The Emotion Expression Robot through the Affective Interaction: KOBIE

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***Abstract*— In this paper, we propose the method for expressing emotion for the emotional robot through the affective stimuli such as 'hit,' 'stoke,' 'tickle,' 'poke,' 'embrace,' etc. We developed the experiment platform, KOBIE, for experiment the emotion expression system. The KOBIE is the emotional robot which is made for an interaction between a human being and a robot through the affective interaction. Our system can be used in developing the cyber character (Avatar) having an emotion or developing the apparatus having an emotion in the ubiquitous environment.**

***Index Terms*— Emotion expression system, emotion engine, affective interaction, emotional robot, KOBIE.**

I. INTRODUCTION

Recently, researches are being actively conducted to develop robots that can help a user to do a desired job so as to accommodate the convenience of the user. Special interests are being taken to develop an intelligent robot that can make an intelligent determination through an interaction with a user and can perform a corresponding operation [1], [2]. Robot technologies are being developed to provide an intelligent with a function for generating a corresponding emotion in accordance with a predefined condition and expressing a corresponding action on the basis of simple external sensor information. In addition, researches are being actively conducted to develop an intelligent robot that can interact with a user by detecting the emotional state of the user through an image taken by a camera and reflecting the detected emotional state in creation of an emotion.

However, such a conventional method, in which a human emotion is detected by recognition of a human image or by recognition of the strength, tempo and tone of a human voice, has a limit in terms of accuracy. A conventional emotion expression method mainly uses a human face, but emotion expression technologies using other body portion is still insufficient. The conventional technologies merely provide an emotion expression means where a human face is mainly used and different emotion models and action expression models exist in respective platforms, which is unsatisfactory in providing an emotional communication with humans by touch with humans.

AIBO [6] of Sony Corporation is a pet-type robot that can control natural actions like those of a living thing so as to express emotions. These emotion expression technologies express emotions by simply calculating the degrees of like and dislike on the basis of object information that is detected through a cognitive model that is trained using external information of vision, voice and touch sensors, which have a limit in expressing a variety of emotions depending on conditions. WE-R4II (Waseda Eye No.4 Refined II) is humanoid robot in order to develop new mechanisms and functions for a humanoid robot that has the ability to communicate naturally with a human by expressing human-like emotion. This robot expresses the emotions using face and body-gestures. WE-4RII can express emotions such as "happiness," "angry," "disgust," "fear," "sad," "surprise," and "neutral" based on the basis 6 emotion of Ekman[18]. Moreover, WE-R4II has 3D mental space [3]-[5]. The seal-type robot, Paro, is designed using a baby harp seal as a model, and its surface is covered with pure fur. Also, Ubiquitous surface tactile sensors are inserted between the hard inner skeleton and the fur to create a soft, natural feel and to permit the measurement of human contact with Paro. Paro is a mental commit robot that provides mental value to the subject, such as joy, happiness, relaxation, etc., through the physical interaction [8]-[10]. Specifically, MIT is conducting a Huggable project [7] for installing a sensitive skin on the entire body of an intelligent robot to provide a more natural interaction with the human being. Also, many researchers have studied the multiple modal emotion recognition method which together considers the voice information in order to improve performance and stability about the method for recognizing [16], [17]. Therefore, what is required are a method for processing information that is collected through various sensors in an intelligent robot, a method for determining an emotion, and a method for expressing a corresponding action. In this paper, we propose the emotion expression system, which can express a specific emotion of the intelligent robot in the form recognizable by a user so that an affective communication between human and robot is possible through affective interaction.

The rest of this paper is organized as follows. In section II, we present emotion expression system architecture. Section III describe experimental robot platform. In section IV, we conclude the paper and give our directions for future research.

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II. EMOTION EXPRESSION SYSTEM

A. *Emotion Engine*

The emotion expression system is comprised of emotion feature information collector component, internal status management component, and action expression component. Fig.1 shows the architecture of emotion engine. The emotion engine is the main component of the emotion expression system. The emotion engine is composed of the EFGM (Emotion Feature Generation Module), the ISGM (Internal Status Generation Module) and BDM (Behavior Decision Module). In brief, the EFGM, generate emotion features, is composed of the Stimulus Process Module and Fusion Module. The ISGM generates emotions and manages the internal status information. The BDM determines the behavior for emotion expression.

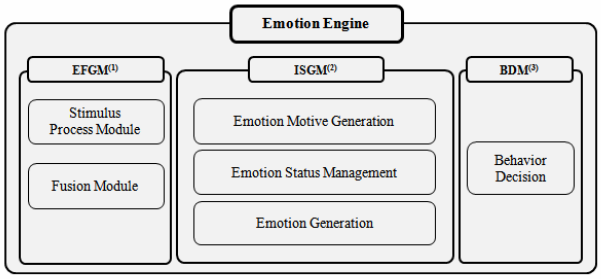

Fig.1 Architecture of Emotion Engine

B. *Needs Model*

Needs model is based on the Maslow's Hierarchy of Needs. The emotion need parameters are constituted by a 5-step layer including physiological needs, safety needs, love and belongingness needs, esteem needs, and self-actualization needs [11]-[12]. In this paper, we use the emotion needs parameters are defined on the basis of physiological needs, safety needs, and love and belongingness needs. Examples of emotional needs parameters for physiological needs are hunger, sleepiness, coldness, fatigue, and thirstiness. Examples of emotional needs parameters for safety needs are self-defense parameters for coping with conditions that are regarded as threat stimuli. Examples of emotional needs parameters love and belongingness needs are: curiosity for expressing interest for strange things and persons; and loneliness that may arise when there is no change and stimulus during a predetermined time period. The emotion motive generator uses such parameters to generate emotional need motives.

As shown in Fig.2, so that each of the emotion needs parameters can maintain the equilibrium range of an emotion in the activation regions of an emotional needs motive, the emotion motive generator satisfies emotional needs motives while changing a satisfaction level through expression of emotions and emotional actions.

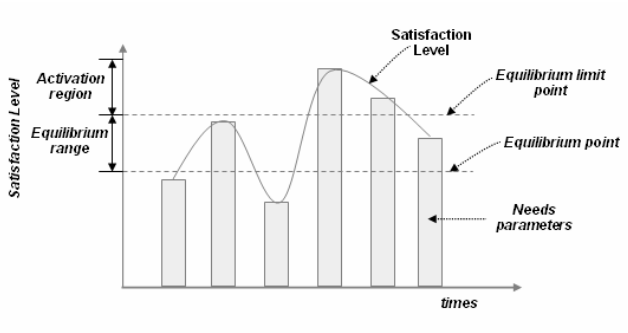

Fig.2 An example of needs-based emotion motive generation

For example, for external state information such as 'hit,' 'stroke,' 'tickle,' and 'embrace', an emotional motive is determined when a stimulus occurs through the emotional parameters such as needs and mood parameters.

C. *Mood Model*

The mood model has six parameters to determine the change of moods through internal/external stimuli. The mood parameters are as follows, 'happy,' 'gloomy,' 'comfort,' 'irritable,' 'listless' and 'depressed'.

The moods parameters affects the emotional motive generation. Also, moods parameters maintain previous robot status information.

D. *Emotion Motive Generation*

The emotion motive is affected by the results that keep to changes of the emotional parameters. First, the needs parameter based emotions are generated in the priority order of physiological needs, safety needs, and love and belongingness needs, and the emotion parameter based emotions are generated sequentially and repeatedly in a predetermined priority order.

The emotional motive generator determines the motive of a corresponding emotion on the basis of the current state information about the intelligent robot that is received from the EFGM. That is, the emotional motive generator determines an emotional motive according to the level of satisfaction with needs-based needs parameter, which is based on the internal stimulus information received from the internal sensor, and with a state-information-based emotion parameter, which is based on the external stimulus information received from the external sensor.

E. *Emotion Factor Table*

The emotion factor manager stores and manages the status information of the intelligent robot that is generated by internal/external stimuli. In addition, the emotion factor manager stores and manages occurrence for internal/external stimuli, 'daily rhythm' information, and internal status information for the emotion of the intelligent robot. The emotion factor manager stores and manages emotion information, which is newly generated by the emotion generator with an initial emotion status of the intelligent robot set to a neutral emotion status, and current action information

that is used by the action expression component so as to finally express a corresponding emotion. Table I shows an example of the emotional factor table.

TABLE I
AN EXAMPLE OF THE EMOTION FACTOR TABLE

	Happy	Unhappy	Arousal	Asleep	Certainty (Emotion Features Possibility)
1	Happy(+)	Hunger(+)	SelfDefense(+)	Sleepiness(+)	-
2	Comfort(+)	Sleepiness(+)	Hotness(+)	Loneliness(+)	-
3	Curiosity(+)	Fatigue(+)	Happy(+)	Evening(+)	-
4	-	Irritable(+)	Depressed(+)	Gloomy(+)	-

In addition, using emotion factors, the emotion factor manager manages factors for calculation of a vector on the emotion vector space. The emotion factor table is comprised of 'Happy,' 'Unhappy,' 'Arousal,' 'Certainty,' and 'Asleep' that are predefined. For example, when the robot status information is recognized as the 'stroke' touch behavior pattern, it is managed as the features of 'Happy' factor. Information such as 'sleepiness,' 'hunger,' 'irritable' and 'fatigue' is managed as an 'Unhappy' factor.

Also, the 'daily rhythm' information, daytime-related information, such as 'morning,' 'afternoon and evening' and self-protection needs due to dangerous conditions are manages as an 'Arousal' factor. That is, the external stimulus information is pre-classified and used as emotion feature information for determination of an emotion vector.

Using emotion factors managed by the emotion factor manager, the emotion generator calculates emotion feature values so as to determine an emotion from an emotion model.

F. *Emotion Model and Expression*

The emotion model has two major models as OCC model and dimensional model. The OCC model 13], [14] is based on interaction related emotion words, which are intuitively assigned from observation of human interaction. The representative model about the OCC model is the OZ project [15]. But, The OCC model is difficult to express the continuous change about emotion values. On the other hand, the dimensional model, such as 3D model, can maintain the continuous change about emotion values.

Our system uses the 3-dimensional model. The emotion model is implemented using a Takanishi's model that is a vector space including "Pleasantness (E_p)," "Activation (E_a)," and "Certainty (E_c)". Accordingly, a calculated emotion feature value corresponds to a vector $E = (E_p, E_a, E_c)$. There are many way expressing emotions. Our system provides three emotion expression types such as face, sound, and gestures.

III. THE EXPERIMENTAL ROBOT PLATFORM FOR EMOTIONAL EXPRESSION: KOBIE

A. *KOBIE (**K**oala r**OB**ot with **I**ntelligent and **E**motion)*

The appearance of the emotional robot, KOBIE, is shown Fig.3. The KOBIE is the emotional robot which is made for an interaction between a human being and a robot through the affective interaction.

Fig.3 KOBIE

As shown in TABLE II, the KOBIE has 21-DOFs. It can be express seven emotions (fear, surprise, joy, anger, sad, shame, and neutral) through the facial expression, sounds and body-gestures.

TABLE II
KOBIE HARDWARE CONFIGURATION

Head	5 (Eyelid 1, Ear 2, Neck 2)
Back	2
Foreleg	8
Hind leg	6
Total	21

B. *Emotion Expression through the Affective Touch*

We use the FSR (Force Sensing Register) and on/off sensors to detect the touch behaviors including 'hit,' 'stroke,' 'tickle,' 'poke,' 'embrace,' etc. The Fig.4 shows the placement of touch sensors. The FSR sensors are adhered to the back (7), the head (4), the side (5), and the chin (4). The On/Off sensors are adhered to the legs (8), the paw (4) and the tail (1).

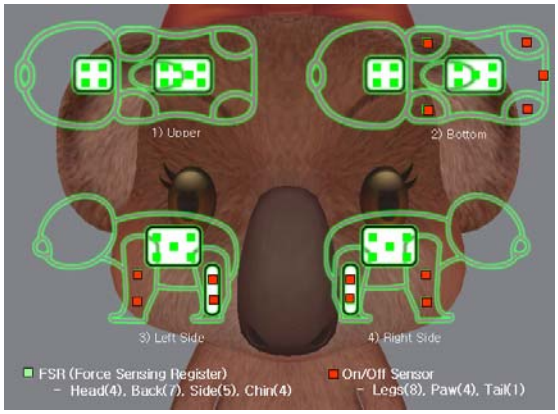

Fig.4 Placement of touch sensors

The Fig.5 shows the emotional communication through affective touch. The KOBIE can sense the affective stimuli of tickle, stoke, hit, poke, and etc. The KOBIE diversifies the emotion such as fear, surprise, joy, anger, sad, shame and neutral, and it can show the various actions to a user. For example, if a user strokes the head or back, the KOBIE shows the cute tricks.

Fig.5 Emotional communication through affective touch

The Table III shows about the behaviors of KOBIE changing according to a stimuli and emotions.

TABLE III
KOBIE BEHAVIORS

Behaviors
stoop
openEye & upNeck
loudSound & prickEars
angerSound
shakeHead
standBody & lookAround
struggle
pushBody &fearSound
stoopBody
stepBackward
upNeck & joySound
embrace
closeEye & downNeck
cuteTricks
leftTrace rightTrace backTrace
closeEyeLid & downNeck
sadSound & goForward
blinkEyeLid
wagEars
Basic posture

IV. CONCLUSION

In this paper, we propose the method for expressing emotion for the emotional robot KOBIE. Our system can express a specific emotion of the emotional robot in the form recognizable by a user so that an emotional communication between a human being and a robot is possible through affective interaction. Also, KOBIE can contribute to the emotion stability of the human which dislikes a pet or worries about an allergy, an infection, etc. and is unable to breed a pet. In the future, we are planning to add the memory and personality model in KOBIE.

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