Rendering Facial Expression Within a Social Robot to Enhance Communication and Human Interaction

Daniella L. Massa

Union College

Instructor(s): Kristina Striegnitz and Nick Webb

February 16, 2022

Introduction

Over the past several decades, the industries of computer science and technology in the United States have developed at a significantly rapid rate. Within these fields, there exists many sub-divisions of research. Two major areas-of-interest that relate to my research project are social robotics and Human Computer Interaction (HCI). A social robot is one that is able to communicate and interact with people, build social relationships, adapt to its environment, learn throughout its lifetime, and integrate new experiences into its understanding of the world.[1] My research focuses on the first two aspects of social robotics previously listed. In order to design a robot that has the functionality to communicate and interact with others and build social relationships, my implementation consists of mimicking human behavior.

Humans are complex creatures whose actions are continuously analyzed through the field of psychology. Nevertheless, one key behavioral component humans use to reflect their emotional state is through their ability to display facial expressions. Previous research has shown that facial expressions play an important role in the communication of emotion and the regulation of social interactions.[2] In other words, socialization is significantly hindered with the absence of facial expressions. Due to this significance, I aim to simulate the capability of expressing emotion via virtual facial appearances within a robotic design.

My research within the CroCHET Lab involves modifying a PeopleBot robot named Valerie (see title page). Her purpose is to mimic human behavior and emotion in order to interact with students on campus. This will be accomplished through digital representation of facial expressions within a computer science program. Once the program to render facial appearances is fully integrated into Valerie's software, I will be able to simulate a variety of scenarios

[1] Breazeal, C. *Designing Sociable Robots*. 2004
[2] Gratch, J. "Evaluating a Computational Model of Emotion." 2005.

between Valerie and the students. These scenarios will involve task-driven interactions. For example, I will have Valerie ask a student to open the elevator door for her and I will measure the student's response. In social robotics, it is vital to develop robots that can exercise human functionality, but it is also equally important to monitor a person's reaction when communicating with a robot. Will a student hesitate more when engaging with a robot compared to a real person? Will a student refuse to complete a task that Valerie asks them to do? How can I improve these interactions? Finding the answers to these questions has structured the overall purpose of my research.

Background

In order to develop an authentic replication of human facial expression in a technology-based implementation, I relied on previous research that determined what specific facial features are best perceived by individuals. These perceptions have been rated on six dimensions: friendliness, trustworthiness, intelligence, human-likeness, gender, and age. Studies have shown that facial designs lacking in a mouth and pupils are perceived as less friendly, less trustworthy, and less humanlike. Additionally, facial designs that include eyelids are typically perceived as masculine, and designs including closed eyes are perceived as less intelligent and younger in age. In regards to human-likeness, designs that included eyebrows and a nose were also shown to be significant.[3]

Further research shows how certain emotions can be represented via rendered images of facial expressions on a screen. More specifically, studies have evaluated how the positioning of a mouth (with open, closed, or narrow) and the positioning of eyebrows (raised, lowered, or turned-inward) is perceived by individuals in relation to emotional expression. These expressions include: neutral, happy, sad, scared, angry, disgusted, and surprised. Overall, the participants

---

[3] Kalegina, A. "Characterizing the Design Space of Rendered Robot Faces." 2018.

were able to correctly identify six out of the seven virtual facial expressions that contained mouth and eyebrow placement similar to real human expression (i.e. open mouth for scared, eyebrows turned-inward for angry, etc.). The one emotion the participants were unable to correctly identify in the virtual implementation was disgust.[4]

Current Work

So far Professor Striegnitz and I have designed an assortment of facial expressions that Valerie is able to display on her main screen (see Figure 1). These expressions contain specific characteristics for perceptions of friendliness, trustworthiness, and human-likeness, based on the previous research detailed above. These designs were generated in a simplistic fashion, with the purpose of being able to animate these expressions in the future. Furthermore, our facial expressions are representative of the seven emotional states from prior research: neutral, happy, sad, scared, angry, disgusted, and surprised. Professor Striegnitz and I also included a design for the feeling of "anticipation," due to the nature of Valerie's physical implementation being task-driven.

These designs are imperative to the project because they promote advanced forms of communication for Valerie. Although she has the ability to speak, it is critical for Valerie to mimic human emotion because doing so allows her to have a comprehensible method of relaying information. Moreover, these designs help foster a stronger and more personal connection between Valerie and the students at Union. Therefore, I need to ensure that these expressions are easily understood by other people, in order to prevent miscommunication. Although previous research details the relationship between humans' perception of digital facial appearances, I need to ensure that the specific designs Professor Striegnitz and I generated are also universally readable.

[4] Seib, Vi, et al. "Enhancing Human-Robot Interaction." (2013).

As of right now, four of the facial designs need to be revised:scared, surprised, disgusted, and anticipation. These emotions are more complex compared to basic ones like happy and sad, which means that implementing them in an efficient and comprehensible manner proves to be a difficult task. In order to overcome this obstacle, I am currently developing an online psychological experiment in the form of a survey via Qualtrics to better understand the most precise method of representing facial expressions within a robotic implementation. These surveys ask the participants to view each of our facial expression designs, and to describe which feelings they think might cause this emotion. Additionally, the participants are given a list of 27 dimensions to pick from (i.e. anxiety, confusion, boredom, etc.); they are prompted to select the words they think apply to the given facial expression. These 27 dimensions were adapted from Cowen and Keltner's Distinct Varieties of Emotional Experience scale.[5] The results of this experiment will help Professor Kristina Striegnitz and I modify our designs, in order to better represent human emotions within Valerie. By the end of spring term, we plan to have facial designs that can be reliably interpreted by humans.

Summer Project

Over the course of the summer I will be working on accomplishing two major tasks. The first is to integrate the previously mentioned facial designs within Valerie's current operating system. Prior to the summer, all of my experiments will be conducted online, and they will contain static images of the emotional states. However, the next step in my research is to take these static images and convert them into an animated application within the schematics of the PeopleBot. I plan to execute this via script development in Python within a ROS environment for communication, and Javascript for facial implementation. By generating software that dynamically displays the faces with the rest of the robot framework, I will be able to ensure that

[5] Cowen, A. "Self-Report Captures 27 Distinct Categories of Emotion." 2017.

the transition from online experimentation to in-person experimentation runs smoothly. Live communication and interaction with Valerie will be fully supported.

The second task I aim to accomplish over the course of my summer research is to design and prepare an in-person psychological experiment, which I plan to conduct during the fall trimester. This study will require student volunteers to participate, and it will entail outlining a variety of scenarios for Valerie to behave in. Examples of these scenarios will include Valerie asking a student to perform a simple task, like opening a door or pressing an elevator button.

Beyond analyzing the psychological aspect of these interactions, I will also need to solve one major problem: how can I structure Valerie's performance to respond in a certain way, given the situation she is placed in? To be more specific, if Valerie is interacting with a person, it is critical that she displays the correct emotional response based on that person's behavior. For example, if Valerie asks a student to complete a certain task, but they fail to do so, she should display sadness on her screen. Moreover, if Valerie asks a person to complete a certain task, and they succeed in doing so, she should display happiness on her screen. Finally, if Valerie is waiting for a student to complete a task, she should display anticipation.

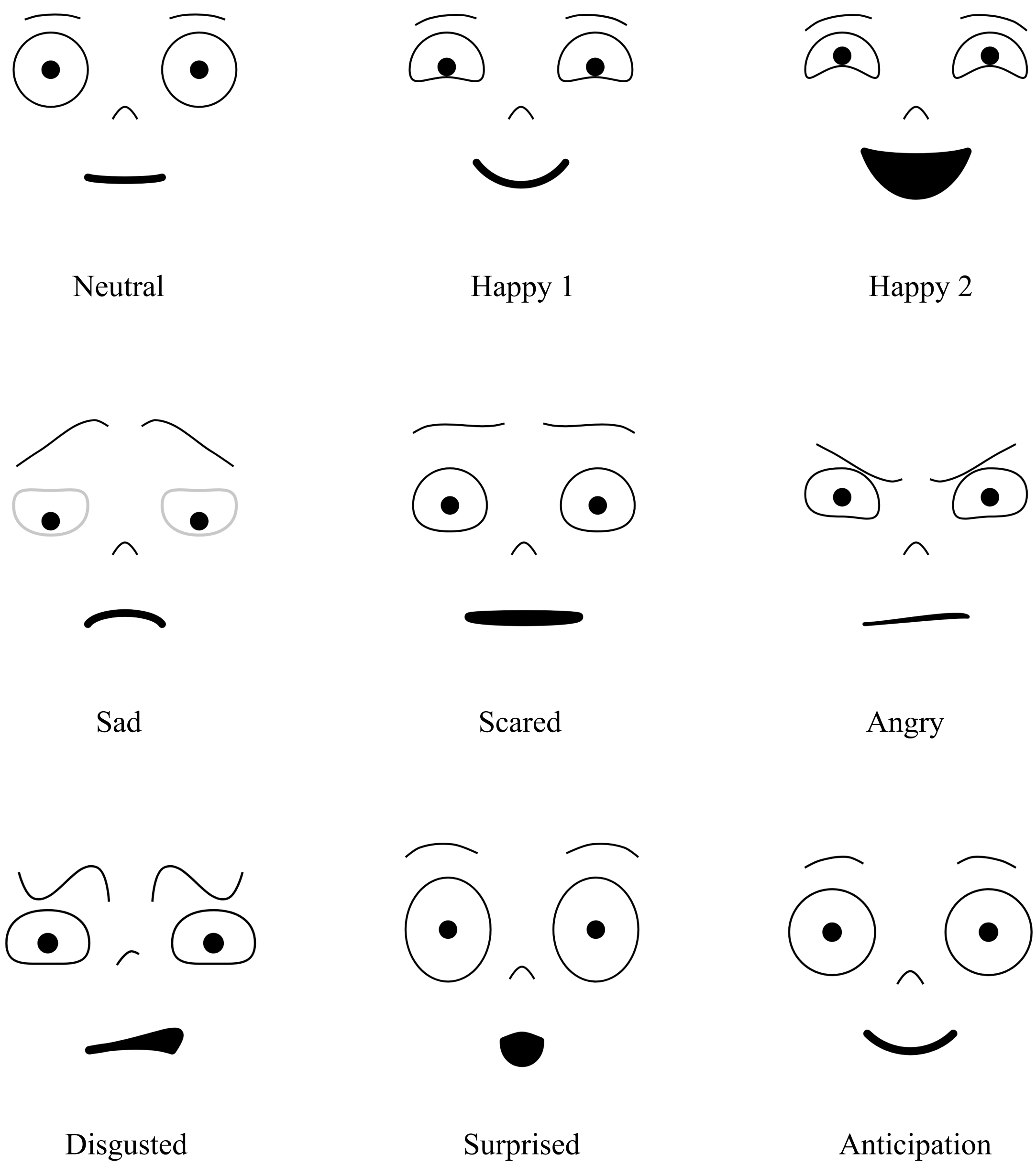
I will be working with professors Nick Webb and Kristina Striegnitz in the Computer Science department to modify the underlying architectural setup of Valerie's code. By having Valerie change emotional expressions, she will have the capability to dynamically function in a given environment. Kristina Striegnitz, Nick Webb, and I also plan on analyzing her performance in both a dynamic and static manner (i.e. displaying an unchanging neutral facial expression throughout an interaction), and we will compare the differences of student responses within these two conditions.

Goals

The first goal I plan to accomplish prior to a summer research position is to modify the pre-existing facial expression designs to better represent human emotion. These designs need to be universally readable and easily understood by students on campus. Throughout the summer, I strive to alter Valerie's internal infrastructure to support both static and dynamic applications of these facial expressions, and I will integrate this software with the rest of the PeopleBot's framework. Another goal I have set for the summer is to design and plan a live experiment, which will require an in-depth psychological analysis of human behavior in relation to social robotics. My final overall goal is to prepare a fully functional social robot for students to interact with when they return in the fall.

Figure 1

Valerie's Facial Expressions to be Rendered on Main Screen



References

Breazeal, Cynthia. *Designing Sociable Robots*. MIT press, 2004.

Cowen, Alan S., and Dacher Keltner. "Self-Report Captures 27 Distinct Categories of Emotion Bridged by Continuous Gradients." *Proceedings of the National Academy of Sciences* 114.38, 2017.

Gratch, Jonathan, and Stacy Marsella. "Evaluating a Computational Model of Emotion." *Autonomous Agents and Multi-Agent Systems* 11.1, 2005.

Kalegina, Alisa, et al. "Characterizing the Design Space of Rendered Robot Faces." *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 2018.

Seib, Victor, et al. "Enhancing Human-Robot Interaction by a Robot Face with Facial Expressions and Synchronized Lip Movements." 2013.