Emotional Model Focused on Robot's Familiarity to Human

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Abstract: This paper deals with the emotional model of the software-robot. The software-robot requires several capabilities such as sensing, perceiving, acting, communicating, and surviving. and so on. There are already many studies about the emotional model like KISMET and AIBO. The new emotional model using the modified friendship scheme is proposed in this paper. Quite often, the available emotional models have time invariant human respond architectures. Conventional emotional models make the sociable robot get around with humans, and obey human commands during robot operation. This behavior makes the robot very different from real pets. Similar to real pets, the proposed emotional model with the modified friendship capability has time varying property depending on interaction between human and robot.

Keywords: Human-Robot Interaction, Friendship, Artificial Emotion.

1. Introduction

Recently, pet robots and amusement robots have been developed as the next generation of electronic toys. They aim to mimic the behavior of real pets. The pet robots require several capabilities such as sensing, perceiving, acting, communicating and surviving. With these capabilities, a pet robot could behave similar to a real pet, nevertheless, they have limits to mimic real lives. To overcome such limits many emotional models were introduced [1], [3], [7] and [8]. Conventional emotional models have common internal structure like recognition, perception, planning, and learning, though they have different implementation schemes. Their studies have focused on constructing relationships between internal blocks and remodeling each block by their own theories. Conventional studies have also adopted the notion that sociable robots must obey humans, and get around with them. Thus, eventually, the robot's behavioral reactions to humans have been tailored to appreciate and obey human. This monotonic behavior could make the robot more robotic, and can be harmful to the robot itself. In this paper, a new emotional model is proposed to make pet robots or toy robots to perform behaviors similar to that of real pets. A real pets does not get around with a human suddenly. Rather, it takes some times for interactions before treating a human as a friend. In this paper this kind of emotional mechanism is implemented by modeling friendship capability. In general, friendship means only positive relation but definitely with interaction between two people or between a human and a pet they may have bad relationships also. Moreover, humans or pets can have good emotions between them just because they live nearby, even though they may not have any special interaction. Considering this, we suggest the modified friendship capability. The friendship function is resolved in to positive and negative forms that represent good and bad relationship. In addition to that, static friendship is defined to represent good relationships that are generated with no special interaction. The paper is organized as follows: Section 2 describes details of friendship function. Section 3 describes the overall structure of the emotional model with the modified friendship function. Section 4 explains the simulation results of the software-robot with the developed emotional model augmented by the modified friendship function. Section 5 discusses and concludes the contribution of this work.

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2. Modeling of friendship

Usually robot decide his next action based on current state of robot, such as emotion, motivation, intention and so on. In previous works that kind of internal states are invariance. For example, if there is a internal action decision rule that when robot hear bad sound from human he refuse human order, it is invariance. Whenever robot hear bad sound he refuse human order but real pet or human doesn't do like that. If time doesn't go much after pet meet the human above rule is affected but after time goes much if friendship are bigger than nominal value pet endure and obey human's order. This mechanism needs friendship. Friendship give tolerance and variation to emotion, motivation and intention. Actually robot feels friendship only about human and friendship makes robot do or don't like human. If robot doesn't like human due to the friendship mechanism then robot focuses on other things.

In here the meaning of friendship is extended to describe good, bad relation and static relation which means good relation generated by sharing space with no extra interaction. Mathematical model of this is like (1), (2) and (3).

$$f_{static}(t) = w_b \times time|_{HI} \tag{1}$$

$$f_{positive}(t) = w_p \times \int_{t_0}^{t} (emotion(\tau) > 0) d\tau|_{HI} \tag{2}$$

$$f_{negative}(t) = w_n \times \int_{t_0}^{t} (emotion(\tau) < 0) d\tau|_{HI} \tag{3}$$

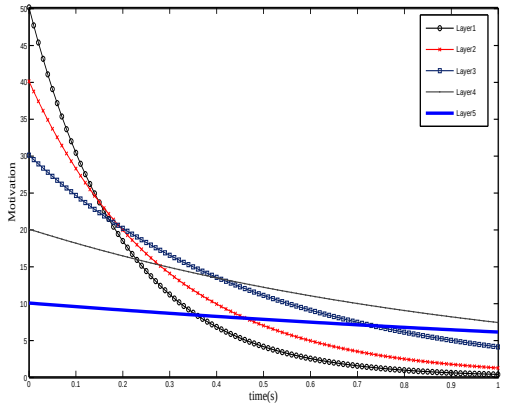

Fig. 2. Property of Motivation

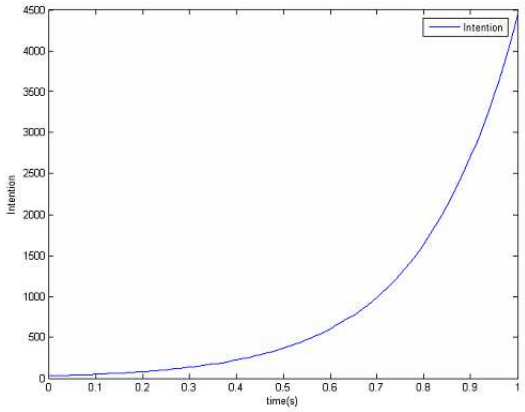

Fig. 3. Property of Intention

where f is friendship. w_b, w_p, w_n are positive values of weight for each friendship. t_0 is initial time. t is evaluation time. HI represents human interaction.

Equation (1), (2) and (3) describes each about static friendship, positive friendship and negative friendship. In (1) static friendship only depend on time and piled up as time goes. For positive and negative friendship each is depend on positive and negative value of emotions which are activated by human robot interaction.

3. Overall structure of emotional model

In Section 2 the modified friendship is described. In this section overall structure are presented using that scheme, fig.1. Most of block have been implemented in previous works such as [1], [3], [5] and [7]. The new one are friendship block and action selection block. Detail of the software-robot's emotional model are followed.

- Sensor : This block transfer the external stimuli to a numerical index.
- Perception : Knowledge reasoning about environment are happened using sensor block output.
- Motivation : Give the motivation to each activated perception. Motivation is different based on the layer of activated sensors.

$$Layer\ k\ : Motivation_i = Motivation_{i_{init},k} \times e^{-w_k(t-t_{init})} \tag{4}$$

where i is sensor number. t_{init} is sensor activation time. k is layer. w_k is positive number such as $w_1 \geq w_2 \geq w_3 \geq w_4 \geq w_5$, $Motivaton_{i_{init},k}$ is positive number such as $Motivaton_{i_{init},1} \geq Motivaton_{i_{init},2} \geq Motivaton_{i_{init},3} \geq Motivaton_{i_{init},4} \geq Motivaton_{i_{init},5}$.

Fig.2 shows roughly property of each layer's motivation. The characteristic of each layer of reaction is followed.

– Layer1 : Reaction about the most reactive stimuli which require instant response to survive.

– Layer2 : Most of reactive stimuli which have no effect on robot activity though that doesn't reacted.

– Layer3 : Mainly related to explorer, obstacle avoidance and wall following reaction.

– Layer4 : Human interaction related reaction.

– Layer5 : About stimuli which doesn't need instant reaction like long distance obstacle, sound of virtual environments.

Because layer1, 2 require a moment reaction their initial value is high but steeply decreased. Layer4 is about human robot interaction so to be looked as real life robot must show reaction though it is not instant reaction.

- Intention : This state value is given to mainly human interaction reaction and object in virtual environment. Intention has exploit property. For example when human order 'come' robot must obey within a temporary time and the strength of obligation must be increased after stimuli, fig3.

$$Intention_i = Intention_{i_{init}} \times e^{w(t-t_{init})} \tag{5}$$

where i is sensor number. w is positive number of weight.

- Emotion : Emotion is implemented similarly with conventional works, [1], [3] and [7]. Five states of emotion are defined as happy, sad, anger, boring, nor. Boring has different characteristic with other emotion. Other emotion except boring are varied when related stimuli are excited but boring is varied when robot focus on same action for some sampling times.
- Mood : Mood is already studied in previous works, [3]. In previous works mood is defined as sum of all activated emotion. Naturally mood must go to zero state as time goes while no external stimuli. Considering this property mood is defined as equation.

$$mood_{after}(t) = \int_{t_{e0}}^{t_{ef}} emotion(\tau)d\tau \pm w_m \times time + mood_{before}(t_{e0}) \tag{6}$$

where t_{e0} is emotion manifestation time. t_{ef} is emotion manifestation end time. w_m is positive weight. Sign of w_m is dependent on current mood value. If $(mood > w_m)$ sign is negative, else if $(mood < -w_m)$ sign is positive. $|mood|$ is decreased to zero as time passed.

- Friendship(positive, negative, static) : Friendship is defined in (1), (2) and (3).

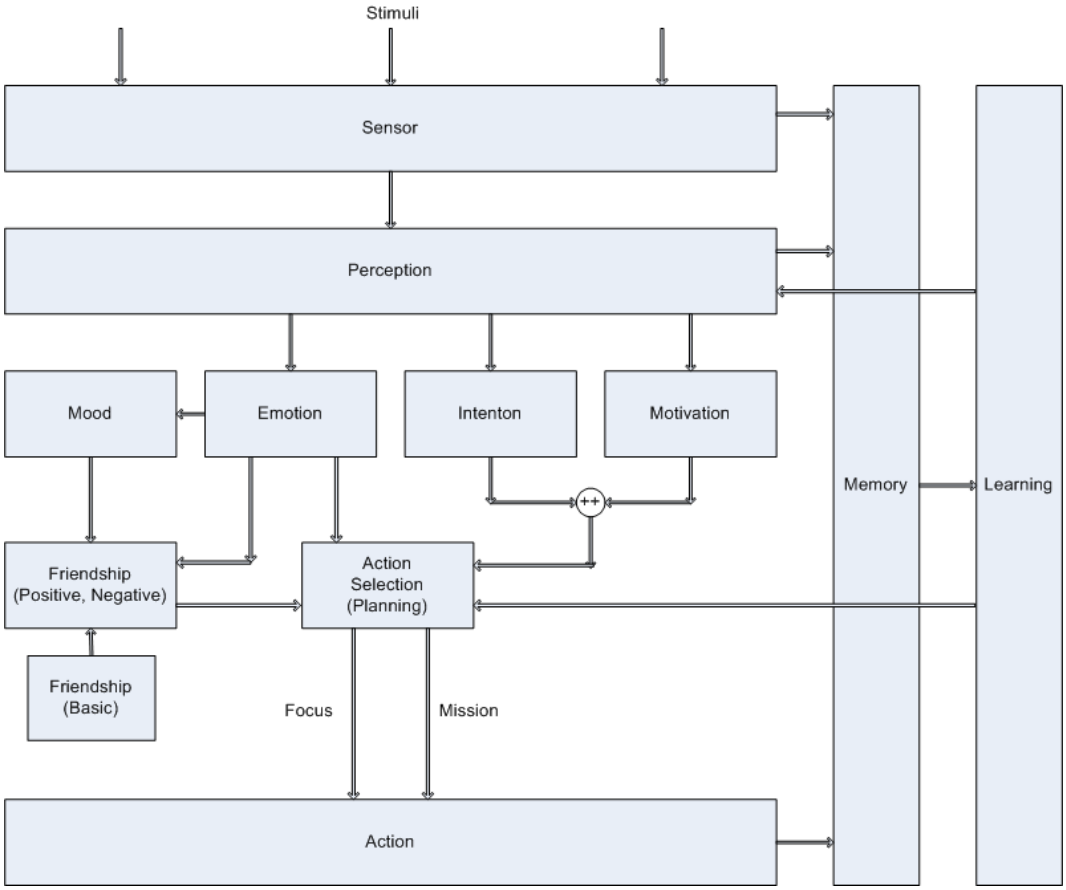

Fig. 1. Overall structure of emotional model of Software-Robot

• Mission : The activation of mission is depend on friendship degrees. Suppose that robot playing with human without any interesting object. Then if very interesting object is appeared robot can move his focus on new object. In this case mission flag set by friendship degrees force robot to focus on human consistently.

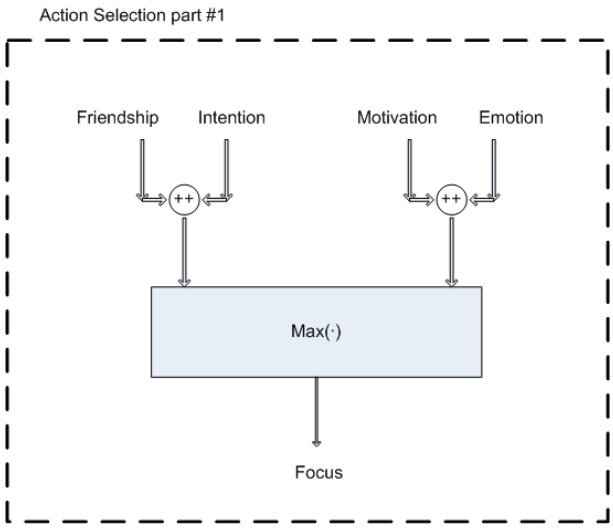

Fig. 4. Action selection, Focus

• Action selection : Decide the robot action based on friendship, emotion, intention, motivation and mission. Basically robot action is selected by sum of intention and motivation.

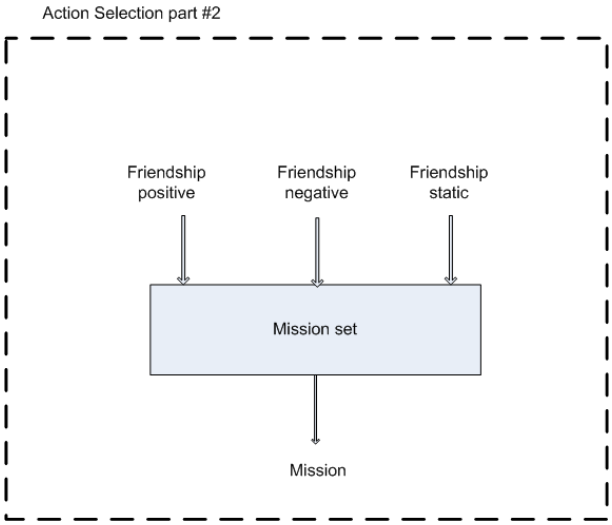

Fig. 5. Action selection, Mission

Additionally friendship increase intention related to human and object interaction and Emotion increase or decrease motivation about current action depending on emotion states, fig.4 $\sim$ 5.

• Memory : This block save history of activated sensor, perception and action. This information guide robot to modify his internal states.

4. Simulation studies

Proposed emotional model with the modified friendship was tested using the software-robot [10]. Two types of simulations have been executed by scenario about positive friendship and negative friendship. Software robot is coded with Visual C++, and tested on Pentium4 2.4GHz PC with 512 RAM. One software-robot, one human, one ball were used in the virtual environment to test the proposed emotional model. All mathematical models of motivation, intention, emotion, mood and friendship were described as continuous signals, whereas stimulation was represented as a discrete signal.

Initially robot used to like the human and ball equally, but because layer of ball is higher than human, motivation difference between ball and human makes the robot focus on ball at the beginning of the simulation.

4.1. Positive friendship

Scenario is like that at the beginning of simulation robot more focus on ball than human. After some times passed robot begin to like human more than ball by interaction with human. In other words positive friendship which has been increased by praise makes robot like human.

Simulation results show that at begin time robot focus on ball and continuing of praise increase positive friendship. Finally robot like human more than ball and focus on human. Focusing on human, robot chases the human and don't care ball on the way to reach human and chase the human despite human's complaint. Fig.6 $\sim$ 12 shows detail of internal states of robot during simulation time. In fig.6 ripples in the middle of graph represent focus variations by human praises. Finally positive friendship piled by praise makes robot chase human. Negative friendship is staying in zero states because there aren't special stimuli which are included in negative friendship. Static friendship is increasing by a little bit because of human robot space sharing. In simulation static friendship is increased by just staying of both of robot and human in virtual space during temporary times. Intention of fig.10 describes value of intention which is of current focus. Fig.10 is mixing of three robot action because robot focus is varying. Intention is about action of 'chase' before ripples, is about action of 'ball chase' and 'happy' by praise during ripples and is about action of 'human chase' after ripples. Motivation of fig.11 is similar with fig.10.

Mood goes to zero while there are no emotion activations as intended, fig.12.

4.2. Negative friendship

Scenario is similar with positive friendship test. At the beginning of simulation robot focus on ball more than human. After human appear on virtual environment static friendship makes robot like human. By acting complaint consistently after enough time passed, robot begins to dislike human. In other words negative friendship which is increased by complaint makes robot dislike human and like ball more than human and robot chase the ball though human is on the way to go ball, fig.13 $\sim$ 19. Noticeably fig.14 $\sim$ 16 shows negative friendship is bigger than sum of positive friendship and static friendship, and large negative friendship makes robot chase the ball. In case of exist of another object robot have to judge whether to chase ball or to act something about new object. In simulation robot just chase the ball because robot dislike human and there isn't anything to care for. Robot has no selection options. Figure descriptions are similar with positive friendship cases. The difference is replacement of 'praise' to 'complaint' and fig.13, 17 and 18 shows process till robot decision of chasing balls.

5. Conclusion

The emotional model with friendship has been implemented for sociable software-robots. The proposed emotional model helps the robot to be more intelligent, and delivers the capability of getting familiar with human companions. Especially friendship is resolved into its variants such as negative, positive and static forms, to make the robot behave more like a real pet.

The mood function has also been modified. Previous work has not considered the decreasing property of natural mood. Proposed mood function in this paper has the property of decreasing the mood gradually, and makes the robot act more naturally.

In the proposed model, deciding an action concerns many internal states, emotion, motivation, intention, friendship and mission. To merge many internal states, the designer must tune the strength of each state heuristically. Designing a tuning method to mixing many internal states is needed.

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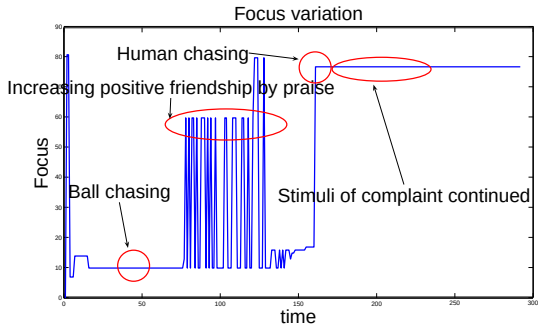

Fig. 6. Focus variation(Positive Friendship)

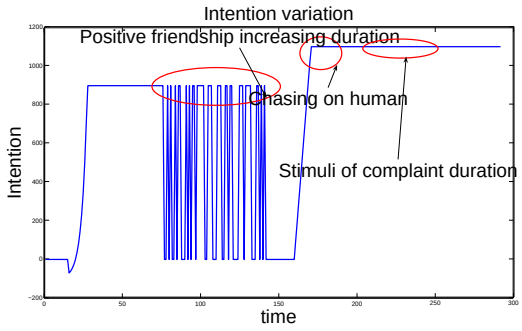

Fig. 10. Intention variation(Positive Friendship)

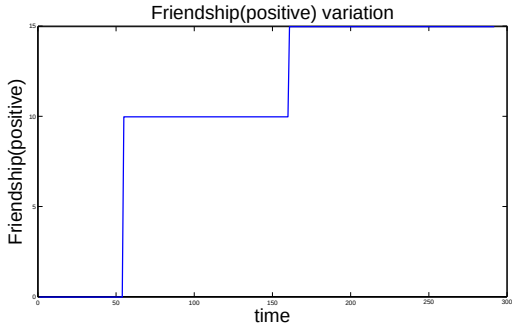

Fig. 7. Positive friendship variation(Positive Friendship)

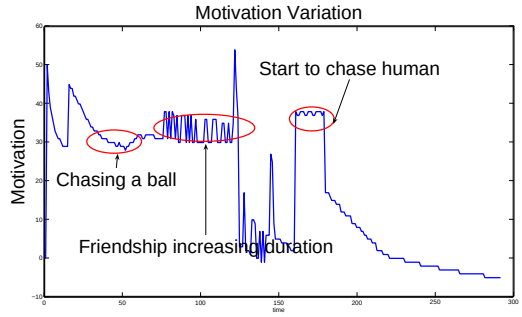

Fig. 11. Motivation variation(Positive Friendship)

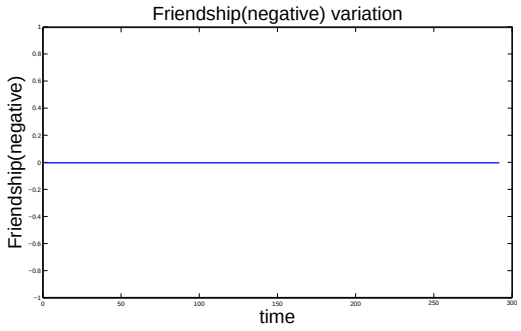

Fig. 8. Negative friendship variation(Positive Friendship)

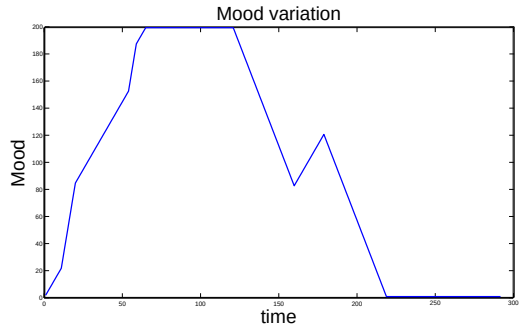

Fig. 12. Mood variation(Positive Friendship)

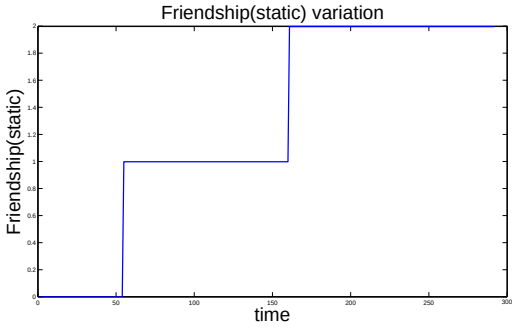

Fig. 9. Static friendship variation(Positive Friendship)

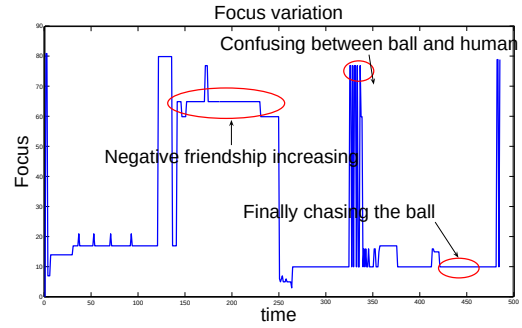

Fig. 13. Focus variation(Negative Friendship)

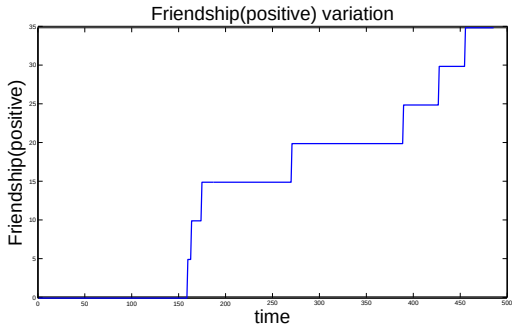

Fig. 14. Positive friendship variation(Negative Friendship)

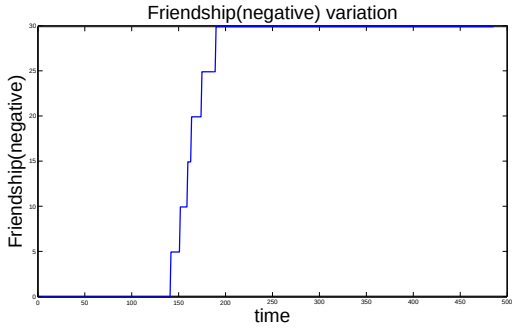

Fig. 15. Negative friendship variation(Negative Friendship)

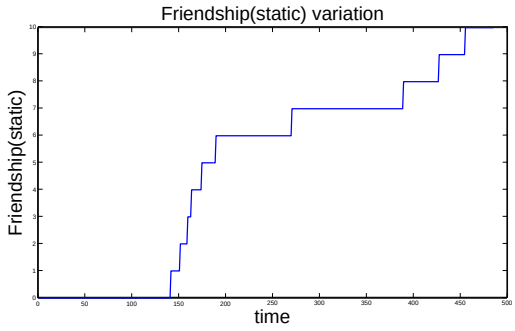

Fig. 16. Static friendship variation(Negative Friendship)

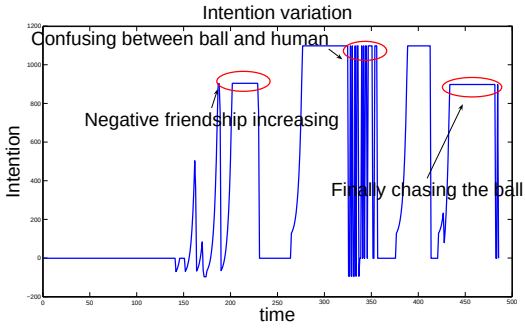

Fig. 17. Intention variation(Negative Friendship)

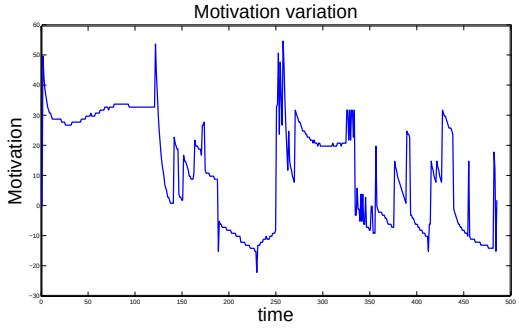

Fig. 18. Motivation variation(Negative Friendship)

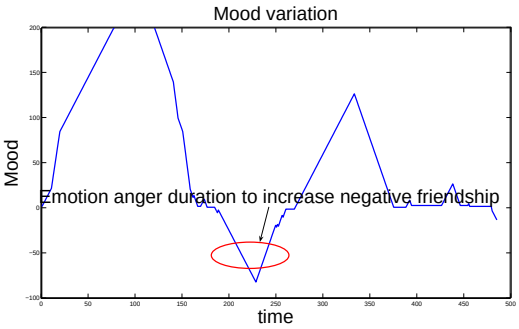

Fig. 19. Mood variation(Negative Friendship)