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Implementation of Emotional Model of Software Robot Using the Sensor Modules for External Environments

이준용, 김창현, 이주장
JoonYong Lee, ChangHyun Kim, and JuJang Lee

한국과학기술원 전기및전자공학과
Department of Electrical Engineering and Computer Science, KAIST
E-mail : junyoni@odyssey.kaist.ac.kr

Abstract **Abstract**

Recently, studying on modeling the emotion of a robot has become issued among fields of a humanoid robot and an interaction of human and robot. Especially, modeling of the motivation, the emotion, the behavior, and so on, in the robot, is hard and need to make efforts to use our originality. In this paper, new modeling using mathematical formulations to represent the emotion and the behavior selection is proposed for the software robot with virtual sensor modules. Various points which affect six emotional states such as happy or sad are formulated as simple exponential equations with various parameters. There are several experiments with seven external sensor inputs from virtual environment and human to evaluate this modeling.

Key words : Emotional modeling, software robot, behavior, and sensor module.

1. Introduction

Commonly, thinking about a robot among the people is changing slightly. A robot has been considered as just a machine for manufacturing some merchandise and replacing human being in dangerous work. It has been thought that it should be obedient for master's orders and it is not important to consider its internal state such as its intention, will, emotion, and so on. However, as robot technology has developed rapidly, the field of its application has become more various and has been concerned about its intelligence and emotion to easily interact with human being who is substantial user. [1][2] For example, studying about the emotional robot for elder people and the educational robot for kids is in progress. [3] Therefore interacting with a user using emotion of robot is a good issue. There is, however, no official concept of 'emotion'. In other words, 'emotion' means human's in this field mainly. Besides, there is a big difficulty, from the neuroscience point of view, is that there does not seem to be any emotional center in the brain. [4] In [4] and [5], it is thought that some of the basic functions of emotions with the hope that understanding what emotions are for will inform an understanding of what emotions are. Namely emotion in the robot can be considered as some set of various functions to interact with human user.

There are so many studies about human robot interaction using the concept of emotion, which represents internal state of robots. [8][9] From the functional point of view, the interactions between a human and a robot can be formulated as numerical problems and parameterized as objective functions with various factors. Actually, the modeling of a robot architecture [12], which should consider for composing and assigning the various factors such as emotion, homeostasis, inner motivation, attention, and so on, becomes an issue. These factors affect a robot to select its behavior or some reaction.

In this paper, modeling of emotional state is concentrated for interaction with an environment, which means whole of the external stimuli and internal states. In most case, the emotion of robots is conventionally considered as one specific state in that context. [11][12] Therefore, co-existence of emotional states

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of robot is proposed in this paper. In section 2, whole modeling of the robot system is proposed and each component of modeling is described briefly. Next, in section 3, simulation of this modeling for the environment is following. Finally, it makes a conclusion of this study.

2. Robot Architecture

Robot architecture can be classified as three types. They mean a reactive one, deliberative one, and the hybrid one. [11] In this section, the overall structure is described briefly first and each part is dealt with more specifically.

2.1 Overview

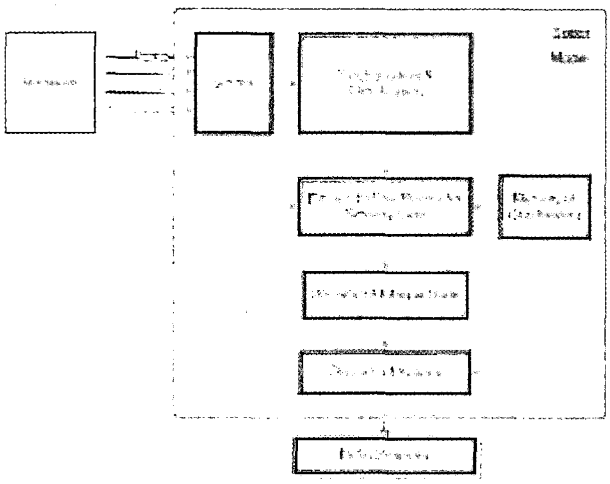

Fig.1. Overview of robot modeling

As shown in the figure 1, whole structure of proposed robot architecture is almost similar to existing ones. However different points with other ones can be discovered through the collection of more specific parts.

In advance, it is assumed that sensor inputs mean packets that have real values in virtual surroundings, not binary type. In this case, neuron filters are needed for defining the activation of sensors and symbolizing the real valued inputs using some threshold values. After the symbolization and identification process, a robot selects the valuable input data and sorts feasible behaviors from them in good order. In that time, a robot decides the emotion and action state. Finally the data packet with the information of decision of actions has to be forwarded to the motion planner in order to show proper behaviors for given situation. Actually, to copy human behavior architecture, the modeling should be more complicated and sub-dividable than this structure. Therefore, this model can be an example for examining the new structure of behavior modeling. Now each part is considered lucidly.

2.2 Sensor Modules

Each sensor should be defined a prior and threshold value of each one should be determined by designer. These parameters can be defined differently to represent the sensitivity. S_{in} can be denoted by normalized signal given by the nth sensor and S_{tn} can be denoted by the threshold value of the nth sensor. The nth sensor data is defined as follows.

$$S^n = \begin{cases} 0, & if \;\; S_{in} < S_{tn} \\ S_{in}, & otherwise \end{cases}, \quad n = 1,\ 2,\ \cdots,\ N \qquad (1)$$

N is the total number of sensors. In this work, 28 situations perceived by sensor module inputs are used, which are called by sensor module states This filtering procedure helps for sorting the sensor data.

Table 1 Sensor Module States

Ultrasonic Sensors	Obstacle Detection	Obstacle exist
		Distance_near
		Distance_mid
		Distance_far
		Suddenappear
		Suddendis-
		Cliff
Microphone	Sound Detection	Sound_noisy
		sound_normal
		sound_calm
		sudden_loud
		sudden_calm
	Voice Detection	voice
		voice_good
		voice_bad
		voice_hello
Vision Sensor	Object Detection	object1_detect
		object2_detect
		object3_detect
	Object Closeness	object1_close
		Object2_close
		Object3_close
	Face Detection	face_detected
		face_close
Voltage Current Detector	Battery Information	battery_low
		battery_normal
		battery_full
		food

2.3 Internal state modeling

In this subsection, internal state is considered as emotional state and motivation using some memory of good feeling. From the engineering point of view, usually, an emotional state can be sub-dividable to emotion, mood, and feeling. [13] It means a context must be considered. Therefore, data of sensor excited previously can affect the current behavior selection. Moreover the motivation of each group of behavior can't be negligible for the selection. Memories of emotion and motivation can be significant factors [12], which they should be obtained by good feeling about those. They should be dependent and take some influences for each other. If the importance of the emotion should be greater than one of the motivations, behavior selection of a robot should be considered to represent the current emotion. Conversely, for example, if a human master commands a robot to send somebody on an errand, a robot must obey this command first of all in concurrence with inhibiting the emotion representation. Therefore it is necessary for excitation and inhabitation of these factors to be well defined.

Emotional state can be estimated by sum of multiplications of the 'emotional value' and the priority of each sensor input which are assigned according to each sensor. In this work, emotional states can be classified by happy, sad, angry, intimate, fearful, and relieved, which can be paired. For instance, if a robot meets favorite person, it should be happy. In this time, its 'happy value' should be increased. Moreover, since the emotional state may be on the time domain, the 'emotional value' should be defined with the time sequence. There are two modes. First one is the 'excitation mode' which means that a sensor owning a specific emotional value is exciting. Second one is the 'appeasement mode' which describes that an emotional excitation doesn't occur and then a robot recovers composure of an emotion. If the specific emotional value is over the threshold in the 'excitation mode', the specific emotional state should be exciting. If a robot is in the 'appeasement mode' for a specific emotion, the specific emotional value should be decreased.

$$E^k_{exc}(t) = f\left(E^k(t-1), E^k_{\text{var}}\right) = E^k(t-1) + \left(\sum_{i=1}^{N} S^i_{on} S^i_{urg}\right) E^k_{\text{var}} \quad (2)$$

$$E^k_{app}(t) = d^{t_s} E^k(t-1) + 0.5E_{\max}\left(1 - d^{t_s}\right) \quad (3)$$

In equation (2) and (3), $E^k_{exc}(t)$ and $E^k_{app}(t)$ mean the current value of *k*th emotional state in the excitation and appeasement mode respectively and $E^k(t-1)$ means the previous value of *k*th emotional state, where k is an index for representing the six emotions. In equation (2), E^k_{var} means the update size for *k*th emotional state and this parameter is adaptable for sensor inputs using the concept of good feeling. S^i_{on} represents by either 0 or 1 whether *i*th sensor is exciting or not and S^i_{urg} describes a predefined value for defining the priority order of *i*th sensors by the robot value system.

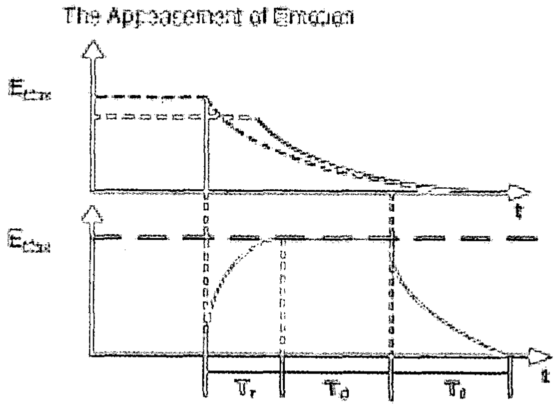

Fig.2. Appeasement function of an emotion value

In equation (3), $E_{\max}$ means the maximum of the emotional value, which is 100 in this work. *d* means the decline rate in the appeasement mode and t_s is the sampling time of the system.

A role of memory should adapt the good feeling to interact with a person. If this part can be learned by given situation, a change of emotion and behavior selection may happen according to the person's emotion and the robot's sensor input. Therefore, good feeling can be initialized for a person a prior. In this case, if the person says 'Good job!' to praise his robot, the robot's good feeling about the person should be increased. This parameter is assigned into the memory space.

2.4 Behavior Selection

77 behaviors are used in this paper. These are similar in [12]. Final behavior to be selected by a robot is determined by voting. For keep the continuity in robot's behavior, previous behavior needs to obtain one vote. One vote has the integer value between 0 and 10, since according to the excited sensor and its degree of importance the behavior selection should be changed. In addition, other voting should be considered according to the emotional state.

$$AV^n_{sen}(t) = AV^n(t-1) + \gamma_s \sum_{i \in R_n} \left(S^i_{on} S^i_{urg}\right) \quad (4)$$

$$AV^n_{emo}(t) = AV^n(t-1) + \gamma_e \sum_{k \in R_n} E^k(t) \quad (5)$$

Equation (4) and (5) denote the voting function for the selection of nth action according to the sensor input and current emotion state respectively where n is the index of the 77 behaviors. γ_s and γ_e mean the voting ratio of a senor input and an emotion state. $i,\ k \in R_n$ means when the voting of nth behavior is affected by *i*th sensor input and *k*th emotional state respectively.

3. Simulation

As shown in figure 4, 28 sensor state are considered in this simulation, where they can be classified by seven categories according to the given environment though the middleware. Figure 5 describes the change of 'happy' emotional value when the sensor state, like as 'Face closed' and 'Voice good', is received.

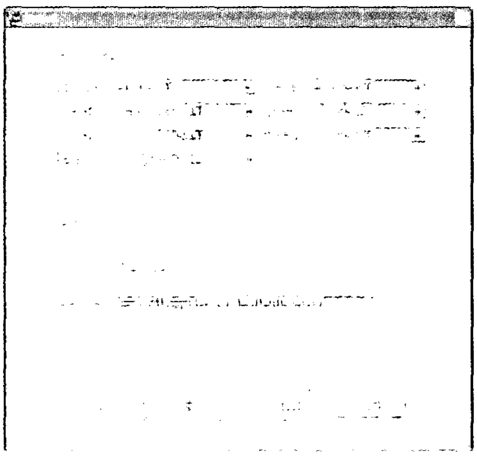

Fig.3. Test simulator

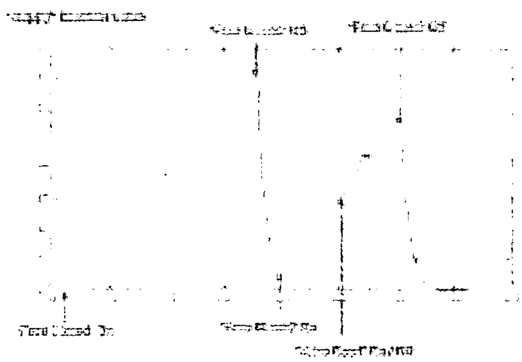

Fig.4. An example 1, 'Happy' Emotion

There are three scenarios to verify this modeling. First one is the case that arbitrary sensor states are randomly received. In Figure 6, each set of data is obtained for the sampling time of 200ms. In this result, it can be found that six emotional states can be co-existent in the same time, since the previous emotional value is not disappeared and it is successive. Second one is the case that a person praises his robot to have good feeling more. It can be shown that increasing rate is greater than before some praises from figure 7. Otherwise, in figure 8, it can be shown that emotional state changes badly.

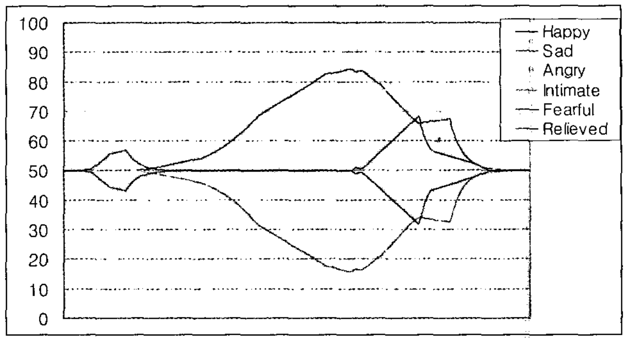

Fig.5. Emotional states, when arbitrary sensor input are given.

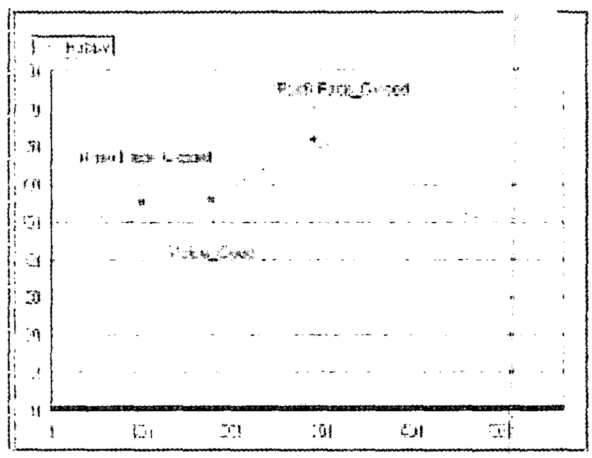

Fig.6. 'Happy' Emotion, effect of some praise

4. Conclusion

Modeling of interaction can be focused on the emotional modeling using sensor states for the given environment.

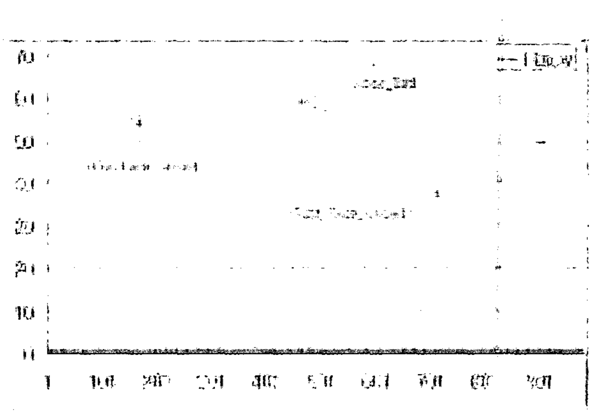

Fig.7. 'Happy' Emotion, effect of some scolding

The structure for the modeling of robot architecture is proposed and the each part of the structure is introduced. Finally, in several situations, the feature of this system can be verified by some results. In the future, more complex structure should be proposed and learning algorithm for various parameters should be defined clearly.

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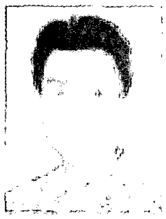
저 자 소 개

Joon-Yong Lee received the B.S. degree in Electronics Engineering from Ajou University, Suwon, Korea in 2002. And the M.S. degree in electrical engineering from the Korea Advanced Institute of Science and Technology (KAIST), Daejon, Korea, in 1998, where he is currently a candidate for the Ph.D. degree. His research interests include evolutionary computation, biped robot, and intelligent control.



Chang-Hyun Kim received the B.S. and M.S. degrees in Electrical and Electronic Engineering from the Korea Advanced Institute of Science and Technology (KAIST) in 2000 and 2002, respectively. He is currently working toward the Ph.D. degree at KAIST since 2002.
His research interests include artificial intellingence, intelligent control, and robotics. He is a member of ICASE.

Ju-Jang Lee (M'86−SM'98) received the B.S. and M.S. degrees, both in electrical engineering, from Seoul National University in 1973 and 1977, respectively and the Ph.D. degree in electrical engineering from the University of Wisconsin in 1984.

From 1977 to 1978, he was a research engineer at the Korean Electric Research and Testing Institute, Seoul. From 1978 to 1979, he was a design and processing engineer at G.T.E. Automatic Electric Co.,

Waukesha, WI. In 1983, he was briefly the project engineer with the Research and Development Department of the Wisconsin Electric Power Co., Milwaukee, WI. He joined the Department of Electrical Engineering, KAIST, Korea in 1984, where he is currently a professor. In 1987, he was a visiting professor at the Robotics Laboratory of Imperial College Science and Technology, London, U.K.. From 1991 to 1992, he was a visiting scientist at the Robotics Institute of Carnegie Mellon University, Pittsburgh, PA. His research interests are in the areas of intelligent control of mobile robot, service robotics for the disabled, space robotics, evolutionary computation, variable structure control, chaotic control system, electronic control units for automobiles, and power system stabilizers.

Dr. Lee is a member of the IEEE Robotics and Automation Society, the IEEE Evolutionary Computation Society, the IEEE Industrial Electronics Society, KIEE, KITE, and KISS. He is a vice president of ICASE in Korea and a director of SICE in Japan.