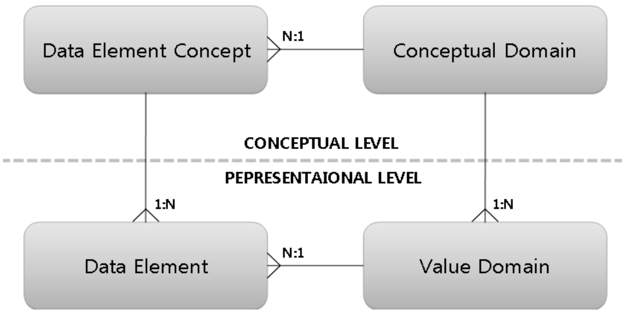

Fig. 1. ISO/IEC 11179 - Metadata Registry

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].

An explanation of each sphere is given below.

1) Data Element Concept: concept expressing the data form,
2) Conceptual Domain: concept for expanding the value domain assemble,
3) Data Element: a unit for the definition, division and expression
4) Value Domain: assembly of a permissible value of more than one data factor

In reference to Figure 1 and Table 1, if the data element, the value domain of vocal emotional expression word factor are defined as 19 emotion expression words, the vocal emotion expression word factor can be included in the data element concept, then the vocal emotion measurement method, the data element concept and the data element can be connected as 1: N, as shown in Figure 1. Additionally, the vocal emotion measurement method can include the upper concept conceptual domain, vocal emotion. It can also have a 1:N connection.
The value domain can be connected to the data element as 1:N, implying that emotion expression words can be used under other data elements.
For example, emotion expression words (value domain) can be used for face emotion expression words (data element), as well.
The relationship between the conceptual domain and value domain is 1:N because vocal emotion can include a wide value domain. Therefore, vocal emotion can be in the area of emotion expression

words or in the so und frequency areas in expression emotion.
The concept of emotional data is shown in Table 2.

Table 2. The Concept of Emotional Data

ISO/IEC 11179	Emotional data
Conceptual Domain	Vocal Emotion
Data Element Concept	Vocal Emotion Measurement Method
Data Element	Vocal Emotion Expression Word
Value Domain	Emotion Expression Words

Most researches are under a bias toward as follows:
Picard et al. show pictures eliciting happiness, sadness, anger, fear, disgust, surprise, neutrality, platonic love, and romantic love [2]. The physiological signals measured were GSR, heartbeat, respiration, and electrocardiogram. The algorithms like Sequential Forward Floating Selection (SFFS), Fisher Projection (FP) are used to analyze the data. The best classification achievement was gained by the hybrid method, which resulted in 81% overall accuracy.
Nasoz fully qualified the measured data, stored them in three-dimensional arrays, and measured the emotion condition using the following three algorithms [3, 4, and 5]:

1) k-Nearest Neighbor Algorithm (KNN)
2) Discriminate Function Analysis (DFA)
3) Marquardt Back Propagation (MBP)

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].
These studies successfully find a pattern of physiological signals for each of the emotions elicited. In summary, the results of these studies show that physiological patterns can successfully be identified using statistical procedures [6].
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 each 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 which 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 which can recognize 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 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.
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, Genetic 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 3.

Table 3. The Training Data Table

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

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

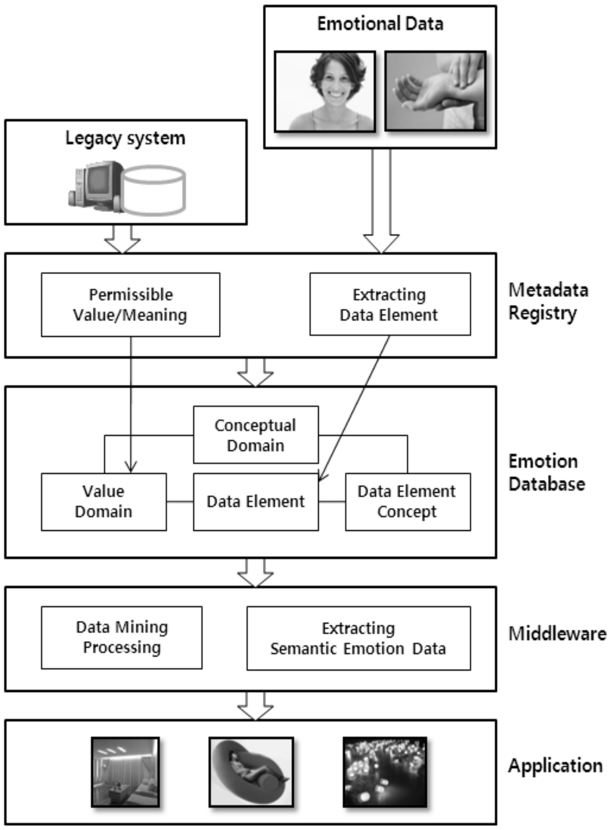

Fig. 2. The emotional data and ISO/IEC 11179

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 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.
There is ambiguous emotional data collected and stored in the database. For instance, when face countenance data collected by the sensors is stored, the type of data and how to store those data must be determined.
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 System Structure

The LED affective lighting system can be moved by intelligent LED affective lighting control middleware. This middleware consists of four distinct parts:

1) A sensing interface component with a user's affective signal and space context for on-demand lighting control
2) An affective metadata extracting component based on bio-signal recognition
3) An intelligent LED affective lighting middleware component
4) An individual on-demand LED affective lighting component

The first part is a sensing technology with a user's affective state and space context for the on-demand lighting control as shown in Figure 3.

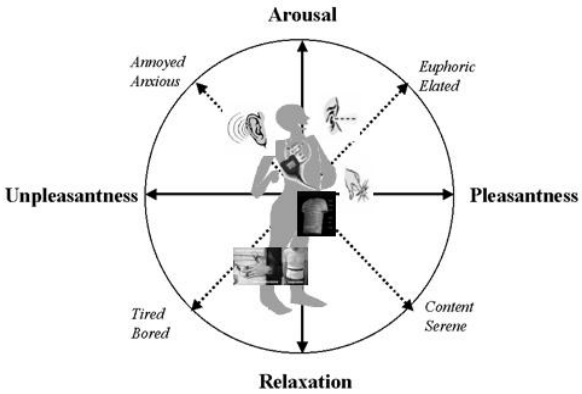

Fig. 3. Sensing and Transmitting of a User's Affective State Information

The second part is the affective metadata extracting technology based on bio-signal recognition and the third part is the intelligent LED affective lighting middleware core as shown in Figure 4.

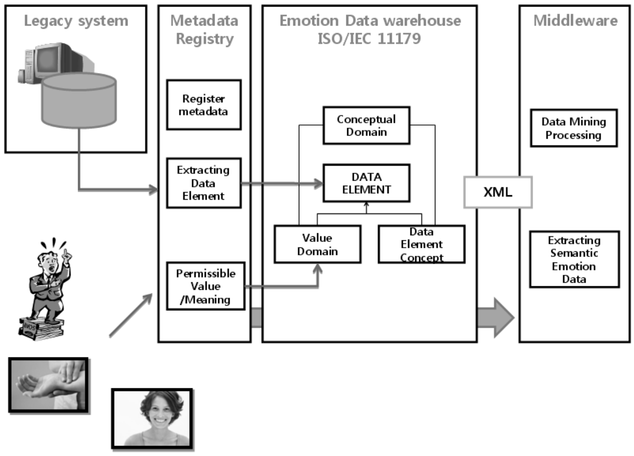

Fig. 4. The Affective Metadata Extracting and The Intelligent Affective Lighting Middleware

The last part is the individual on-demand LED affective lighting as shown in Figure 5.

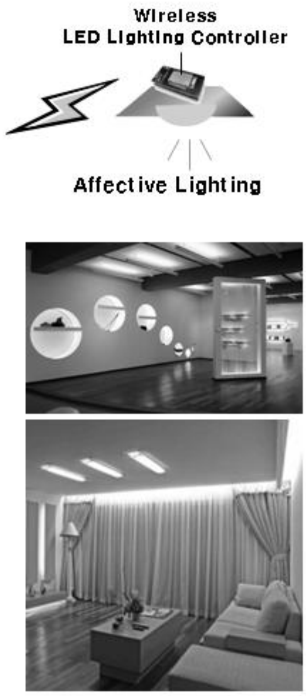

Fig. 5. The Individual on-Demand LED Affective Lighting

Finally, the whole system architecture is as shown in Figure 6.

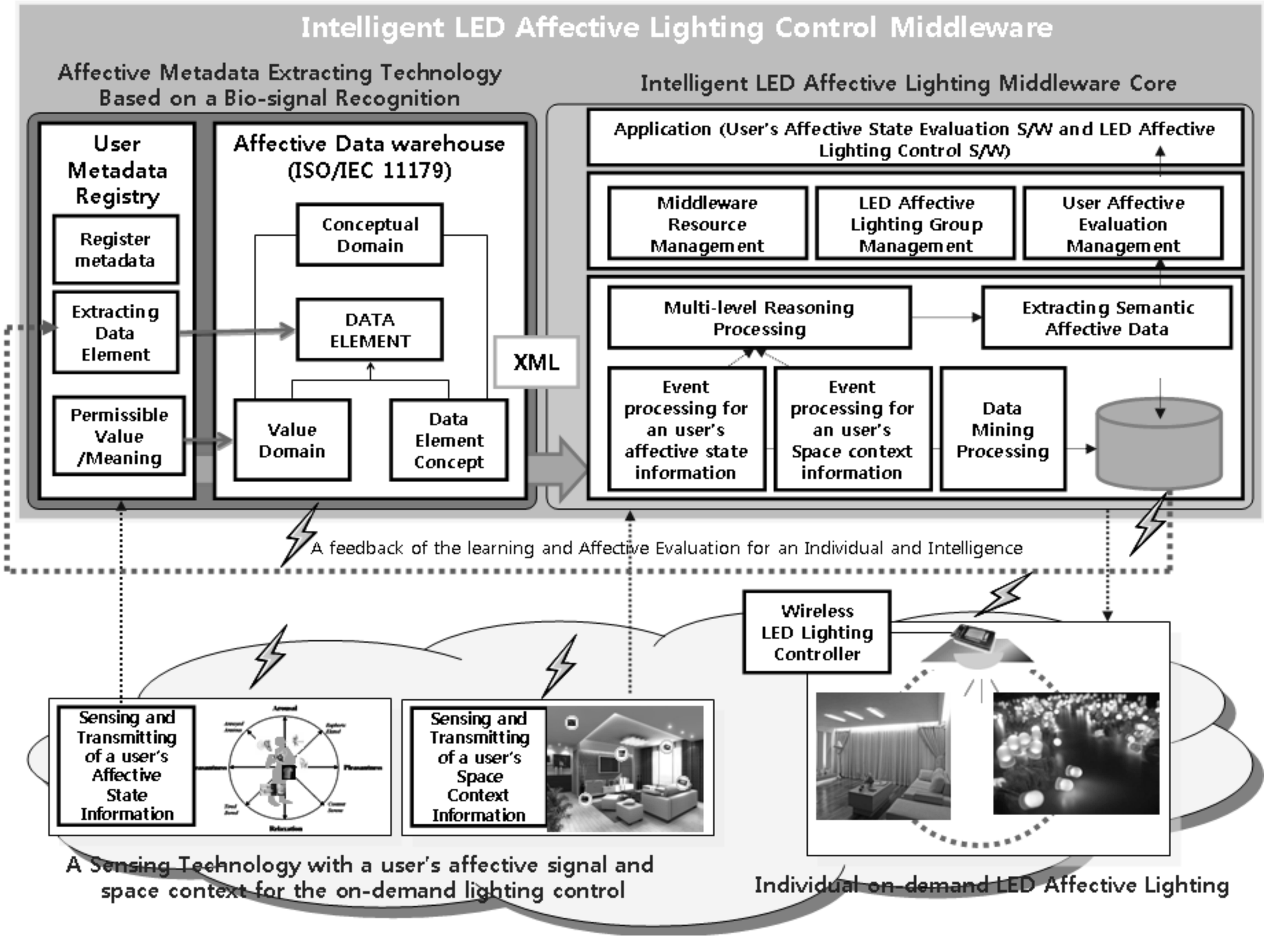

Fig. 6. A System Structure

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 lighting controller and supplies the personalized affective lighting service according to user emotions.

An operational test using a test-bed of the intelligent 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.

4 Simulation

An operational test using the test-bed is as shown in Figure 7.

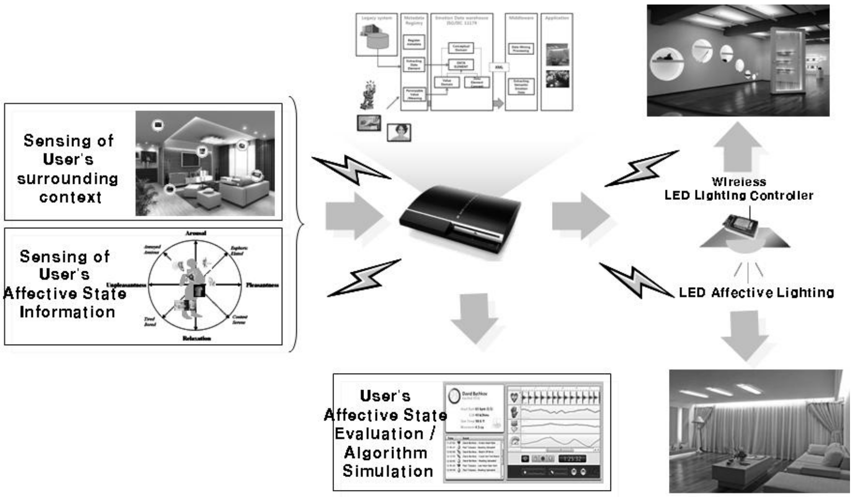

Fig. 7. The Operation Test using the Test-bed

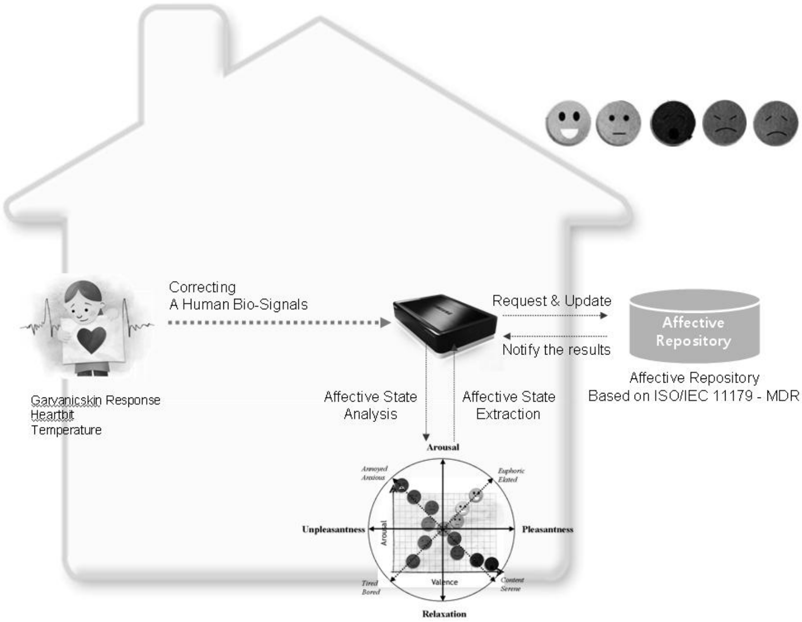

Fig. 9. Emotion Determination

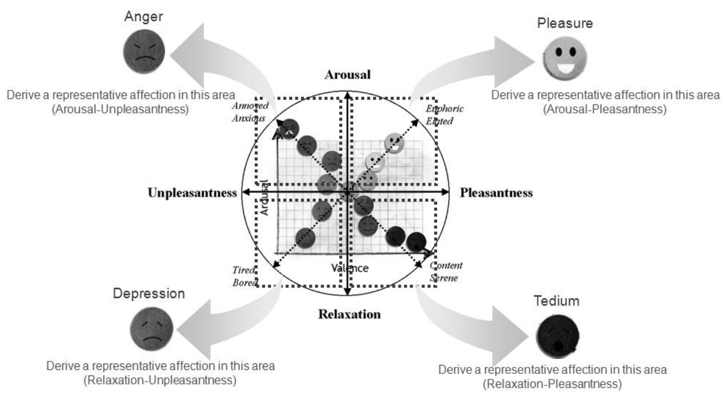

Fig. 8. Emotion Determination

In this test, the system recognizes the emotion condition using four typical previously known emotion classification factors: anger, pleasure, depression, and tedium as shown in Figure 8 and Figure 9.

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 lighting controller. Furthermore, the server tests whether the system operates normally and an additional emotion condition is tested to verify whether the system measures the emotional condition of the user precisely as well as the development of algorithm simulation software to determine emotion accurately should be induced.

5 Conclusion

The paper suggests adaptively recognizing the physiological responses and life space of a user during activity. The study designs an intelligent 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 affective lighting system were designed.

Henceforth, for emotional determination and condition recognition, a good effect is expected on account of the design of a generalized model by comparing and analyzing accumulated data in emotion database while considering individual attributes. Moreover, the established personalized emotion database and emotion condition determination algorithm can make possible not only affective lighting but also applied services such as affective entertainment, affective education, and affective gaming. In this way, a higher value-added new business model can be created. Therefore, this study can be perceived as foundation research in the creation of such a service and is expected to provide the opportunity provisioning a service of emotion technology connected to an IT system.

References:

[1] ISO/IEC 11179, Information Technology - Metadata Registries (MDR) - Part1: Framework, ISO/IEC, 2004

[2] R.W. Picard, E. Vyzas, J. Healey, "Toward Machine Emotional Intelligence: Analysis of Affective Physiological State," IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 23, No. 10, Oct. 2001, pp. 1175-1191

[3] Mitchell, T. M., "Machine Learning", McGraw-Hill Companies Inc., 1997

[4] Nicol, A. A., "Presenting Your Findings: A Practical Guide for Creating Tables", Washington, DC: American Physiological Association, 1999

[5] Hangan M. T. and Menhaj M. B, "Training Feedforward Networks with the Marquardt Algorithm", IEEE Transactions on Neural Networks, Vol. 5, No. 6, Nov. 1994, pp. 989-993

[6] Fatma Nasoz, Kaye Alvarez, Christine L. Lisetti, and Neal Finkelstein, "Emotion Recognition from Physiological Signals for Presence Technologies", In International Journal of Cognition, Technology, and Work - Special Issue on Presence, Vol. 6, No. 1, 2003

[7] Schiliti, B., Adams, N. Want, R. "Context-Aware Computing Applications", Proceedings of the 1st International Workshop on Mobile Computing Systems and Applications, 1994, pp. 85-90

[8] Y. Nishibe et al., "Mobile Digital Assistants for Community Support", AAAI Magazine 19(2), summer 1998, pp. 31-49

[9] R. Want, A. Hopper, V. Falcao, and J. Gibbons, "The Active Badge Location System", ACM Transactions on Information Systems, January 1992, pp. 91-102

[10] Kwang-Won Koh, Chang-lk Choi, Kyung-Lang Park, Shin-Young Lim, and Shin-Dug Kim, "A Multilayered Context Engine for the Smart Home", International Conference on Computer Science, Software Engineering, Information Technology, E-business, and Applications (CSITeA-04), Cairo, Egypt, December, 2004

[11] C. Havas, O. Larue, and M. Camus, “Emotions generation and knowledge organization in an auto-adaptive system using shape and color recognition”, 7th WSEAS International

Conference on Applied Computer and Applied Computational Science (ACACOS-08), Hangzhou, China, April 6-8, 2008

[12] G. Morgavi, "An architecture based on emotions for growing up artifacts", Proceedings of the 5th WSEAS International Conference on Applied Informatics and Communications, Malta, September 15-17, 2005 pp. 156-162

[13] F. Piat and G. Stamou, "Refining Rules of Emotion Recognition in Hybrid Systems", Proceedings of the 3rd WSEAS Int. Conf. Circuits, Systems, Communications and Computers (CSCC 1999), Athens, Greece, 1999