Emotion-Based Control

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Abstract

We, Human beings, use both powers of reason and emotion simultaneously, which surely help us to obtain flexible adaptability against the dynamic environment. We assert that this principle can be applied into the general system. That is, it would be possible to improve the adaptability by covering a digital oriented information processing system with an analog oriented emotion layer In this paper. we proposed a vertical slicing model with an emotion layer in it. And we showed that the emotion-based control allows us to improve the adaptability of a system at least under some conditions,

I . Introduction

By using the dynamic correlations of reason and emotion we obtain flexible adaptability against the dynamic environment. We proposed a hypothesis that it would be possible to get the same effect by covering a digital information processing system with an analog emotional layer. To prove this, we presented a vertical slicing model with an emotional layer in itself. Because of its flexibility, The vertical slicing model, an abstract model of the life structure, has been widely used in the field of system design[3]. The suggested model has the dualistic structure of the digital information processing net and the analog potential processing net. If fact, The vertical slicing model seems inevitable for the system which try to implement a great amount of complexity. Because the centralized control,, the typical control model in reduction paradigm, would not be available when the number of modules might increase over certain point. In vertical slicing model, the modules follow the autonomous mechanism with sharing preset rules. The behaviors of them are like independent, distributed and concurrent. With so many numbers, they can keep explicit correlations only with their neighbors in certain range. And in only the limited local range the digital oriented information processing is possible. While the control or information processing from the global viewpoint falls into the emotion layer. The emotion layer controls the process at the system level by using the abstract concept called entropy. In this paper, we analyzed the characteristics of the suggested model and discussed the meaning of them in terms of usefulness using simulation techniques.

II.Vertical Slicing Model(VSM)

The VSM model suggested in our paper is composed of three sub-models: Correlation model, Hierarch Model and Emotion Model.

2.1 Correlation Model(CM)

Correlation Model consists of two sub-models of PM model and CP model.

Potential Module(PM)[1][2]

PM is defined as an object model that has the potential layer in it In the structure, PMs change the quantitative state of the correlations among the system components through the exchange of potentials Fig 2.1 shows the structure of PM.

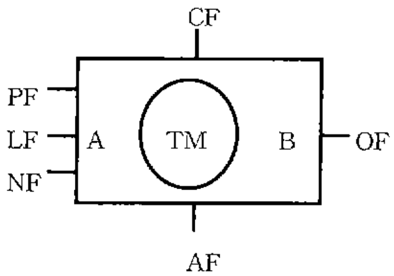

Fig 2.1 The structure of PM

Here, PM consists of TM(Task Module) and PI(Potential Interface) that treats task and potential respectively. PM has four input ports and two output ports. PM also has inner potential which represents the inner energy and outer potential which represents outer influencing power.

Correlation Protocol [CP][1][2]

Diverse correlation among the elements is the essential concept in the theory of emergence. For this purpose we defined the ideal model of correlation as follows based on above PM model.

[1]Antagonistic
---> NF (Val(NF) > 0)
[2]Support
---> PF (Val(PF) > 0)
[3]Cooperate
PF <---> PF (Val(PF) > 0)
[4]Conflict
PF∧NF ---> CF (Val(PF) > 0, Val(NF) > 0)
[5]Compete : NF <---> NF (Val(NF) > 0)
[6]Creation & Extinction
---> AF(Val(AF) > 0 : Creation
Val(NF) < 0 : Extinction)
[7]Increase-Decrease of Conflict
---> SF (Val(SF) > 0 : Increase,
Val(NF) < 0 : Decrease)

Agent

We call the PM network agent which is based on the above correlation protocol. Agent can be considered as the task module at higher level than that of PM.

2.2 Hierarchy Model(HM) [1][2]

In hierarchical system, the information exchange between the hierarchies should be possible to get functions of emergence. That is, the system needs vertical coupling power. By using correlation model we defined the useful abstract concept called entropy. Potential injection based on this entropy allows system to communicate among layers.

Potential Injection

We can inject certain amount of potential into certain port of all PMs(or subset of PMs), which we call "Potential injection". There are three types of potential injection; P-type, N-type and L-type depending on which port is used for injection.

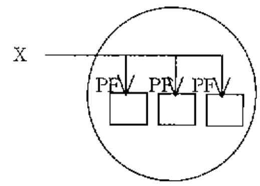

Fig 2-2. P-type potential injection

Static Output : $P_s(x, t)$

Let's assume that we try a potential injection with amounts of x at time t with keeping other conditions constant. When the ouput value of P_w converges to a value we call it "the static value of x at time t" denoted by $P_s(x, t)$.

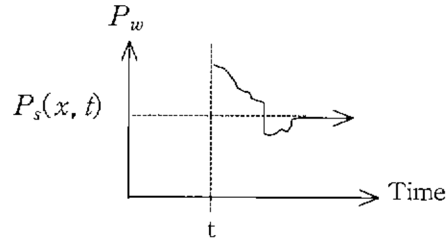

Fig 2-3. Static Output

Maximum output : $P_s^*(t)$

Think about the set of P_s obtained by varing the value of x in $P_s(x, t)$ from $-\infty$ to $+\infty$. Then the greatest value in the set is called "maximum output at time t". denoted by $P_s^*(t)$,

$$P_s^*(t) = MAX\{P_s(x_i, t) | i=1, n\}$$

Entropy

We introduce new terms of "excess of entropy" and "lack of entropy" while we don't want to define entropy itself. For an agent, When $P_s^*(t) > P_w(t)$ and $P_s^*(t) = P_s(x, t)$ we can say that the agent is in either state; "excess of entropy" in case of positive x or "lack of entropy" in case of negative x.

2.3 Emotion Model(EM)

Emotion, we think, is a kind of a phenomena which can be occured in the dynamic system running in the dynamic environment. In case of human beings, the expression of emotion can be seen on the face Though it is very difficult to define the emotion exactly, we might be able to say that the emotion can be classified into two types; happy and unhappy. There seems two types of unhappy situation in connection with task.; "when we couldn't do our best" and "when the result of the task is undesirable". We defined a coordinates with the horizontal axis of the former situation and the vertical axis of the latter one. Fig 2.4 shows all the possible emotion types in this model.

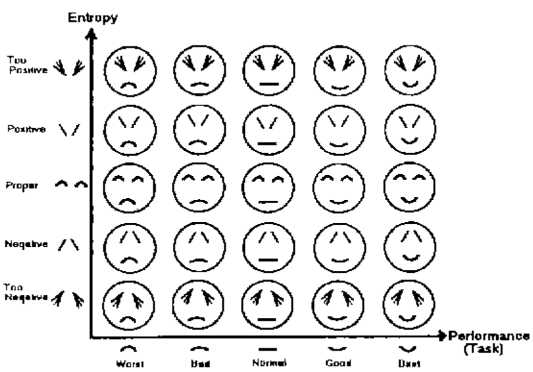

Fig 2.4 Emotion space

Assuming the ideal environment in which the principle "do our best brings in the best result" applies we can reduce the emotion space in fig 2.4 into that in fig 2.5

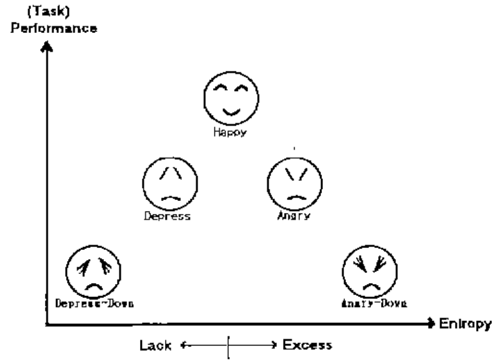

Fig 2.5 Emotion space in ideal environment

III.Characteristics of VSM

3.1 Phase Transition

The entropy of the agent can be varied by the change of the environment((Task, Resource, World, Correlations among TMs). And It is also possible to vary the entropy by the more positive method like potential injection There may occur three types of phase transition with the entropy variation of the agent.

[1]Chaos Mode : Mode 1

In case of the excess state of the entropy, the collisions among TMs increase severely. Thus it creates a terrible situation that no one can obtain the resource(or Task), which results in drastic worsening of the performance We call this situation chaos mode or model.

[2]Stagnation Mode : Mode 2

In case of the lack state of the entropy, the yields among TMs increase severely Thus it creates another kind of terrible situation that no one can obtain the resource(or Task) either, which also results in drastic worsening of the performance. We call this stagnation mode or mode2.

[3]Life Mode : Mode 3

In case of the proper state of the entropy, TMs may easily reach a good compromise on the resource. Thus it can create optimal situation in which we can expect best performance. We call this situation life mode or mode3.

3.2 Partition of the emotion state space

Depressed State

We call it depressed state when the state of the entropy is far enough from the optimal state, in which agent can hardly put forth normal output.

[1]Complete depressed state
Agent falls in fully depressed in case of model and mode2. We call this situation complete depressed state

[2]Active State
Agent is escaped fully from depressed and rather near the optimal in case of mode2. We call this situation active state.

[3]Semi-Depressed State
There may be various level of depressed states along the range of [1] and [2]. In these middle level of depressed state, even though agent is not optimal it can manage to keep steady state without further worsening the situation. We call this situation Semi-Depressed State.

Recovery Possibility

The Recovery Possibility means the property of the recovery by potential injection from the slump such as complete depressed state or semi-depressed state.

[1]Recoverable State
Using the potential injection the system can recover from the slump. If the system can keep the steady situation after recovery without continuing the potential injection it is classified into the recoverable state.

[2]Non Recoverable State
On the contrary, if the system can't recover from the slump or can't keep the steady situation after recovery without continuing the potential injection it is classified into non recoverable state.

Ⅳ. Implementation

The system interface based on VSM model mainly consists of the five windows: Face, State, Agent, Bulletin Board, Potential Injector and Task Pool. Here, The Face shows the image metaphor of the emotional state of the system, The State expresses the entropy state of the system. The units in the agent represent the coupling correlations among PMs of which degree means the encouraged size of each PM respectively in terms of emotion.

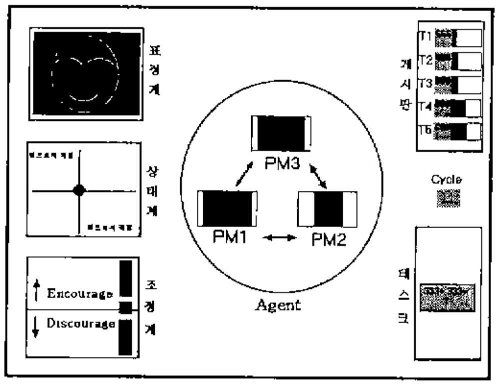

Fig 4.1 The interface of the system

The entropy which represents the emotion state has an important role in the process of the dynamic adaptation of the system. One of the significant characteristics of the VSM model is that we can arbitrarily control the inner emotion state by the potential injection. In this experiment, we will check up how the change of the system is like by the potential injection.

4.1 Competition Mode

Competition mode in this model means that all PMs in an agent are connected as to aggresive against one another.

Scenerio 1

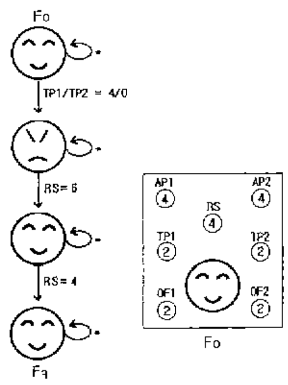

Fig 4.2 Scenerio 1

Scenerio 1 shows that the change of environment may change the state of the emotion of the agent. The agent in "Happy" plunges into "Angry-Down" because of some task change, and can hardly escape from it by himself. Then if the resource happen to change into 6 from 4 the agent recovers initial state of "Happy". Once recovering "Happy" state, it can keep current state even though the resource may change reversely, that is, from 6 into 4

Scenerio 2

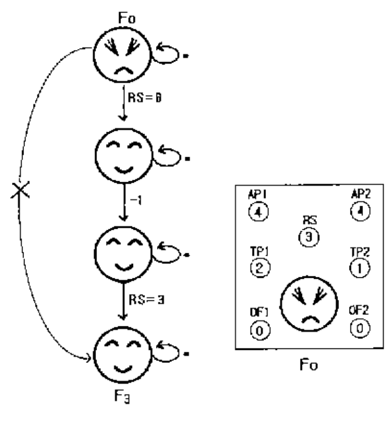

Fig 4.3 Scenerio 2

The scenerio 2 shows that the agent can eascape from the down state through proper combination of environment change and potential injection. The agent in "Angry-Down" can not get out from it by himself. Any type of potential injection in this situation doesn't work. But, even temporally, if the resource happen to change into 8 and be followed by proper potential injection the agent is able to return "Happy" state which the agent can keep it continually then

Scenerio 3

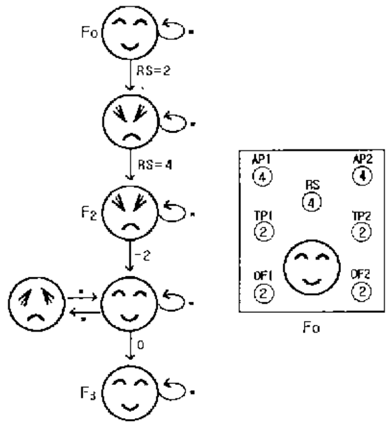

Fig 4.4 Scenerio 3

Scenerio 3 shows the opposite case of scenerio 2. The agent in "Happy" changes into "Angry" because of resource change. Once reaching at this situation, the agent can't recover original "Happy" state even with recovered original resource. By potential injection of -2 the agent begins to circulate through two states; "Depress-Down" and "Happy". During this process, when the agent is at "Happy" state, by stopping potential injection we can let the agent stay in steady "Happy" state.

4.2 Cooperation mode

Cooperation mode in this model means that all PMs in an agent are connected as to be helpful one another.

Scenerio 4

Scenerio 4 shows a funny phenomenon. Initially, the agent is stuck with "Depress" state. Now, we can change the state into "Happy" from "Depress" by potential injection of +1. But, without such a positive interaction, the agent, interestingly enough, can naturally converge into "Happy" state even though it needs much more time.

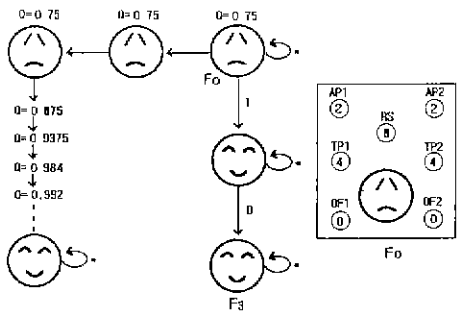

Fig 4.5 Scenerio 4

V. Conclusion

In this paper, the issue on emotion-based control in the vertical slicing model was studied. We proposed a specially designed vertical slicing model with an emotional layer in itself. We analyzed the behaviors of the suggested model in various aspects using simulation techniques. Thus, we could show that the emotion-based control allows us to improve the adaptability of a system at least under some conditions. But we have not studied enough on the coordination problem of the emotion-based control and reason-based control, which will be the next target of our study.

Reference

[1]Sung-Bum Ko, "An Emotion Model in Dynamic Environment", Proceeding of the 1998 Korean Society for Emotion and Sensibility Conference, 127-132, 1998

[2]Sung-Bum Ko, "Emotional Layer Model", Proceeding of the 1998 Korean Society for Emotion and Sensibility Conference. 133-137, 1999

[3]R.A. Brooks, "A Robust Layered Control System For A Mobile Robot", IEEE Journal of Robotics And Automation, Vol. RA-2, No.1, 1986

[4]Bhushan, N. & Rao, The texture lexicon: Understanding the categorization of visual texture terms and their relationship to texture images, 141-154, 1991.

[5]Moo-Soo Noh, Emotion & Sensibility for New Industry and Society, Proceeding of the 1997, Korean Society for Emotion and Sensibility Conference, 6-10, 1997

[6]A Ortony, G. Clore and A. Collins, The Cognitive Structure of Emotions, Cambridge University Press, 1988.