Embodiment of human personality with EI-robots by mapping behavior traits from live-model

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Abstract. The paper deals with problems of development human personality and temperament with emotionally intelligent robots based on mapping cognitive emotional models from humans as biological i.e. live models. The investigations were based on use of the on-line tests to determine profile of human personality and type of temperament as important factors that determine character of human behavior. A young male professional actor was involved as the live model of human personality. The actor engaged in experiments expressed ability of transformation his affective states depending on different imitated life situations. In order to develop affective i.e. personality model different experimental measurements with the actor were performed. His movements, facial expressions and voice effects as affective reactions to the imposed trigger situation (scenario) were acquired. The acquired data were processed and the appropriate analysis, knowledge generalization and data fusion were performed in order to synthesize cognitive affective model of human personality. A method for implementation (mapping) of the obtained models from biological systems to humanoid robot is presented. The human-size robot Robothespian is going to be used for experimental verification of the models synthesized.

Keywords: Personality traits, human temperament, emotional intelligence, affective model, human-centric robots, cognitive robots, social robots

1 Introduction

New generation of personal robots, as form of service robots for support humans (human-centric i.e. human-oriented robots), is expected to have cognitive behavior similar to their biological model - human. This means that the new generation of robots should have an individual personality and temperament as factors of the cognitive emotional behavior so-called emotional intelligence. Individual traits of people, such as the personality type and temperament, but also the external factors of influence such as socio-economic factors and living conditions determine the degree of so

adfa, pp. 1, 2016.

called emotional intelligence. Emotional intelligence (EI) is the ability to identify (perceive), assess (understand), use and control the emotions of oneself, of others, as well of groups [1]. Emotionally intelligent robots, with a strong personality traits, show a greater ability of socialization and integration into the human community. In this way, service robots are becoming more desirable and better accepted by end-users, due to easier interaction with the social environment and a greater degree of mutual understanding.

Under the notion ñpersonalityò it is commonly assumed a special complex, integrated and relatively stable set of psychological traits of an individual that determines oneôs characteristic and consistent behavior [2]. Personality does not change and it is stable over the lifetime. It is acquired by the birth (as consequence of the genetic code transferred from parents). Similarly, under human temperament it is assumed mostly a characteristic way of emotional reactions. Promptness, intensity, duration and kind of reaction will depend on oneôs temperament [3]. Personality traits are expressed by our specific affective and social behavior in different situations and social environments. In the theory of psychology, different personality traits are recognized with humans such as [4]: introverted or extraverted, sensing or intuitive, feeling or thinking, perceiving or judging, etc. By combining these fore mentioned 4 dichotomies (opposite pairs), 16 different personality types are known as presented in [5]. Also, 4 different human temperaments are known in practice [3]: sanguine, choleric, melancholic and phlegmatic. The goal of the research in this paper is to develop a cognitive model of human psychological behavior that includes different personality types and human temperaments and that will be implemented with the humanoid robot Robothespian [6] with aim to verify the methodology how it is possible to make robots feel and social as humans.

The paper is organized into several sections. In the introductory Section 1 research objectives are set and the basic terms that will be used in the paper are defined. The second Section 2 provides a brief survey of the recent results in the area. The third Section 3 presents the emotional cognitive model of human behavior that is the basis of the research presented in this paper. The fourth Section 4 deals with the measurements obtained with the professional actor, his movements and facial expressions, in order to improve the accuracy of the mathematical model of the human emotional intelligence. The implementation of EI-controller planned to be accomplished with the humanoid robot Robothespian along with the conclusions and future directions of the research are described in Section 5.

2 State-of-the-Art

The idea about building personality with robots exists from earlier but recently it seems to become feasible. In 2015, Google owns a new patent outlining a concept of the robot that changes personalities based on circumstance and a wide variety of user information [7]. The system stores useful data in the cloud where it can be accessed by other robots. In one example from the patent, the robot goes so far as to assemble an entire personality on request. The robot in this patent can also modify its personality by inferring the userôs mood through methods like correlating the current weather to previous moods. What is probably the most interesting in the Googleôs patent, the robot may even use oneôs diction and sentence structures from email, texts, or phone calls to estimate emotional state and respond accordingly.

Robots that change their personalities based on collected information like this would certainly be neat. But as far as it is known, the patent only covers the general idea, as opposed to a specific implementation that Google has developed. The patent doesnôt protect a brilliant technical solution or large investment but just an idea that will be realized in the future. Instead, it covers the mere concept of combining existing platforms and data to imbue robots with changeable personalities. This paper should complement in a certain way the patent shortcomings having no ambition to reduce the importance of the Google shiny ideas.

There are ñemotionalò robots on the market now, but their capabilities are as superficial [8]. These robots donôt feel, but they can detect human emotions and respond accordingly. Aldebaran Roboticsô Nao, a two-feet-tall robot equipped with touch sensors, four microphones, and two cameras, can ñlearnò by downloading new behaviors from Aldebaranôs app store, as well as recognize faces, make eye contact, and respond to users. The robot has been implemented in the classroom, particularly for children who are nonverbal, overstimulated, and/or autistic. Autistic children have difficulty discerning othersô emotional states, and Nao helps them practice identifying expressions without feeling shy or uncomfortable. In fact, research indicates that computers are even better than humans at reading expressions, which means it will be increasingly difficult for humans to lie to robots.

Recently, Aldebaran released Pepper, the ñfirst humanoid robot designed to live with humans.ò Pepper can identify a userôs emotional state and then adapt by, for instance, trying to cheer up a user it identifies as sad. Pepper can also mirror a userôs emotional state, which is something all humans do beginning in infancy. Mirroring works in both directions with robots - they reflect oneôs emotions, and even though one knows theyôre robots and instinctively mirror theirs. Studies also indicate that when robots mirror our emotions, weôre more likely to feel a bond with them; weôre also more likely to assist them with tasks. Robots donôt actually feel emotions yet but they can appear as though they do.

Mammalsô brains can produce basic emotions, such as desire, fear, and affection. But these emotions arenôt volitional and donôt require thought. Complex emotions are different [9]. Take jealousy, for example. To feel jealous, one has to desire something, recognize that someone else has that thing, then feel negatively toward that person because of it. In this paper we try not only to make robot to perceive emotions of others but also to produce emotions that are reaction to the context ï physical and social environment.

3 Modeling of cognitive behavior

Human psychological i.e. cognitive (affective and social) behavior depends on several dominant factors. Some of them are acquired by birth (genetic factor), some are generated during the lifetime by influence of the exterior factors (e.g. family and school education, companions, socio-economic conditions, religion, etc.) or some of them are generated by the temporary interior factors (physical and psychological). Human-like affective reactions are based on three dominant excitation signals as information carriers [10]: (i) the ñtriggerò of behavior (that arouses different psychological reactions); (ii) the ñprofilerò (that shapes event-driven emotional state (ES) to fit personality profile of the individual); (iii) the behavior ñboosterò or behavior ñinhibitorò (that increases or decreases the expressiveness of the individual affective manifestations). The high-level block diagram of the cognitive emotional model is shown in Fig. 1. Details regarding to modeling of human affective behavior model are given in [9, 10].

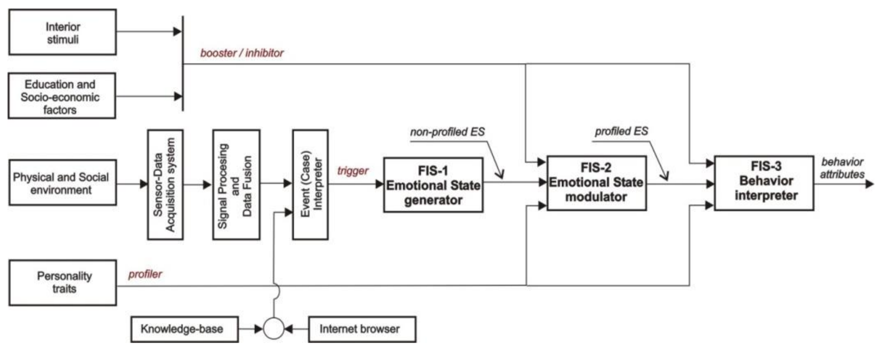


Fig. 1. Block-scheme of a three-stage human affective behavior model.

Fuzzy blocks in the knowledge-based model shown in Fig. 1 are designed to have an appropriate membership function parameters (type of function, focus of figure, inflection points, etc.), adjusted based on the data taken from a group of subjects. Specifically, a group of 237 subjects of different age, gender and education [10] was asked to anonymously fill out on-line questionnaires on the Internet for determining the personality type [11] and temperament [12]. Based on the theoretical model of the human affective behavior shown in Fig. 1 and on the basis of generalized knowledge taken from a database of subjects (whose personality type and temperament are numerically quantified [10]), empirical model suitable for simulation on the computer was synthesized. In order to improve the accuracy of the model and enable the synthesis of EI controller, suitable for implementation on a humanoid robot Robothespian, the methodology shown in Fig. 2 is used. Membership functions FIS-1, FIS-2 and FIS-3 are additionally tuned using the results of measurements from a man as a biological (live) model. For this purpose, a professional young male actor has performed different affective behaviors (angry, happy, surprised, sad etc.) as reactions to different life situations (imagined scenarios). The actor was asked to act out the same scenario in two different ways - very affective (temperamentally) and phlegmatically, respecting the main features of the famous personality types described in the introductory section.

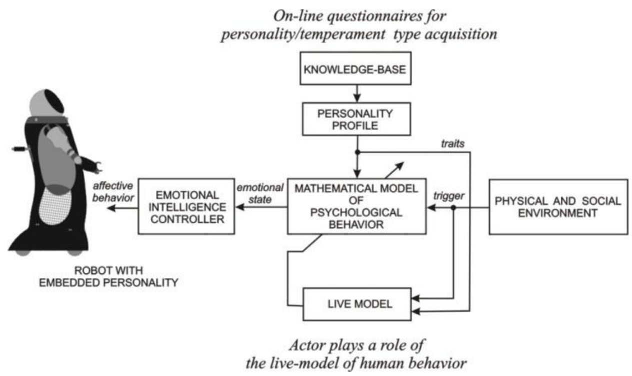


Fig. 2. Block-scheme of tuning the robot emotional intelligence controller based on personality traits acquired from biological model ï human examinees.

As described above, by combining the knowledge about characteristics of different personality types and temperaments (obtained from the psychological questionnaires and stored in the database) and by use the experimental measurements of affective reactions from a live model ï actor, the final adjustments of cognitive affective model of human behavior is accomplished. This model represents algorithmic basis for design of the robot EI controller as shown in Fig. 2.

4 Measurement of affective actions

In the exercises with the actor the following measurements were acquired: (i) tracking of the head and body gestures as result of different affective states caused by the corresponding imposed situations or events, performed by one Kinect sensor (RGBD camera); (ii) upper-body movements detection using X-sens motion capture system based on the use of inertial measurement units (3-axis accelerometer + 3-axis gyro sensor); (iii) facial expressions recorded by digital camera (video and audio stream). In this paper, the audio data are not processed. This information will be considered in our future research work, too.

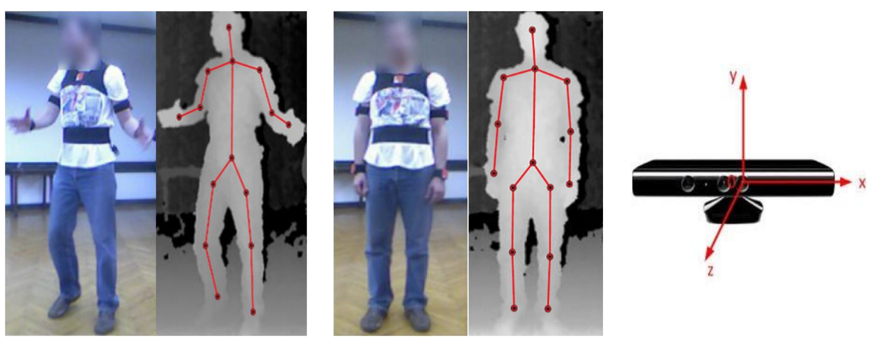
The gestures acquired from the human actor as live-model contain information about specific personality traits characteristic for the individual and for the particular trigger event/situation. The actor has been asked to imitate (reproduce) two types of behavior ï very expressed and temperament and gentle and smooth in order to verify the methodology applied in the paper. The actor used the same trigger event/situation to demonstrate his different attributes of his personality profile.

4.1 Measurement of body gestures by Kinect sensor

In this experiment we investigated upper-body movement expressions during the performance of certain emotional scenarios. Consequently, we have acquired large-range movements of a subject in addition to the facial recordings. We assume that torso and hand movements are more involved when showing emotions such as happiness and surprise, while in the case of sadness, the body posture stays more or less static. This will be confirmed later in our experiments through the analysis of the subject motion during particular scenario performing.

There are many available techniques used nowadays for motion tracking. Marker-based motion capture systems [13] are widely used for movement acquisition. Such systems are very expensive, but can deliver accurate measurements. Other possibilities include the attachment of the different sensors to the subjectôs body, like the inertial sensor system we used [14]. More recently, low-cost marker-free based systems such as the Kinect and Xtion [15] become quite popular as a suitable alternative to complex and expensive motion capture systems. In addition to the inertial sensor system, we have used Kinect device for large-range movement acquisition. Kinect poses a satisfactory accuracy for the indoor mapping applications [16], assessment of the postural control [17] and gesture and pose recognition.

Kinect is the new generation device developed by Microsoft, which consists of a standard RGB camera and a 3D depth sensor (infrared sensor + infrared projector). It operates in a range of approximately 0.6m to 4m and can achieve up to 30 frames per second. Kinect has a built-in algorithm for human skeleton detection and tracking. Namely, the 3D coordinates of the characteristic skeleton joints are collected for every frame during the motion performance. The acquired Kinect data from our experiments consist of RGB and depth video sequences and 3D positions of the fifteen skeleton joints (Fig. 3).



a) b) c)

Fig. 3. (a-b) RGB streams (left) and depth streams with detected skeleton and collected joints (right) and c) Kinect device with axis orientations

We wanted to explore the connection between the particular emotional states (angry, excited and sad) for choleric / phlegmatic or emotional / rational personality type and activity of the upper-body movements. Consequently, we have analyzed the behavior of the head, torso, elbow and hand joints during the performance of the angry, excited and sad emotional scenario. Evolution of the selected joints along X and Y direction (Fig. 3-c) for those scenarios are shown in Fig. 4. Joint trajectories are presented from the 5th second onwards since we omit the calibration phase at the beginning of the sequence in order to synchronize the signals obtained from Kinect and inertial sensors. The Kinect device is calibrated by performing a certain body posture. The joint trajectories in Fig. 4 clearly illustrate the larger activity of the upper-body movements during the angry and excited scenario in comparison to the sad scenario. Raw signals of joint trajectories are filtered with Butterworth low-pass filters with a cutoff frequency of 3Hz due to the measurement noise.

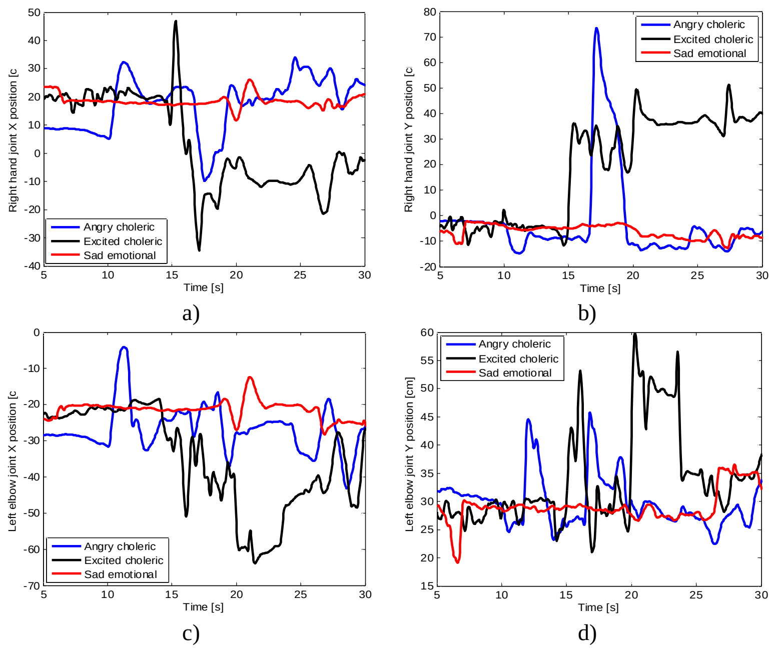


Fig. 4. Evolution of the right-hand joint (a-b) and left elbow (c-d) along X (a-c) and Y (b-d) direction

4.2 Measurement of body gestures by X-sens capture-motion system

Motion tracking of one human upper body is realized with seven XSENS IMU sensors [14]. Sensors are mounted on wrists, biceps, shoulderôs blades and lower-back. Each IMU sensor has five physical sensors: accelerometer, magnetometer, gyroscope, pressure sensor and thermometer. Besides raw sensors data, the sensor fusion scheme calculates free accelerations and velocity increments in three axes (x, y, z), as well as quaternions increments and quaternions. Quaternions have been used for determination of angle values of joints and body posture, because of robustness relative to using Euler angles (Gimbal lock).

Euler angles, presented in Fig. 5 are calculated from the rough measurement data taken from the IMU sensors and processed additionally to be implemented to the life sized humanoid robot RoboThespian designed for human interaction in a public environment. In Fig. 5 are shown the angular joints positions and body posture (torso) for two human behaviors: thrilled choleric (red) and phlegm choleric (blue). Joint angular velocities and accelerations for the same human behaviors are calculated by derivations by taking into account refresh rate of capturing system.

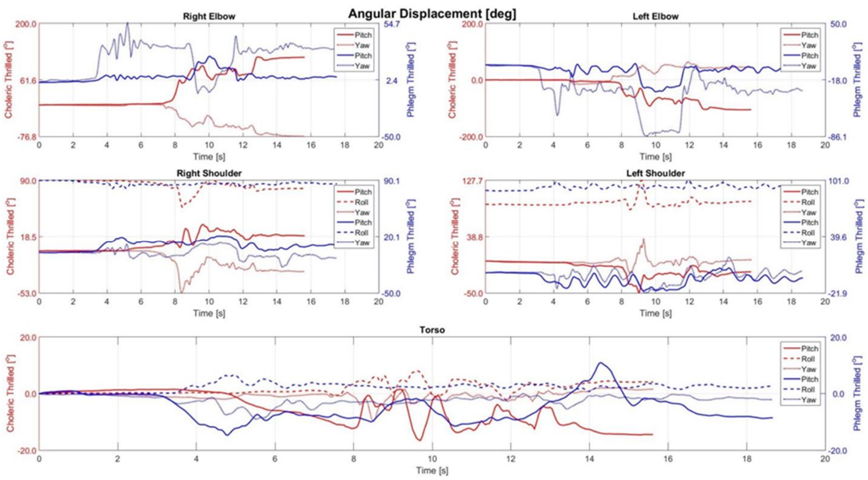


Fig. 5. Angular positions of joints for choleric and phlegm thrilled human behaviors

4.3 Face mime data acquisition

The research presented in this subsection examines emotion expressions and ways of their detection. The aim is to create a basis for further reserch work where the robot will be given the ability to recognize emotions, to be aware of them and to manage its' own.This direction of research in robotics has applications in applications where robots interact with people and where it is essential to create a mutual reaction between robot and human. In the experiments, the actor's task was to display different emotional states through different temperaments, based on the imposed scenario (Fig. 6). The following emotions were examined: happiness, sadness, anger, surprise, fear, disgust, etc. The personalities assumed in the experiments had assigned temperaments (phlegmatic and choleric or emotional and rational personality) in order to cover various combinations of personality profiles. The results are classified and prepared for further research using emotion recognition software.

Fig. 6. Actor performing various emotional states

The basis for emotion recognition is software based on the Facial Action Coding System (FACS). It is a system that classifies human facial movements and puts them in the category of emotional states. The system is based on the teachings of Professor Carl-Herman Hjortsjö, but it is defined in more detail and developed by Professor Paul Ekman [18] the 80ôs. FACS is formed and developed after studies of the anatomy of the human face where the face changes were tracked during expression of different emotions. Facial muscles are grouped into so-called action units (Fig. 7). Based on the geometry of the face, for every action unit the category is defined that includes all the changes of muscles and their combinations that can occur with the human face. After categorizing each of the action units and observation of all of them that make one personôs face, the conclusions about the expressed emotion can be made. The process of detection and analysis is automated using a computer which processes photos and on the basis of that generates the results of the emotional state of the photographed person. This method is widely used in psychology and sociology, as well as in other disciplines dealing with technology that interacts with human.

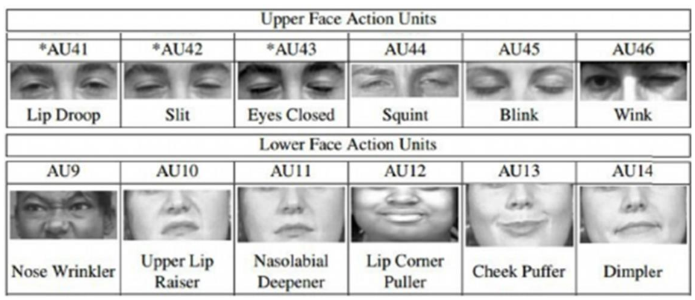


Fig. 7. Action units

To analyze the face of the actor who participated in the above experiment, software developed by Microsoft was used. As part of the Cognitive Services, Microsoft has developed software for face recognition which has created an application that deals with recognizing emotions. Demo version of Emotion API [19] was used in this paper for analysis of the results. From the videos recorded during performance of the actor, where he imitated certain emotional states through different types of personalities, images were generated. The principle of the software is based on an analysis of uploaded photos with face recognition and FACS system where it generates the percentages of each of the emotions displayed on the face (Fig. 8). This method of analysis is acceptable for this phase of work and "happiness" and "surprise" are selected emotions to show the principle of operation. The displayed images show that the software recognizes the emotional states that the actor performed, which is based on the detected face movement and also other emotions that are present are shown. The idea is that, in the future, this principle can be used in the interaction between human and robot. It will be based on the emotional state of human which will determine the behavior or actions of the robot.

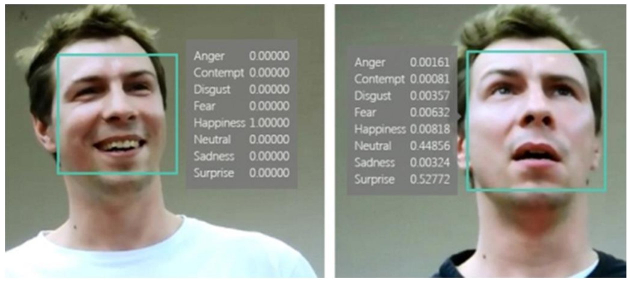


Fig. 8. Face emotion analysis and quantification affective experience

5 Conclusions and future work

The model shown in Fig. 1 and 2, additionally improved by taking into account the results of measurements on a live model will be implemented in the humanoid RoboThespian (Fig. 9) for testing and experimental verification of algorithms of mapping human personality and temperament to the machine. The developed model will be implemented in the second phase of the research project as part of the robot controller of emotional intelligence in situations of robot interacting with people.

Fig. 9. Humanoid RoboThespian ï testbed system for testing robot cognitive EI capabilities

6 Aknowledgement

The results presented in the paper represent research outcome of the project ñEmotionally Intelligent Robots - EIrobotsò, 2015-2017, contract no. 3.4-IP-DEU/112623, supported by Alexander von Humboldt Foundation in the framework of the Research Group Linkage Program funded by the Federal Ministry of Germany.

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