The Thirteenth International Symposium on Artificial Life and Robotics 2008(AROB 13th '08),
B-Con Plaza, Beppu, Oita, Japan, January 31-February 2, 2008

A Control Method of Agent Group with Emotion Model

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Abstract: The purpose of my work was to design the robot system that can understand a human sensitivity and emotion and perform cooperative task by making use of such a characteristic in a relation with a human and the robot. For the purpose of our work, we observed and analyzed an action as the group of agents that gave new emotional action rule. The rule used the interaction of emotions called sympathy and alignment. As the result, it was found that the agents performed the emergence action of "a meeting or a separation". In addition, we defined this emergence action as the basic action characteristic of the group of agents. And we suggested two methods to control the behavior of the group using the characteristic and tested it. The first is a method used agent with small sensitivity. In first result, it is possible to control the action of "a meeting or a separation". The second is a method used place of sensitivity. In second result, it is possible to control the action of "a meeting" by how to give sensitivity of a place.

Keywords: *Emotion Model, Multi Agent System, Emergent System*

I. INTRODUCTION

These days, it is prosperous the research on the care robot which is expected in a field of the medical care and the welfare and the petting robot for the purpose of mental healing and entertainment characteristics. These robots are different from the robot operating apart from a human being in isolated space such as the industrial robot. The cooperative task in a positive relation with the human being is demanded from these robots. Because the human communicates with KANSEI, it is important that we design the system that these robots can understand KAMSEI and feeling and can perform cooperative task [1]. On the other hand, there is the research of the multi agent system this is to produce new functions by interaction with plural agents each other. This system has the characteristics such as adaptability for the environmental change, flexibility for the work demand, the fault tolerance that some trouble is not connected for total trouble, and the rise of the efficiency by multiple work. The agents achieve a useful purpose as the agent group, by cooperative relations and organized behavior [2-3]. The purpose of the research is to design the robot system can understand KANSEI and perform cooperative task by making use of such a characteristic in a relation with a human being and the robot. If we are able to design the system, we can

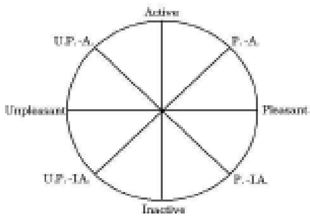

Fig.1. The emotion structure of the human by Larsen & Diener

achieve a purpose without giving a careful order. And the convenience of the robot can improve drastically. In past, we suggested the emotional model that is different from a conventional robot system choosing a task depending on emotion. This model has the autonomous action algorithm that resembles the interaction of emotions. As a result, we were able to do emergence of an action of agents [4-5]. By this report, we suggest new emotion model corresponding to emotion in imitation of human sympathy and alignment. And we confirmed the emergence action of the agent group by computer simulation. As the result, we understood that the agents performed the emergence action of "a meeting" and "a separation". In addition, we defined this emergence action as the basic action characteristic of the group of agents. And we suggested two methods to control the behavior of the group using the characteristic and tested it. The first is a method used agent with small sensitivity. As first result, we

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confirmed "a meeting" and "a separation". The second method is an experiment on the control of an agent group using the place of the sensitivity. As second result, it is possible to control the action of “a meeting” by size of the sensitivity of the place. Therefore, these results showed possibility to control the behavior of the agent group without giving close information.

II. DEFINITION OF AGENT

1. Circumplex Model

The reserch about human emotion is prosperous in a psychological domain. There are various opinions about the classification method of emotion. For example, Larsen & Diener proposes Circumplex model of emotion. Figure 1 is this model. The human emotion consist of 2 dimensions of the induced nature (excellent - unpleasantness) and the awakening (inert - activity). This model is expressed the first quadrant "joy", the second quadrant "anger", the third quadrant "depression", the fourth quadrant "relaxation". It is said that this model can express human emotion. In this study, we use Circumplex Model as emotion model. We give "excellent - unpleasantness" and "activity - non-activity" as inside variable of the agents. We sketch each with excellent value and activity value. And we name two general term emotion value.

2. Emotion Model

In general, many animals process the stimulus of the outside world and offer emotion to the body as an external recognition material. The emotion is an effective method for adaptation and is useful to adapt itself to environment [7]. In other words, an emotion is generated by the stimulation from the outside world, and this becomes the factor to choose an action. On the other hand, the human transmits the emotion with communication. The human communicates with a language and can understand psychological condition from the behavior of the partner. The human being knows the psychological condition of the partner and changes it of the self. And the psychological condition of the partner varies by expressing it of the self. Thus the human performs interaction of emotion. Based on the above, we gave agents an action rule evoked by feelings.

(a) The agent has a constant field of vision to circumference and gets information from environment in the field of vision range.
(b) The movement speed of agent is in proportion to an excellent value.
(c) When "activity value" increases, the agent does activity. And the frequency of the direction change increases.
(d) When there is another agent in the field of vision of a certain agent, a certain agent goes along with the agent and approaches it. The value is in inverse proportion to distance between positions and distance of the emotion value.
(e) We define a difference of the sensitivity of emotion as "sensitivity". When sensitivity increases, the changes of the emotion value increase.
(f) When there is an agent in a field of vision, agent oneself sympathizes with the partner in the field of vision, and emotion value is similar to it, and the quantity of change is in inverse proportion to distance of the position space.
(g) When there is not another agent in a field of vision, the emotion value of a certain agent nears neutrality.

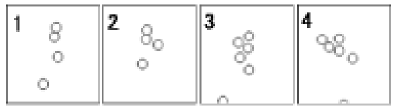

Fig.2. A weak meeting

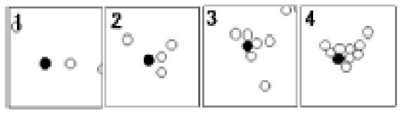

Fig.3. A strong meeting

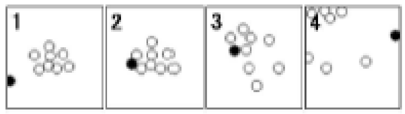

Fig.4. A separation

$$Pv_{i(t)} = Pv_{i(t-1)} + Chi \sum_{j=0}^{n} \frac{Pv_{j(t-1)} - Pv_{i(t-1)}}{r_1 ij} l \quad (1)$$

$$Av_{i(t)} = Av_{i(t-1)} + Chi \sum_{j=0}^{n} \frac{Av_{j(t-1)} - Av_{i(t-1)}}{r_1 ij} l \quad (2)$$

$$Vg_{i(t)} = \frac{1}{n} \sum_{j=0}^{n} \frac{V_{2ij}}{r_{1ij}(r_{2ij}+1)} \quad (3)$$

$$Pv_{i(t)} = Pv_{i(t-1)} + \{Pv_0 - Pv_{i(t-1)}\} Chi \quad (4)$$

$$Av_{i(t)} = Av_{i(t-1)} + \{Av_0 - Av_{i(t-1)}\} Chi \quad (5)$$

$$V_{i(t)} = \left(V_{i(t-1)} + a \cdot \frac{V_{Avi(t)}}{\|V_{Avi(t)}\|} + k \cdot \frac{V_{gi(t)}}{\|V_{gi(t)}\|} + \frac{V_{mi(t)}}{\|V_{mi(t)}\|} \right) \frac{Pvi(t)}{Pv_{max}} \quad (6)$$

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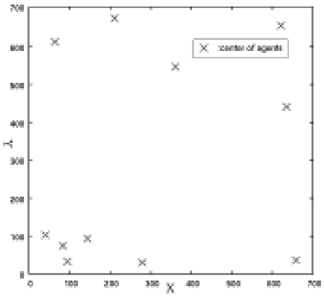

Fig.9. A center of gravity coordinate of agent group (l=0.01)

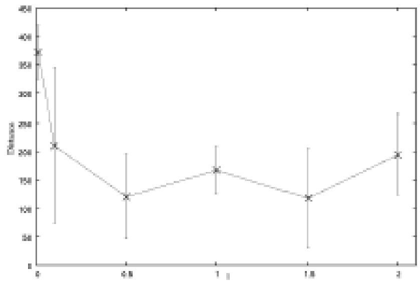

Fig.10. Relations with average of the distance from the center of gravity coordinate to the maximum and emotion influence degree l

i : ID-number of the agent
j : ID-number of another agent
t : The number of turns
$Pv_{i(t)}$: An excellent value at time of t turn of agent i
Pv_0 : The neutral value of a excellent value
$Av_{i(t)}$: An active value at a time of t turn of agent i
Av_0 : The neutral value of a activity value
Ch_i : Sensitivity of agent i
n : The number of agents
r_{1ij} : Distance between agent i and j
r_{2ij} : The difference of emotion value between agent i and j
$Vg_{i(t)}$: The attunement vector at a time of t turn of agent I
$V_{Avi(t)}$: The random vector that occurs in Av[%] at a time of t turn of agent i
$V_{i(t)}$: The speed vector at a time of t turn of agent i
$V_{mi(t)}$: The distance vector between an agent and destination
Pv_{max} : The maximum of excellent value
a,k,l : The coefficients

The expression (1) and (2) support action rule (f). Action rule (e) affects Clause 2 and updates the emotion value. The expression (3) supports action rule (d). The expression (4) and (5) support action rule (g). Action rule (e) affects Clause 2 and updates excellent value Pv

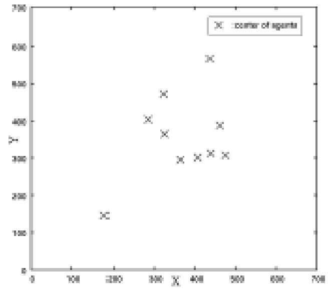

Fig.11. A center of gravity coordinate of agent group (l=0.5)

and activity value Av. Clause 2 of the expression (5) supports action rule (c). Clause 3 of it uses value that is updated by the expression (3). In addition, the coefficient to hang over all vectors supports action rule (b).

III. BASIC MOVEMENT CHARACTERISTIC EXPERIMENT

1. Experiment environment and setting

Pv, Av, Ch are ranges of the ($0 \leqq$ Pv, Av, Ch $\leqq 100$). The space builds 700×700 two dimensions space (x,y). The agents are posted at random. We set an initial value with a=1.5, k=0.11, l=0.5 and set Pv, Av, Ch at random. And we observed movement of agents.

2. Experiment result and consideration

Figure 2, figure 3, figure 4 is basic movement of the agents when "a meeting" and "a separation" were confirmed by a simulation experiment. The number on the left in each figure expresses a turn. In addition, a white agent of figure 2, figure 3, figure 4 is a agent with near emotion value Pv and Av. A black agent of figure 3 is an agent with small sensitivity and emotion value. The black agent of figure 4 is a agent with high sensitivity and small emotion value. In figure 2, the agents with near emotion value Pv, Av go along and come close and form "a weak meeting". In figure 3, a white agent sympathizes around a black agent with small emotion value Pv, Av and small sensitivity and goes along and approaches it. The agents finally form the meeting that is denser than agents of figure 2. In figure 4, the black agent with small sensitivity and high emotion value Pv, Av approached and sympathized the white agent group. And emotion value Pv, Av increased. As a result, the agents became "a separation". Therefore, it shows the possibility that can control behavior as the agent group by using a agent with small sensitivity.

IV. AGENT GROUP CONTROL EXPERIMENT (When we used a basic movement characteristic)

Based on the basic movement characteristic provided by the basic movement characteristic experiment, we perf

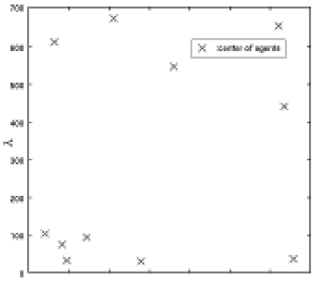

Fig.9. A center of gravity coordinate of agent group (l=0.01)

p using an agent with small sensitivity.

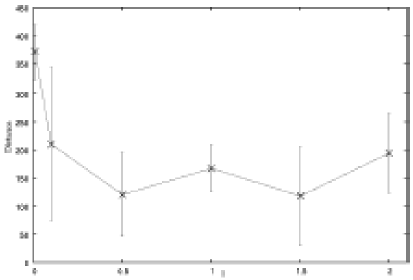

Fig.10. Relations with average of the distance from the center of gravity coordinate to the maximum and emotion influence degree l

1. Experiment environment and setting

Pv, Av, Ch are ranges of (0 ≦ Pv, Av, Ch ≦ 100).
The space builds 700×700 two dimensions space (x,y). The agents are posted at random. We set an initial value with a=1.5, k=0.11, l=0.5 , n=30 and set Pv, Av, Ch at random. The destination is decided at random to let agents search on a field. We make one place of point with random in a certain place in the field. And we set emotion value of a agent which passed by over the point first in (Pv,Av)=(0,0). In addition, we set the sensitivity of the agent to Ch = 0 to quit the influence from the other agents.
We call this agent "key agent". The emotion value of the key agent is set with (Pv,Av)=(100,100) after 10000 turns since we discovered a point. The key agents are replaced afterwards when we change a point position and a agent passed by again. We observed movement of the agents when we performed this operation to t=50000 repeatedly.

2. Experiment result and consideration

Figure 5 is a state on the field after 10000 turns. Figure 6 is emotion distribution at that time. Agents gather around a key agent. Because the emotion value of the key agent became "unpleasantness - inert", the emotion value of other agents falls down slowly when a key agent is in the field of vision. And it is thought that the agents came close and movement stopped like a key agent. Figure 7 is a state on the field after 15000 turns.

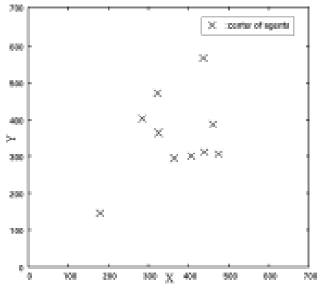

Fig.11. A center of gravity coordinate of agent group (l=0.5)

Figure 8 is emotion distribution at that time. The key agent starts movement so that emotion value becomes "excellent - activity". According to figure 8, because there is a general rise of an excellent value and the activity value, the agent which formed other agent group starts movement. We confirmed "a meeting" and "a separation" of these agents by t=50000 twice. Therefore, we were able to confirm emergence called "a meeting" and "a separation" in the agents by the simulation experiment.

V. AGENT GROUP CONTROL EXPERIMENT

(When we gave the place sensitivity)

Based on the basic movement characteristic provided by the basic movement characteristic experiment, we perfo rm an experiment to control behavior of agent group usi ng sensitivity of a place.

1. Experiment environment and setting

Pv, Av, Ch are ranges of (0 ≦ Pv, Av, Ch ≦ 100). The space builds 700×700 two dimensions space (x,y). The agents are posted at random. Position of the agent, Pv, Av are set at random. We set an initial value with n=50, a=1.3, k=4.0, l=0.01,0.1,0.5,1,1.5,2 and tried ten times. We set sensitivity Ch of the agent with the solution of the function of the expression (7) that depended on agent position (x,y). Pv,Av,Ch of the agent changes to (Pv,Av,Ch)=(0,0,0) in a constant ratio between t=500. We observed the position of the agents in t=50000.

2. The experiment result and consideration

Figure 10 is relations with average of the distance from the center of gravity coordinate to the maximum and feelings influence degree l in t=50000. The trial number of times is ten times. In addition, figure 9 is a coordinate of the centers of gravity in case of l=0.01. Figure 11 is a coordinate of the centers of gravity in case of l=0.5. The trial number of times is ten times both. According to figure 10, when a value of l is small, it was found that average of the distance becomes big. According to figure 9, the characteristic is not seen in the center of gravity position. Because sensitivity Ch of the agent was low, sympathy, an action of the alignment did not happen. On the other hand, according to figure 11, the positions of the center of gravity gather in the center

(350,350) neighborhood of the coordinate. Therefore, we showed the possibility that could control an action of "a meeting" as a agent group by how to give sensitivity Ch.

VI. CONCLUSION

By this report, we gave the agent the new emotion action rule that paid its attention to the interaction of emotion called sympathy and the alignment. And we observed an action as the agent action and analyzed it. As the result, it was found that the agents performed the emergence action of "a meeting" and "a separation". In addition, we defined this emergence action as the basic action characteristic of the group of agents. And we suggested two methods to control the behavior of the group using the characteristic and tested it. The first is a method used agent with small sensitivity. The second method is an experiment on the control of an agent group using the place of the sensitivity. As first result, it is possible to control the action of "a meeting" and "a separation". As second result, it is possible to control the action of "a meeting" by size of the sensitivity of the place.

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