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The Model with the Changing Internal Emotion

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Abstract **- Generally, it is known that human beings have both emotion and rationality. Especially, emotion is so subjective that human beings might act in different way for the same environment according to their own emotion. Emotion also plays very important role in communication with someone else.**

For an agent, even though it is designed to act delicately, when it is designed without internal emotion, it can not interact dynamically just like human beings. In this paper, we suggest an agent which action is effected by not only rationality but also emotion to make it interact with human beings dynamically. It is composed of supervised learning, SOM (Self-Organizing Map) and fuzzy decision.

I. INTRODUCTION

Usually, emotion is defined as the psychological variation caused by physiological and physical environment, or social and cultural environment. This kind of variation is subjective and may cause different result depending on individual emotion when people do something. Especially, it is known that emotion is indispensable when people do interaction like conversation.

Of course, it is not clear to separate emotion from rationality in analysing human beings, but we assume that emotion and rationality have different role respectively. That is, rationality is relative with selecting the wisest solution in the faced problem and emotion is relative with a subtle difference on doing action[1]. With this assumptation, we propose the model that can learn rationally and has internal emotion.

II. SYSTEM OVERVIEW

A. The definition of intelligence

The definition of intelligence has been changed. In the beginning of this century, intelligence simply means the ability of memorization and calculation. However, this definition has been disappeared. About ten years ago, the definition of intelligence included the term of learning. In addition to learning, the decision also was regarded as intelligence. Nowadays, it is well known that machines are able to learn or decide well and they show sometimes better result than humans. So, we need to re-define what intelligence is. Human brain can represent emotion, willingness and consciousness. This is the feature of human. Human thinks that he may understand someone's emotion even though he is not sure about other's emotion. In virtue of emotion, human can interact with others well. Therefore, intelligence should include the aspect of emotion, consciousness and so on.

B. Proposed Model

The proposed model consists of three main parts and is shown in Fig. 1. In the first part, the model learns the rational actions. That is, the model receives the degree of illumination, humidity and noise as inputs and then selects the genre of music. The second part is for

realizing the change of emotion. The model receives information from external environment as input and estimates the strength of input and then changes internal emotion. The last part combines outputs form first part with output from second part to select the pieces of music and to control the tempo of music.

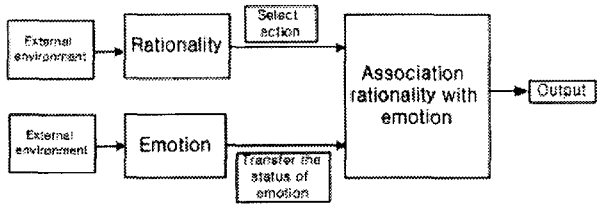


Fig. 1. The proposed model

C. Back-propagation Algorithm

Supervised learning is used in order to embody the rationality of the model. The structure of multi-layered neural network that is popular supervised learning method is shown in Fig. 2. Supervised learning has similarity with human's learning because both of them need teacher.

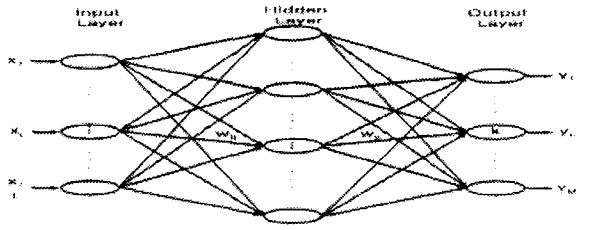


Fig. 2 The structure of multi-layered neural network

D. Self-organizing Map (SOM)

In competitive learning method, we select winning output cell as the one with the smallest dissimilarity measure between all weight vectors $\mathbf{w}_i$ and the input vector $\mathbf{x}$. The equation is following,

$$\| x - w_c \| = \min_i \| x - w_i \| \qquad (1)$$

where c is the winner cell and $\|\cdot\|$ is Euclidean distance.

For SOM method, however, we update not only winning cell's weights but also all of the weights in a neighborhood of winning cells with each iteration. Nc denotes a set of index corresponding to neighborhood around winner c. The weights of the winner and its neighboring cells are then updated by

$$\Delta w_i = \eta(x - w_i), i \in N_c \qquad (2)$$

where η is a small positive learning rate[2].

In order to adjust degree of learning according to the distance from winner cell, SOM needs neighborhood function. We choose Gaussian function as neighborhood function because it is known that Gaussian function is stable and is easy to embody. The equation is following.

$$\Omega_c(i) = \exp\left(\frac{-\| p_i - p_c \|^2}{2\sigma^2}\right) \qquad (3)$$

where p_i and p_c are the positions of the output cells i and winner cell c, respectively, and reflects the scope of the neighborhood.

By using neighborhood function, the final update formula can be rewritten as

$$w_i(t+1) = \begin{cases} w_i(t) + \eta\Omega_c(t)(x(t) - w_i(t)), i \in N_c \\ w_i(t) \end{cases} \qquad (4)$$

SOM can be applied to model internal emotion because it is changed dynamically responding external environment[3].

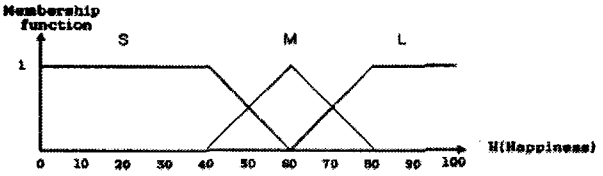
In this paper, the output layer consists of hundred cells. It is a two-dimensional torus structure, which means the upper and lower sides, as wells as the left and right sides, are connected to each other. The emotion is divided into the states such as happiness, angriness and calmness. The three states are competitive each other at output layer. When input is positive, happiness is increased. On the opposite case, angriness is increased. There is no input and the state of emotion converges to calmness. Finally, we adjust the number of iteration with the strength of inputs to control sensibility of the change of emotion.

E. Fuzzy Decision

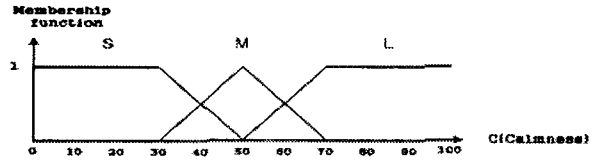
In this paper, fuzzy singleton method is used as

fuzzification method. The membership function is triangular function. Mandani's method (min-max method) is used as fuzzy inference. Finally, the center of gravity method is used as defuzzification method.

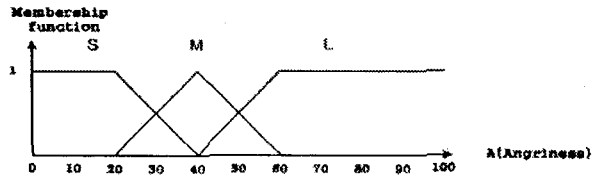
In Fig. 3, (a),(b) and (c) are premise inputs such as happiness, calmness and angriness. They are presented with three linguistic variables respectively. (d) is consequent output that represents the tempo of music with seven linguistic variables. We suppose that angriness is easy to be recognized than happiness. We eliminate the rules that never happens and composite rule base that consists of eighteen rules. The table of rule base is shown in Table 1.



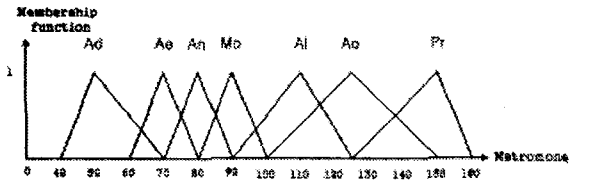
(a) Premise : Happiness



(b) Premise : Calmness



(c) Premise : Angriness



(d) Consequence : Tempo of music

Fig. 3. Membership functions of premise and consequence

H/C \ A	L	M	S
L/L			
L/M			Pr
L/S		Ao	Pr
M/L			Mo
M/M		Mo	Al
M/S	Ae	Mo	Ao
S/L	Ae	An	Mo
S/M	Ad	Mo	An
S/S	Ad	An	Al

Table 1. Rule base for tempo of music

In the table 1, Pr, Ao, Mo, An, Ae and Ad mean Presto, Allegro, Allegretto, Moderato, Andantino, Andante and Adagio respectively.

III. COMPUTER SIMULATION

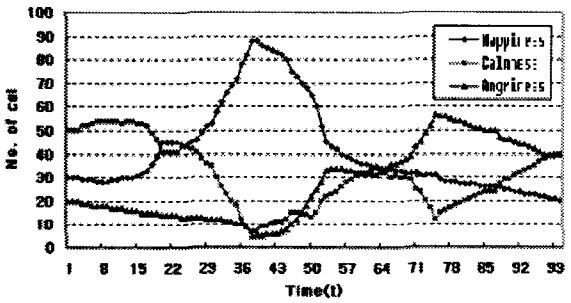


Fig. 4. The change of emotion by external information

Fig. 4 is the result about the change of emotion when the model is received negative or positive information from the external environment such as information from human. External information goes through competitive learning to change emotion. At fifteen second, low positive information is provided into model and happiness is increased little by little. And then, at twenty nine second, high positive information is provided and happiness is increased rapidly. Later, angriness is increased because of negative information. After seventy eight second, the model receives nothing, the emotion

goes calm.

The output from SOM is used for fuzzy inference to change the tempo of music as Fig. 5. In result, when happiness is major emotion, music with quick tempo is selected. On the opposite, music with slow tempo is selected.

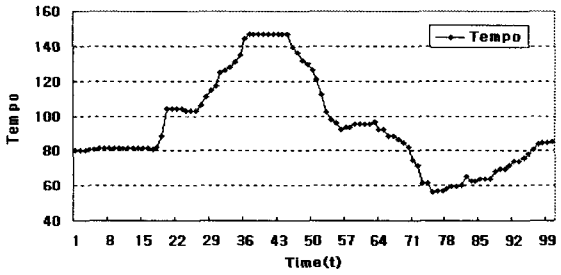


Figure.5 The tempo of music with the change of emotion

IV. Conclusion And Disscusion

In this paper, the model that has rationality and emotion is proposed. The rationally and emotion of the model is represented by music. As result, internal emotion of the model is changed dynamically depending on both the current state of emotion and external environment like human. Finally, further considerations arise to present models which are able to interact with human in various ways.

Acknowledgement

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