Model of Personalized Affective Responsiveness for Human-Centered Robotics

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Abstract. Modeling empathic behaviors in social robots seems to be relevant to improve the overall human-robot interaction for the user. This paper proposes a technology that accommodates the differences between the human users, equipping humanoid robots with “personality”–as a pattern of affective behavioural traits that distinguish human partners from one another.

Keywords
Human-robot interaction, emotional model, humanoid robot.

1. Introduction

Human-centered robotics is a challenging topic, and the key research area is the development of systems that respond appropriately to human expectations and actions. Moreover, a person working with a robot should not be required to learn a new form of interaction and should enjoy the long-term interaction with the artificial agent to enjoy the collaboration with the system. Thus, the global challenge of our research is to design socially engaging robots and interactive technologies that provide people with long-term social and emotional support – in general to help people live healthier lives, connect with others, and learn better. Machines cannot feel and express empathy. However, it is possible to build robots that appear to show empathy, which is commonly understood [37] as the capacity to “put your-self in someone else’s shoes to understand his/her emotions.”

This paper introduces our approach of simulation of empathetic robotic behaviour; the system reacts to the stimuli subjectively, depending on the user’s preferences. For the implementation of the emotional human-robot interaction we use the SDK kit created by Microsoft [30] and we test the software using the Nao humanoid platform. The simulated empathy of the system can be seen as a process mainly composed of two phases:
1. the assessment of the other’s affective state–the system has to recognize the user’s state,
2. the subject reacts taking into account the other’s state (either by affective responses or more “cognitive” actions)–there is a need to define a set of empathic behaviours to be displayed by the robot taking into account the user’s state.

We believe that equipping machines with the ability to simulate empathy can drift towards intuitive mutual man-machine cooperation.

2. State of the Art

2.1 From Human to Artificial Empathy

There is a convergence between cognitive models of imitation, constructs derived from social psychology studies on mimicry and empathy, and recent empirical findings from the neurosciences, e.g. [3][4][5][6][7][8][9][10]. According to [6], empathy research indicates that it is made possible by a special group of nerve cells called mirror neurons, at various locations inside the brain. Mirror neuron activity helps people understand actions and intentions of others and is also involved in understanding emotions. Empathy may be facilitated through a process of automatic mapping between self and other. Perception of the actions and emotions of others activates areas in our own brain that typically respond when we experience those same actions and emotions.

Fig. 1. In study by [7] test subjects were asked to imitate facial expressions of others. fMRI scans revealed less brain activity in regions associated with mirror neurons in individuals with autism spectrum disorder (b) than in the control group (a).
Picard [32] enumerated the following motivations for giving machines certain emotional abilities:

- to build robots and synthetic characters that can emulate living humans and animals – for example, to build a humanoid robot,
- to make machines that are intelligent, even though it is also impossible to find a widely accepted definition of machine intelligence,
- to try to understand human emotions by modeling them and
- to make machines less frustrating to interact with.

2.2 Empathetic machines

We enrich the interaction between the human and the machine, a humanoid robot, with the expressions of personalized emotions. The current research beyond the hypothesis that giving machines the capability of expressing empathic emotions towards users demonstrates its great potential on improving the overall interaction, e.g. in [36][35][34][33][31][32].

Coming back to the roots of artificial intelligence, Turing by himself was fascinated by the notion of affective responses, such as joy, interest, and surprise, in human interaction with computers [1]. Turing’s initial questions have led to more complex investigations into the ability of the computer to model human emotions, and to evoke emotional responses in its human user.

As an example of recent studies in the area of social robotics, Kanda et al. [27] has achieved to improve route guidance interactions with a robot by incorporating cooperative body movements (e.g. synchronization of arm movements), enhancing both reliability and sympathy.

Breazeal [29] investigates emerging robotics applications for domestic or entertainment purposes which are slowly introducing autonomous robots into society at large. She claims that a critical capability of such robots is their ability to interact with humans, and in particular, untrained users. She explores the phenomenon that people will intuitively interact with robots in a natural social manner provided the robot can perceive, interpret, and appropriately respond with familiar human social cues.

Riek et al. [28] studied the effect of automatic head gesture mimicking with a chimpanzee robot. The robot would listen to participants while either mimicking all head gesture, only nodding or no mimicking, resulting in different levels of interaction satisfaction. This work extends the state of the art by explicitly evaluating facial expression mirroring in contrast to head, arm or body gestures.

2.3 Subjectivity in Emotion Modeling

Emotions comprise subjective experience and expressive behaviour, are motivators for actions, and will change according to the range of actions that the subject is able to take in a given situation [21]. On the other side, computer science and robotics use techniques which have been developed through objectivism. The domain of human-robot interaction is different machines are not only evaluated by objective measures, but also subjectively. This phenomena as a specific research phase represents a new stage of computing based on the subjectivity in the human perceptual process.

Suzuki [22] from University of Tsukuba, introduced an approach of Subjective Computing (SC) in 1995, tightly related to cognitive science and including an integrated physical robot system for investigating varieties of mechanisms relevant to embodied. A modelling taking insight from the human subjectivity and individual preference is the main issue of this research. SC includes the terms of individual emotional resonance, comfort and satisfaction. It differs from a conventional evaluation based on objectivity and logic used in physics or mathematics.
The subjectivity and individual preference should be treated as psycho-physiological interrelationship.

Harrel [23] at MIT Imagination, Computation, and Expression Laboratory, uses the term of Subjective computing systems for artificial intelligence and cognitive science-based computing systems for creative expression, cultural analysis, and social change.

3. Design of the Model

The goal of the research is to create user friendly interface, where a humanoid robot expresses emotions according to the preferences of human user interacting with. It is difficult to define emotional affects for each person specifically, because every person has different express of emotion on different situations and circumstances (e.g. personal memory of each person). Thus it is very difficult to create system which is specified for wide spectrum of users. We developed a personalized system—a user assigns the type of the emotion to given stimuli (on the web interface of directly during the interaction), and then the chosen emotion will be implemented into the robot in that concrete situation, based on the individual preferences of the user.

The system has the following parts:

1. Giving emotional meaning to a word in conversation as a verbal part of the communication;
2. Giving emotional meaning to a gesture, posture or a motion pattern of people as a non-verbal part of the communication;
3. Word recognition with the assigned emotional meaning using modified speech recognition algorithm developed by Microsoft;
4. Gesture (or body-based posture/motion) recognition using ARTMAP-like neural networks combined with fuzzy approach;
5. A learning framework for body-based expressions from human to robot (a user can add body-based emotional expressions to the system without any programming knowledge-the robot imitates users’ expressions);
6. The emotional model, where the basic emotions are combined into complex emotional spectrum using Plutchik’s psychoevolutionary theory of emotions which combines eight basic emotions to the entire emotional spectrum;
7. A visual system for monitoring the interest of people in the interaction with the robot to test the system.

For the experimental setup we use a humanoid platform Nao-a humanoid robot created by Aldebaran Robotics, French company. His height is 57cm and the advantage is his simple manipulation. The API supports programming in various languages, e.g. C#, Python, C++, among others. We use the program API provided by the company Microsoft, concretely Microsoft for Kinect SDK beta, Microsoft speech platform, which is used for recognition of speech commands and API Naoqi created by Aldebaran Robotics for programming robot Nao.

We designed a loop system, in which the robot tries to recognize emotional expressions in the form of audible and visual stimuli of the human. He is able to copy these gestures and use them to communicate its internal state. The basic logic of the system consists in the following steps:

1. A web interface for the creation of a personalized dictionary of words and gestures was designed. Here the user assigns the emotional affect based on his preferences.
2. The personalized database of the emotional affects for the most common words used in the conversation with the humanoid robot is used during the proximate interaction—the audible stimuli. The system can identify a speech command from user, which is followed by expressed emotion of the robot (for example, if the human assigns the emotional affect of “Joy” to the word “mother”, the robot performs the expression of joy every time when he recognizes the word “mother” during the communication with the human).
3. The personalized database for the gestures is designed for the visual stimuli-similarly to the audible stimuli database.
4. The Kinect sensor captures the word, compares it to the words saved in the database and if the human uses a word that is situated in the dictionary, the robot expresses assigned emotion. The speech commands are written in the form of dictionary.
5. In the same time, the system recognizes gestures performed by the human and reacts according to the stimuli.
6. This process runs in cycle from start until end of program.

To identify the types of emotions a user may feel during human-machine interaction, we explore the work of Plutchik [25]. Plutchik’s psychoevolutionary theory of emotions is one of the most influential classification approaches for general emotional responses. He considered there to be 8 primary emotions - anger, fear, sadness, disgust, surprise, anticipation, trust, joy. Plutchik’s proposed that these basic emotions are biological primitive and have evolved in order to increase reproductive ability of animals.

We designed the internal model of the system which represents the “life and the evolution of his personality” during the time. Every stimulus can increase or lower the corresponding emotion and this forms the memory of the system which develops. As the humanoid platform Nao does not have face to create facial expressions, we implemented body-based expressions of emotions, by setting angles of the joints of the robot. Expressed emotions are based on technical capabilities of Nao and common human emotion expressions.
4. Discussion

Emotions and their expressions belong to the nature of every human, but are not so common in robots and computing systems. Systems capable of expressing emotions may have big impact not only on field of computing technology but psychology as well.

A wide spectrum of existing projects and applications (e.g. [11][12][13][15][16][17][18][19][20]) are trying to better understand human emotional behavior and develop a model according to their needs and expectations, implementing this model in machines that interact with people. Such projects assume that during the process of system migration to human society they will be considered beneficial and intuitive partners. How we believe future cooperation between robots and ourselves will look can be summed up in these words: machines fully adapting to man – that man no longer has to adapt his behavior to machines.

The computational models of emotions have great application potential, as they have ability to improve complex, interactive programs. Software agents may use emotions to facilitate the social interactions and communications between groups of agents and this way they can help in coordination of tasks, such as among cooperating robots. Moreover, synthetic characters can use a model of emotion to simulate and express emotional responses, which can effectively enhance their believability. Furthermore, emotions can be used to simulate personality traits in believable agents. Recently, however, cognitive neuroscience and related fields have demonstrated the inseparability of emotion from rational thought and normal human function [39] – as Minsky believes, “the issue is not whether intelligent machines can have emotions, but whether machines can ever be intelligent without them [14].”

This paper introduces our approach of the interactive human – robot system with elements of emotions. There are countless possibilities where a robot which can express empathy could help. Now we need to conduct various experiments to prove whether mirroring emotional affects has a positive influence on the human-robot interaction.

Future work will explore the contribution of the simulation of empathy in real environments, measuring and comparing the interest of human subjects in the interaction with and without the elements of the artificial empathy.

This work is part of a wider tendency to rethink the way that interfaces operate: “a shift toward a human-centered interaction architecture, away from a machine-centered architecture[38].” This shift recognizes the importance of human emotion and response in the design of interfaces and points up some changes in the human-machine relationship. For example, machines have begun to adapt to their users, rather than the other way round; the interface is becoming a responsive entity, rather than a passive portal.

Acknowledgements

I would like to thank my supervisor Prof. Peter Sinčák for his great support during my study.

References


[22] K. SUZUKI, Center for Cybermics Research & Faculty of Engineering, Information and Systems, University of Tsukuba, http://i-www.iit.tsukuba.ac.jp/~kenji/
Mária VIRČÍKOVÁ was born in Košice, Slovakia. She graduated as bachelor of Cybernetics and continued his master studies in the field of Artificial Intelligence, graduated with honors in 2005 and received “IT valley” prize for the best diploma thesis. She is a member of IEEE and EuCog. She published more than 20 papers (6 in SCOPUS) and 1 book. She presented her work at MIT Media lab, Tsukuba University, Tokio Institute of Technology, Chukio University, University of Minho, University of Ljubljana, Max Planck Institute, KAIST, Bauman State University in Moscow, Tokio University among others. Currently she is a PhD. candidate at the Center for Intelligent Technologies, Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical University of Kosice, under the supervision of Prof. Peter Sincak. Her research focuses on developing software for personal robots that are socially intelligent and which can interact with people in human-centric terms and learn from people and their environment.