Empathetic Communication in Socially Assistive Robots Based on Perceived Nonverbal Cues from an Individual

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Introduction

A person walks into a therapy session expecting there to be a person waiting in a chair with a pen and clipboard ready to go. Instead, they are met with an SAR, or Socially Assistive Robot. Just like a person, the robot starts the session off with a simple, “Hello, how was your day?” and as the person responds, the robot perceives and communicates with the person all while maintaining a sense of empathy in the conversation. Empathy is defined as the act of understanding and interpreting what others feel and showing signs of emotion and movements in order to console them based on the context of the scenario. (Mataric; Tapus, 2007) Empathy is important since the main goal of the SAR in this situation is to create the essence of a real life conversation and to maintain that social relationship between the person and the robot.

The question we now have to ask ourselves is if an SAR can imitate the essence of empathy like a human. Many experiments have been conducted regarding the interactions between humans and robots, also known as the field of human-robot-interaction (HRI). Each method implemented empathy but not all the same type or form. For example, maybe the robot would give a compliment to the user when it sees that the user is feeling down, or it will give a

There have been multiple studies regarding how robots perceive empathy through nonverbal cues. For example, one could refer to the SAR called ICat. ICat is known for its reaction and empathetic behavior based on nonverbal cues. When a user interacts with the robot, it reacts and responds in a certain way based on the nonverbal cues such as face movement and head direction. With this, the robot can select an action to perform in the situation. For example a small “Good move!” or “Good try!” Using this as a basis of how SARs process nonverbal cues, research can be thoroughly explained and carried out.

In this paper, we focus our scope on the nonverbal (NV) cues of a human that a robot interprets. Examples of nonverbal cues are posture, eye movements, and body language. Nonverbal cues are a fundamental necessity in communication between humans, expressing emotions which verbal cues won’t be able to express. (Mandal, 2014) In the analysis article *Perceptions of Cognitive and Affective Empathetic Statements by Socially Assistive Robots* exhibits two relevant scenarios of how robots react to nonverbal cues such as posture. In one scenario, a woman is sitting in a tensed posture and the SAR is in a more relaxed and helpful posture. The second scenario is where a man is in a relaxed posture and the SAR is in a more stricter, normal posture. In this experiment, the human's posture was interpreted by the robot and allowed the robot to take the most appropriate, assistive action.Like this, many experiments have taken place that have observed an SAR’s response to cues all while maintaining empathy.

Given the importance of empathy in HRI, this paper will not only analyze certain methods and experiments targeted at emulating empathy in SARs. It will also provide an in depth explanation for how an SAR can communicate with a person while emulating empathy through perceiving nonverbal cues in humans.

Definitions and Background

There are a number of concepts and terminologies that are relevant to the field of socially assistive robots. The following section defines the fundamental concepts and ideas that influence the findings in the studies that will be discussed in future sections.

A. *Socially Assistive Robots (SAR)*:-

A basic definition is that a socially assistive robot (SAR) is a robot specifically designed to assist individuals in a social manner.

I. Embodiment: Physical form of the robot
II. Emotion: Feelings expressed by robot
III. Dialogue: What the robot says to express emotion
IV. Personality: Character developed by the program of the robot

Each of these properties can be modified and altered through user populations, or the support type of each individual. (Feil-Seifer, 2005) Support types include elderly, disabled, teenagers, toddlers, etc.

Compared to a normal Assistive Robot that specializes in physical assistance, a Socially Assistive Robot specializes in social assistance. An SAR can support a more diverse set of support types whereas an AR is only limited to individuals who are in need of physical aid and disabilities.

B. Empathy

There are many ideas we need to consider when referring to empathy. Empathy itself is very broad. We could be referring to a definition, a model, or a measurement.

There are four main parts to empathy:

I. Empathic concern

Empathetic concern is the act of feeling emotions and responding with those emotions to others. These emotions reflect concern, which is a form of empathy. An example of empathetic concern is sympathy. Sympathy is an emotion that reflects concern towards someone else. (Mataric; Tapus, 2007)

II. Perspective taking

Perspective taking is nothing more than the ability to understand different sides of the interaction. For example, if one person says something, they would need to acknowledge the other sides of the argument and/or scenario in order for their claim to be valid and useful. In the same way, empathy implements taking multiple perspectives and building off of them in order to establish an interaction between a robot and a human. (Mataric; Tapus, 2007)

III. Personal distress.

Personal distress is the ability to feel negative emotions or distress when necessary. For example, when talking about a tragedy, there will be signs of distress compared to when talking about an achievement. The robot needs to understand the appropriate times to show what emotions. Specifically, in terms of empathy, distress.
(Mataric; Tapus, 2007)

C. *Nonverbal Cues*

Nonverbal communication is nothing but “conveying information through signs.” (Mandal, 2014) NV cues help indicate the social situation and can be separated into three categories:
Verbal vocal, Nonverbal vocal, and nonverbal nonvocal. (Mandal, 2014) These classes are defined as named. Verbal vocal communication is nothing but the act of verbally vocalizing something. For example

saying to the waiter at a restaurant "I do not like this dish" is nothing but verbal vocalization since you are verbally telling the waiter directly what is wrong with the dish. Now imagine that same scenario with nonverbal vocal cues. It doesn't mean directly saying that the food isn't good, but it is instead using factors such as pitch, volume, and other vocal alterations that can hint at a distaste. The third class is nonverbal non vocalization, which means just not talking at all and using body language in order to communicate. (Mandal, 2014)

In terms of SARs, the communication that is being analyzed in this paper is nonverbal non vocalization. Nonverbal cues can help the robot determine their empathetic decisions. It can help the robot set themselves up for a conversation.

Review of Works

In this paper, we center our research into how robots take in nonverbal input and process it in order to produce empathetic reactions. To produce empathetic responses, a robot should be able to first simulate, perceive and interpret the different nonverbal cues from humans. The sources that will be discussed in this review of works all highlight the key processes and criteria that an SAR uses to do each step to produce an overall empathetic behavior.

A. *Simulating Empathy in SARs*

As stated by Maja J Mataric in the article titled *Simulating Empathy,* in order to simulate empathy, robots should be able to determine the environment and the different perspectives of their surroundings and produce a response fit to the situation. In the article *The Influence of Empathy in Human-Robot Relations* the robot iCat was tested for its relationship with the surroundings and its responses to those surroundings. The experiment that was conducted involved two users playing a game of chess with iCat while commenting on the game and reacting to certain moves and aspects of the game.

The user who is controlling the white pieces, receiving neutral comments and expressions from the robot, is considered the control group. The users controlling the black pieces are the experimental group, receiving empathetic statements from the SAR based on their moves throughout the game. (Leite, 2012) The users who are controlling the white pieces are considered the control group, who are receiving neutral comments and expressions, while the user controlling the black pieces is receiving the empathetic statements. (Leite, 2012)

Based on the affective state of the SAR established by the environment it is in, it reacts in a certain way to a bad or good move. For example, if the player makes a move that is good and unexpected, then the SAR would respond with an empathetic statement such as, "Wow! What a great move! I wasn't expecting that!" The SAR itself was able to establish empathy through its own affective state. (Leite, 2012)

After the game of chess is completed, participants were asked to fill out a questionnaire. This questionnaire tested user perceptions of the SAR's companionship, assistance, intimacy, alliance, validation, and security. Out of the results, many of the participants stated that they liked the Cat and that it provided well served feedback and validation. Many of the participants also said that they felt no insecurity during any point of the game. According to the feedback that participants gave, it stated that iCat was able to provide compliments and emotion throughout the game. (Leite, 2012)

This source provided an in depth analysis on how a social robot can simulate empathy with user participation. It proved that through user actions a robot can determine what type of response to give and in what manner it should be communicated in.

B. *Perceiving Nonverbal Cues From Humans*

Nonverbal cues allow people to communicate more efficiently. (Mandal, 2014) There are many forms of Nonverbal cues. [Refer back to *Background, Nonverbal Cues*: Page 3] In terms of SARs, verbal communication is more direct and prompt.(Mandal, 2014) Nonverbal communication allows the SAR to establish how the user truly feels. Based on a position or stance of an individual, the SAR is able to establish the stress levels or the emotions of the individual and act based upon that. (Sirithunge, 2019)

A study showed in *Understanding Nonverbal Communication Cues of Human Personality Traits in Human-Robot Interaction* by Zhihao Shen, et. al, based on certain features such as gaze, head movement, pitch, etc. Data was collected on how the robot should perceive certain cues in the form of feature representation, in which the researchers study the movements that the participant or user does. Using this data collected, the authors implement the Big Five personality traits of Extroversion, Agreeableness, Conscientious, Emotional Stability, and Openness of each user through the data that they collected from each user. This study establishes that perceiving certain nonverbal cues (e.g., gaze, head movement, pitch etc.) can predict a SAR user's personality. This information can then be later used by the SAR to tailor its interactions appropriately to a user's personal and emotional needs. The question is, however, if the robot can interpret those nonverbal cues.

C. *Interpreting Nonverbal Cues From Humans*

A robot can perceive nonverbal cues from humans through certain features such as eye gaze and head movement. However, the ability to interpret those perceived cues and produce a response is what an SAR needs to be able to communicate efficiently. Based on the perceived emotions that the SAR perceives through nonverbal cues, the robot can respond. A framework has been made by Emilia I. Barakova and Tino Lourens in order to explain the interpretation that SARs go through to perceive these cues. First, the robot needs to be aware of what nonverbal cues mean and what they are. The program that the robot follows has a certain description of each nonverbal cue. One way to express this is through the Laban Movement Analysis, which is a form of analyzing human movement. (Barakova, 2010) Based on the Laban Movement Analysis, the robot can perceive nonverbal cues by analyzing the weight, space, time, and flow of the cue. (Barakova, 2010) For example, if someone waves and smiles the robot perceives that as a movement of the arm in appreciation. Compared to that of someone punching the air, which has more weight and force put into the gesture. When looking at both gestures side by side, the SAR can interpret both of them and conclude that since the punch had more weight to it, the user is probably in a more stressful situation. Based on the Laban Movement Analysis, robots can interpret human emotions as well as actions, which adds more depth and understanding to the surroundings of the robot and can allow them to determine what specific statement or behavior they need to carry out to satisfy the user.

Discussion and Conclusion

The studies analyzed in this paper explained how a socially assistive robot can simulate empathy, perceive nonverbal cues, and interpret those same cues in order to produce an empathetic response. To develop empathy, specifically from nonverbal cues, the SAR must have knowledge of the environment as well as the people it is with in order to receive and interpret the cues to produce an empathetic response. Relating back to the iCat and chess game study, the SAR was able to respond based on expected or unexpected outcomes. For example, the game of chess. Due to this, the SAR has a specific programmed response to each move. When a player makes a good move in which the SAR expects, the SAR produces a response that is either, "Good move!" or "Great job!" (Leite, 2012) With these types of scenarios, the SAR is able to perceive nonverbal cues and act based upon these programmed responses. The SAR has to first establish certain assumptions based on those cues. For example, if a person is stiff and tense, the robot needs to be able to identify that based on those cues and say that the person may be stressed. In conclusion, SARS can understand and exhibit empathy by understanding a user's personality given the surroundings and interpret the cues into human emotional states in order to produce an empathetic response and communicate that response with the user.

There were many drawbacks, however, with the sources. For instance, the existing studies each utilize a single robot. Different robots may have different features, designs, and capabilities that could affect the way they function as well as perceive and interpret nonverbal cues. This paper has shown that significant research exists already in the field of empathy with SARs, however there are many opportunities for future study. There can be more research done in order to enhance already existing research as well as help to understand the effects of empathy and the way that empathetic behaviors play into the approachability and functionality of the robot. This can also explain how certain character traits can be programmed into a robot. There is still much more to learn about how SARs can implement empathy into their communication with humans.

It is also worth mentioning that future research in this field may also be related to service robotics, a topic that focuses on the services that robots accomplish to help people. For example, medical assistance and hospitality robots are two service areas that are currently being studied and advanced in. In these real world applications, empathy becomes a more crucial factor in helping others and with the advancements in robotics and HRI, SARs will become more useful and prevalent in the real world.

Works Cited

Barakova, Emilia I., and Tino Lourens. "Expressing and interpreting emotional movements in social games with robots." *Personal and ubiquitous computing* 14.5 (2010): 457-467. https://link.springer.com/article/10.1007/s00779-009-0263-2

Davis, Mark H. "Measuring individual differences in empathy: Evidence for a multidimensional approach." *Journal of personality and social psychology* 44.1 (1983): 113. https://student.cc.uoc.gr/uploadFiles/179-%CE%9A%CE%A8%CE%92364/Davis1983.pdf

Feil-Seifer, David, and Maja J. Mataric. "Defining socially assistive robotics." *9th International Conference on Rehabilitation Robotics, 2005. ICORR 2005.*. IEEE, 2005. https://arl.human.cornell.edu/879Readings/Feilseifer.pdf

Leite, Iolanda, et al. "Empathic robots for long-term interaction." *International Journal of Social Robotics* 6.3 (2014): 329-341. https://user.it.uu.se/~ginca820/IL-EtAl-IJSR-2014.pdf

Leite, Iolanda, et al. "The influence of empathy in human–robot relations." *International journal of human-computer studies* 71.3 (2013): 250-260. http://gaips.inesc-id.pt/~apaiva/Ana_Paiva_Site_2/Home_files/TheInfluenceOfEmpathyInHuman-robotRelations.pdf

Fatik Baran Mandal (2014) “Nonverbal Communication in Humans”, *Journal of Human Behavior in the Social Environment*, 24:4, 417-421 https://doi.org/10.1080/10911359.2013.831288

Sirithunge, Chapa, AG Buddhika P. Jayasekara, and D. P. Chandima. "Proactive robots with the perception of nonverbal human behavior: A review." *IEEE Access* 7 (2019): 77308-77327. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8734064

Tapus, Adriana, and Maja J. Mataric. "Emulating Empathy in Socially Assistive Robotics." *AAAI spring symposium: multidisciplinary collaboration for socially assistive robotics*. 2007. https://www.aaai.org/Papers/Symposia/Spring/2007/SS-07-07/SS07-07-020.pdf