Implementation of Friendship in the Emotional Model for 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, surviving. There are already many studies about the emotional models like KISMET, AIBO and so on. This paper focused on the modeling of new emotional model using the modified friendship scheme. Though many emotional models are implemented their human respond architectures are invariance as time passed. The emotional model with the modified friendship has variance property depends on interaction between human and robot like real dogs.

Keywords: Human-robot interaction, friendship, artificial emotion.

I. INTRODUCTION

Recently, pet robots and amusement robots have been developed as the next generation of electronic toys. They aimed to mimic the real dogs or pets. The pet robots require several capabilities such as sensing, perceiving, acting, communicating and surviving. With these pet robot can be looked like the real dogs or pets but they have limits to mimic real lives. To overcome limits many emotional models are introduced [1], [3], [7] and [8]. Conventional emotional models have common internal structure like recognition, perception, planning and learning though details are different. Their study focus on constructing and making relation among each internal blocks and remodeling each block by their own theories. Also conventional study commonly have been obeyed the rule that robot must follow and like human. So they have invariance architecture to react human. In conventional model robot always like and follows human. When they are powered start to like human until be broken. This characteristic of robot makes robot not real pets but more robot.

In this paper to make pet robots or toy robots looks like more real pets new emotional model is proposed. When real pets meet their owner, human, at the beginning they don’t like human and shun the human. As time goes, if pet and human have many interactions and then pet start to like human. This kind of emotional mechanism is implemented by friendship modeling. In dictionary friendship means only positive relation but definitely with interaction between two people or between human and pet they can have bad relationship. Also; Human or pets can have good emotion just because two of them stay in same place though have no interaction. Considering this the modified friendship is suggested. Specially friendship is distinguished as positive and negative friendship to represent good and bad emotion states and static friendship is defined to represent good emotion generated with no interaction.

Section 2 describes detail of friendship. Section 3 describes the overall structure of emotional model with friendship. Section 4 explains the simulation results of software-robot which have friendship. Section 5 discusses and concludes the contribution of this work.

II. 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).

\[
f_{\text{static}}(t) = w_s \times \text{time}|_{HI} \quad (1)
\]

\[
f_{\text{positive}}(t) = w_p \times \int_{t_0}^{t} (\text{emotion}(\tau) > 0)d\tau|_{HI} \quad (2)
\]

\[
f_{\text{negative}}(t) = w_n \times \int_{t_0}^{t} (\text{emotion}(\tau) < 0)d\tau|_{HI} \quad (3)
\]

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

\[
\text{Layer } k : \text{Motivation}_i = \text{Motivation}_{i_{init}, k} \times e^{-w_k(t-t_{init})} \]  

where \( i \) is sensor number. \( t_{init} \) is sensor activation time. \( k \) is layer. \( w_k \) is positive number such as \( w_1 \geq w_2 \geq w_3 \geq w_4 \geq w_5 \).

\[
\text{Motivation}_{i_{init}, 1} \geq \text{Motivation}_{i_{init}, 2} \geq \text{Motivation}_{i_{init}, 3} \geq \text{Motivation}_{i_{init}, 4} \geq \text{Motivation}_{i_{init}, 5}.
\]

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, fig.3.

\[
\text{Intention}_i = \text{Intention}_{i_{init}} \times e^{w(t-t_{init})} \quad (5)
\]

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.

\[
\text{mood}_{after}(t) = \int_{t_{ef}}^{t} \text{emotion}(\tau)d\tau \]  

\[\pm w_m \times \text{time} + \text{mood}_{before}(t_{ef})\]  

where \( t_{ef} \) 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
Fig. 1. Overall structure of emotional model of Software-Robot

\[
(mood > w_m) \text{ sign is negative, else if } (mood < -w_m) \text{ sign is positive. } |mood| \text{ is decreased to zero as time passed.}
\]

- Friendship (positive, negative, static) : Friendship is defined in (1), (2) and (3).
- 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.
- 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. 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 ∼ 5.
- Memory : This block save history of activated sensor, perception and action. This information guide robot to modify his internal states.

IV. SIMULATION STUDIES

Proposed emotional model with the modified friendship is tested on software-robot, [10]. Two types of simulation are 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 are used in virtual environment to test proposed emotional model. All mathematical models of motivation, intention, emotion, mood and friendship were described as continuous notations but in simulation are converted into discrete notations.
Initially robot like human and ball equally but, because layer of ball is higher than human, motivation difference between ball and human makes robot focus on ball at the beginning of simulation.

A. 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 focus on human. Focusing on human, robot chases the ball though human is on the way to go ball, fig.13 ~ 19. Noticeably fig.14 ~ 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, ?? and 18 shows process till robot decision of chasing balls.

V. CONCLUSION

The emotional model with friendship is implemented. Proposed emotional model make robot more familiar to human and intelligent. Specially friendship is extended as negative, positive and static scheme to make robot looks like more real life.

Mood is also modified. previous works doesn’t care decreasing property of mood. Proposed mood in this paper has decreasing property and make robot act more naturally.

There are some drawbacks. Deciding one last action is concerning many internal states, emotion, motivation, intention, friendship, mission. To merge many internal states designer must tune the strength of each states. This is so heuristic so design a tuning method to mixing many internal states is needed.

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REFERENCES

Fig. 6. Focus variation (Positive Friendship)

Fig. 7. Positive friendship variation (Positive Friendship)

Fig. 8. Negative friendship variation (Positive Friendship)

Fig. 9. Static friendship variation (Positive Friendship)

Fig. 10. Intention variation (Positive Friendship)

Fig. 11. Motivation variation (Positive Friendship)

Fig. 12. Mood 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)