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Parameterized Facial Animation for Socially Interactive Robots

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Abstract

Socially interactive robots with human-like speech synthesis and recognition, coupled with humanoid appearance, are an important subject of robotics and artificial intelligence research. Modern solutions have matured enough to provide simple services to human users. To make the interaction with them as fast and intuitive as possible, researchers strive to create transparent interfaces close to human-human interaction. Because facial expressions play a central role in human-human communication, robot faces were imple-mented with varying degrees of human-likeness and expressiveness. We propose a way to implement a program that believably animates changing facial expressions and allows to influence them via inter-process communication based on an emotion model. This will can be used to create a screen based virtual face for a robotic system with an inviting appearance to stimulate users to seek interaction with the robot.

1 Introduction

Human-Robot Interaction (HRI) researchers suggest that humans prefer to interact with machines like they interact with fellow humans (Fong et al. 2003). To make the user feel empowered and competent, it is necessary to adhere to human social expectations to provide a natural, intuitive and enjoyable interface that needs no training to use it. Facial expressions are a fundamental aspect of social interactions and can be rapidly recognized, enabling us to draw certain conclusion about the inner state of fellow humans faster. Using facial expressions it is possible to translate certain states of the robotic system to facial expressions and add to the information provided by the already widely used text and voice output. Various fields of study from psychologists to computer scientists work on synthesizing facial expressions (Ghent 2011) and several research groups have developed humanoid robots with animated faces. An example of this is Albert HUBO, a human scale humanoid robot with an almost lifelike animatronic face, which features a layer of skin made out of a sponge-like elastomer to create movement as close as possible to real facial soft-tissue (Oh et al. 2006). However, the realistic human-like face may influence user acceptance negatively (see “Uncanny Valley” problem in section 2) and animatronic parts are likely to increase the need for maintenance.

The industrial robot Baxter by Rethink Robotics communicates with users through a simplified face displayed on a screen. Instead of being programmed to perform certain repetitive tasks, it can learn a series of actions from human trainers and repeat them afterward. Line workers can train Baxter within minutes by guiding his arms with their own hands, to show Baxter how to perform a task (learning by demonstration). The human trainers do not need to know anything about software, robotics or engineering. Baxter's head displays a pair of eyes and eyebrows to show whether it could interpret the user's input and to look at the current task, or where it is going next (Guizzo & Ackerman 2012). Baxter's expressions are limited to changing the angle of the eyebrows and eyelids, opening closing of the eyes and moving the pupils. Expression changes are quickly animated but the facial features remain static and lifeless between transitions. SociBot by Engineering Arts Limited is a 60-centimeter high robotic bust, which features an animated face projected onto the roughly human-face-shaped head of the machine. The facial features can be customized and transitions between expressions are animated, but the facial features remain static otherwise, except for blinking and talking animations. SociBot could be used as a terminal in a mall, airport or bank. In addition to focusing its eyes on a point in space, the robot can mechanically move its head, e.g. to look at a person (Marks 2014). The facial features can be continuously transformed by manipulating values based on the Facial Action Coding System (FACS) by using a custom-built facial animation software.

1.1 Goal

To enhance the interaction with socially interactive systems we focus on creating a lively parameterized facial animation software with an underlying emotional model, which can be controlled by other processes. Liveliness animations, like breathing and blinking, will signal users that the system is active and motivate them to seek interaction. The parameters of the facial expressions should be based on an expression model, rather than on parameter rich and abstract systems, like FACS. This paves the way for a meaningful and easy interface of the facial animation software, which will continuously render the face on a screen.

2 Face Design

Realistic depictions of human faces tend to have imperfections that put them in the much discussed “Uncanny Valley” (Mori et al. 2012), which may create feeling of eeriness in the users. Studies suggest that human-like face designs may also create expectations of human-like mind and abilities (Broadbent et al. 2013). It is therefore not advisable to design a robot's face as realistically human-looking as possible. The design should rather fit the tasks that the robot will perform and its abilities. For the proposed work, we chose to create three high-contrast face designs with very limited details: A more realistically proportioned female and male face, as well as an abstract cartoon-like face (see figure 1). To evaluate what the best level of human-likeness is, without getting into “Uncanny Valley territory”, we designed a questionnaire to find out how sympathetic, trustworthy and natural the designs are perceived by humans. We were also interested in how well we could transport specific emotions with the chosen amount of abstraction. For every face design “neutral”, “happy”, “sad”, “attentive” and “frustrated” expressions were sketched out and rendered onto a photograph of a SCITOS G5 robotic system. Participants were asked to distribute points to specific attributes, like “happy” or “inquiring”, for every expression of every face design. The questionnaire was handed out to 105 participants in the age range of 16 to 59 years and the results showed that the female face design was on average perceived as the most sympathetic and trustworthy design, and its emotion sketches transported the intended emotions more clearly. Therefore the character was deemed suitable to be recreated as a 3D model and prepared for animation.

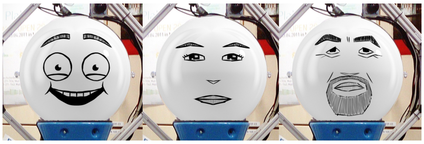
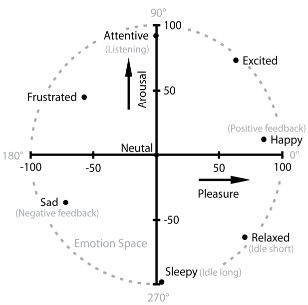


Figure 1: From left to right: Cartoon-like, female and male face design sketches with different expressions

3 Implementation

To parameterize expressions we chose James A. Russell's “circumplex model of emotion” (Russell 1989) and adapted it for an HRI use case. In this model emotion words are placed in a two-dimensional coordinate space (see figure 2). Its two axes describe the emotional parameters arousal and pleasure. Emotion words are placed in a circular pattern around the center, which represents a neutral emotion. The words act like the hues in a chromatic circle and can blend into each other. The distance between an emotion and the neutral center describes the intensity of the emotion.



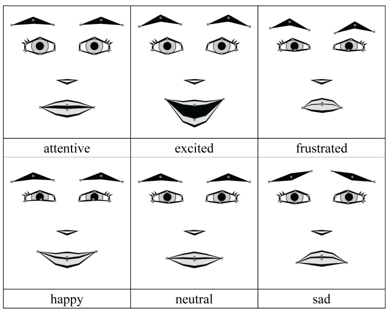


Figure 2 (left): The adapted circumplex model used for parameterizing facial expressions.
Figure 3 (right): Expressions realized in the proposed system

We recreated the sketched out facial expressions and placed them in a two-dimensional blend tree in the Unity engine at the same positions as the corresponding emotion words in Russell's model. The emotion software listens for and interprets UDP messages containing several parameters. It smoothly transitions the parameters via linear interpolation over a certain amount of time, which influences the expression of the 3D face model. Animations to create a lively appearance, breathing, blinking, small random head move-ments and micro movements (like the twitching of an eyebrow) overlay the facial expres-sions. Additional parameters include gaze coordinates and a "talking" parameter. Gaze coor-dinates cause the eyes and head to rotate at different speeds to look at the specified 3D co-ordinate. The talking parameter activates or deactivates a generic talking animation. We implemented a Java program to play prerecorded voice clips while simultaneously send-ing parameters to the facial animation software. This was used for the first evaluation: per-forming a service related scenario on a monitor in front of 12 participants. They were asked to rate how they perceived certain attributes of the character via a questionnaire: It was per-ceived as mostly sympathetic (8.18/10), trustworthy (8.0/10) and intelligible (9.18/10), but not as believable (6.77/10), which we attributed to asynchronous lip movements.

4 Conclusion

We developed a software prototype which allows to parameterize facial expressions based on an emotion model, additional methods were implemented to make the character look alive in interactions. We used empiric research to stochastically find an optimal balance for the first design to enhance human-robot-interaction. While FACS parameter are rich, they are abstract and not intuitive to animate facial expression. However, for some applications, using FACS could still be helpful, e.g. to train a converter from FACS to the Russel's circumplex model. At the current state, the software could be easily integrated in service oriented robotic systems with display screens, running Windows or Unix based OS, to enhance the interaction, speed up robot-to-human communication or to simply raise their appeal.

References

Broadbent et al. (2013). Robots with Display Screens: A Robot with a More Humanlike Face Display Is Perceived To Have More Mind and a Better Personality. *PLoS ONE, 8(8)*, pp. 1–9.

Fong, T., Nourbakhsh, I., & Dautenhahn, K. (2003). A survey of socially interactive robots. *Robotics and Autonomous Systems Vol. 42, no. 3-4*, pp. 143–166.

Ghent, J. (2011). Facial Expression Analysis: A Computational Model of Facial Expression. Saarbrücken: VDM Verlag Dr. Müller.

Guizzo, E. & Ackerman, E. (2012). The rise of the robot worker. *IEEE Spect. vol. 49, no. 10*, pp. 34–41

Marks, P. (2014). Robot head disguises itself as your friends. *New Scientist, 221(2962)*, p. 20.

Mori, M., MacDorman, K., & Kageki, N. (2012). The Uncanny Valley. *IEEE Robot. Automat. Mag., vol. 19, no. 2*, pp. 98–100.

Oh et al. (2006). Design of Android type Humanoid Robot Albert HUBO. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 1428–1433

Russell, J. A. (1989): Measures of emotion. R. Plutchik H. Kellerman (Ed.): The measurement of emotions – Emotion: Theory, research, and experience, Vol. 4, pp. 83–111.