Social Expression of Pet Robot Based on Artificial Consciousness and Biologically Inspired On-line Topological Method

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Abstract

The social robot becomes important to the future world of pervasive computing, where the robot currently facilitates our life. The social behavior and natural action of the robot is one of the most needed function for emerging future realistic human-like robot. Our paper proposes the artificial topological consciousness based on a pet robot using the artificial neurotransmitter and motivation. Since, the significant is cross-creature communication to friendly companionship. This system focuses on three points. The first, the organization of the behavior and emotion model regarding the phylogenetic. The second, the method of the robot that can have empathy with user expression. The third, how the robot can socially perform its expression to human using biologically inspired topological on-line method for encouragement or being delighted by its own emotion and the human expression. We believe the artificial consciousness based on complexity level and the robot social expression enhance the user affinity by the experiment.

Keywords: Consciousness-Based Architecture, Cross-Creature Communication, EQ.

1. Introduction

The personal robot in the boom of the robot market recent years, the long-standing goal of the robotics research is the autonomous behavior, having artificial cognitive and make a human delighted without the conflict. The complexity of the natural behavior, perception systems, empathy, sympathy and a cognitive stream of the robot that exists and cooperate with human is the challenge to archive the personal robot. The personal robot also improves living better for elderly people or a child by being a friend or companionship. The crucial ability of these robots to naturally interaction learn form and accordingly cooperate with human.

The traditional robot stands aloof slightly from utilizing nature cognitive process of the organism with the robot. Accordingly, the behavior and mentation of robot would not have a strategy of intrinsic movement and capability of communication with human. Due to the robot does not have an affinity therefore it is needed to having empathy skill and need its comprehensible expression in order to human understands robot feeling as Fig 1.

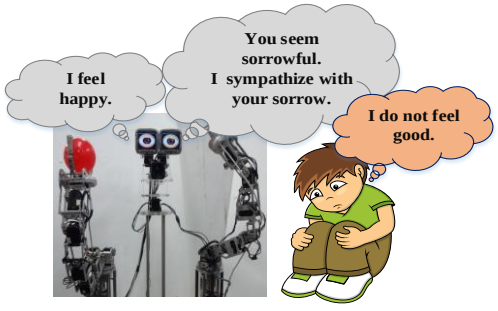

Fig. 1. The proposed concept of the companionship robot based on the social-emotional intelligence.

We have been striving to investigate and develop the personal robot and the related know-how deliberated with the biologically inspired consciousness, the social

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intelligence (SI) and perception system in order to serve the organism-like consciousness and social-emotional intelligence (SEI) of personal robot come along the natural behavior and affinity [1]. In this paper, we develop conscious behavior robot named by "CONBE". This robot includes two manipulators and one face respecting to semi-humanoid. In this paper, we propose the system of consciously behavior robot along with SI using topological adaptive resonance theory (TopoART) [2] as shown in Fig 2. The system implements concerning to organism behavior and emotion by phylogenetic illustrated by consciousness based architecture (CBA). Because of this concept, that significantly enable the robot self-awareness, which emerge naturally social interaction with human, and being a companion technically. The major contributions are the cross emotion expression from the robot toward human and cross facial emotion expression comprehension. Moreover, the robot's expression would interact with user by deliberation of robot emotion and user's emotional expression based on SI likes human being in society. Like human way, given example, when you are happy, however, your friends around you, they are feeling sad from some manner, and then you cannot express your actual emotion as happy. Therefore, you might sometimes express neutral or pretend to be sad as sympathy way.

2. Configuration of Conscious Behavior Robot

In this research, we contribute human-robot interaction based on the upper humanoid-like CONBE robot. It is to develop the artificial consciousness. For the proposed of enhancing the natural behavior in friendly way. The hardware of element of CONBE robot consists of two manipulators and one head as shown in Fig 1.

In the robot construction, the arms were assembled as seven degrees of freedom (DOF) included gripper. Due to the determination of angle for each joint of actuator, it is complicated to move to the target position. We then divided the seven DOF arm relating to human arm, where each part represent to be a shoulder, an elbow, a wrist and a finger. In the section of head robot, that was constructed by two DOF actuators for rotating in left-right and up-down where was equipped with a web camera and two displays. For the vision system, the camera is embedded into the head and each hand for animal world. The robot can express the eyes by two display as shown in Fig. 1.

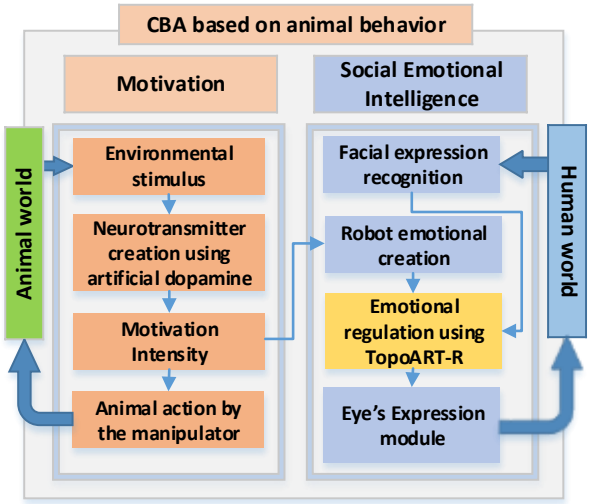

Fig. 2.The overview of the proposed methodology.

3. Robot Biologically Inspired Consciousness with Emotional Intelligence

3.1. *Animal behavior and emotion of the robot*

We developed the system to mimic the biological consciousness embodied to a robot. The system is composed of the animal world perception that represented by the color of interested object, which includes like-red, most favorite green and dislike-blue. For the emotion system, the artificial dopamine is used to induce the emotional motivation and behavior. There is the separated dopamine divided by each object. Each dopamine also performs a long-term memory as a robot experience in behavior process. For the creation of motivation, the intensity is calculated with the total dopamine. Therefore ,The system could naturally perform the creature-like motivation. The waveform pattern is calculated using a second-order of linear differential discretized by Runge-Kutta method [3].

3.2. *Emotional Intelligence*

EQ is the ability to identify, use, understand and manage emotion in positive way in the society of human. EQ encompasses self-awareness, self-management, social awareness and relationship management. Therefore, EQ skill is important for the companion robot to cross-communicate between robot and human and maintain the

relationship among human. Moreover, in sociality, when the robot exists with the human, it has to consider on the etiquette in a society. Therefore, the robot is needed to have EQ skill.

3.2.1 Facial expression recognition (FER)

To archive the ability of EQ, the robot is needed to comprehend the social emotion from user or that means the social awareness in EQ. In this paper, FER system composed of the facial feature extraction by the constrained local model (CLM), and emotional expression classification by Hidden Markov Model (HMM) to process FER [4]. Afterward, the output of FER will feed to emotional intelligence regulation system to consider the proper SI expression to user.

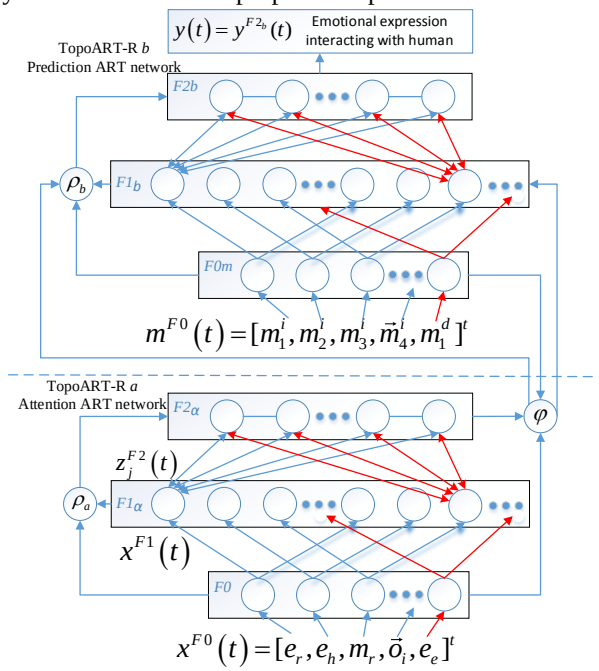

Fig. 3. The SI using TopoART-R.

3.2.2 SI regulation using TopoART-R

Because the Adaptive Resonance theory (ART) is closely related to the cognitive and neural theory of the brain instinct learning categorizing recognition and prediction and the topology relates among consciousness process, expectation, attention, resonance, and synchronization between unsupervised and supervised learning [5]. Because the real world information is dynamic and variant, this system also needs the on-line incremental method to carry out the stable learning and fast therefore we decide to utilize the enhanced ART view by TopoART [2]. TopoART is the fast-online learning and stable, which improve the ART by using the topology learning with addition sub-network in different level of detail. Therefore, this method is more suitable for real-world information.

For the robot SI topology is shown in the Fig 3. x^{F0} represents to input data which encompass the robot emotional parameter e_r, human emotional parameter e_h, motivation value of robot m_r, object parameter vector from the robot perception system o_i and emotional expression (for training) e_e. $y(t)$ denote to the social-emotional expression depend on the user expression and robot's emotion as shown in Fig. 3.

3.2.3 Robot's eye expression for social interaction

Robot eye is the major medium for interaction. The expression includes the emotion of surprise, pleasure or happiness, hope, neutral, fear, sadness, disgust and anger. The eyes were implemented, as the 3D virtual eye regarding human's eye along with the nature expression where the eye's expression is shown in Fig. 4.

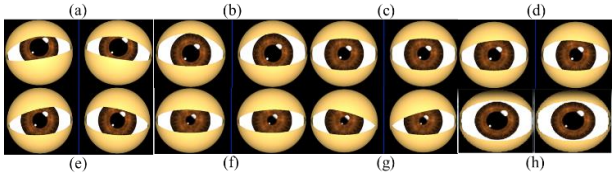

Fig. 4.The robot eye's expression a) pleasure b) hope c) neutral d) fear e) sadness f) disgust g) anger h) surprise.

4. Experimental Results

In this section, we demonstrate the robot behavior, emotion generation and social expression with human by the robot face. The experimental configuration is based on the CONBE robot, which is set the height approximated by human height. For the SI interaction, we firstly extract the facial feature parameter using CLM to predict the emotion expression by HMM. Afterward, the human emotion and robot emotion are used to consider the suitable social expression using the TopoART. The emotional expression is deliberated with the emotional sharing between human and robot, which the expression is acceptable, and not let human unsatisfied. The top of Fig. 5 shows each parameter for the experiment the

emotional motivation based on the neurotransmitter dopamine of each object, which is recognized by overtime. The bottom is observed the robot's emotion, human's emotion and the expression throughout the task period. Fig. 6 shows the capture images of FER and the robot's expression on each time from T0 to T5.

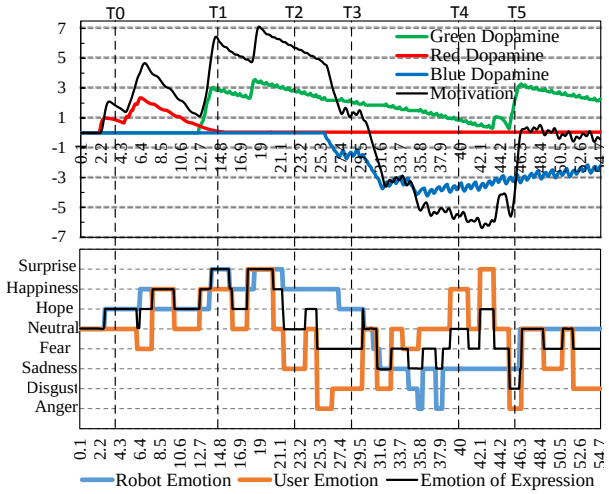

Fig. 5. The robot's motivation and emotional expression

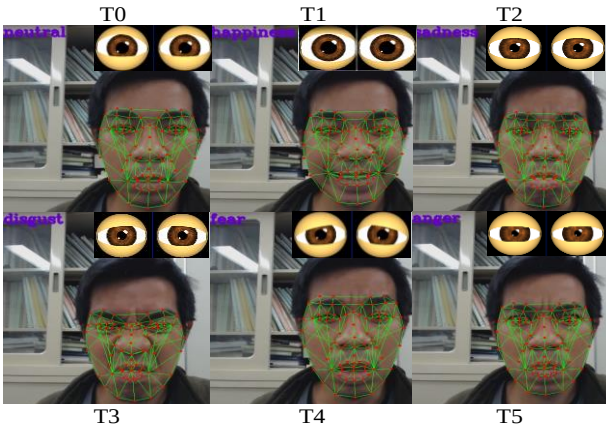

Fig.6 Robot eye's expression and human's expression.

When robot starts, it feels neutral and expresses neutral according to the motivation, when the favorite red object is recognized the motivation increased. On T0, the robot feels hope according to increased motivation and human expresses neutral, then it expresses hope due to encouraging human feeling. On T1, robot feels surprised because the most favorite green is recognized suddenly and human expresses hope then robot expresses surprise. On T2, robot is happy but human expresses sad then robot expresses neutral and masks its happiness because of SI. On T3, robot is hope but human disgust robot then expresses fear. On T4 robot is sad but human is happy, the robot then expresses neutral and mask its sadness due to SI. On T5, robot is sad and human is angry then robot expresses disgust due to the emotion sharing.

5. Conclusion

As the demonstration and the proposed system, the CONBE robot with the emotional intelligence by sharing the emotion from the user could enhance the capability of the human affinity, which is strongly important for personal robot. For our further inspiration, we also expect this system can emerge the social ability to the creature animal due to recent research from the remote animal control [6] which the research proof the nearly future we can connect and control the animal brain. Consequently, if we embed this artificial social emotion intelligence to the animal in near future the animal might communicate with EQ skill likes human that should make the natural cross-communication creature between animal and human.

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