Board 6: Robot Temperament Assessment as a Method to Expose Students to the Humanistic Aspects of Biomedical Engineering

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Introduction

The rapid increase in use of robots in medicine has been driven, in large part, by their ability to enhance surgical, logistical, and other utility and task-oriented applications. Such types of robots are incredibly effective, and in many cases, can be "game-changing," because they can provide clinicians with "super-human" capabilities. Another important but less well-known area of application is assistive robotics, which has been advancing, but at a slower pace. The "weak link" in development and adoption of assistive robotics is that for such assistive robots to be effective, they need to interact with, respond to, and adapt to the needs of the human/patient they assist [1].

The challenge in the design of assistive robots is in selecting the right degree of realism that is required to make the assistant effective and accepted by the user. "Temperament" encapsulates this particular trait of how robots present themselves to the user [2]. Ideally assistive robots should be able to judge whether their user is introverted or extroverted and know how to adapt and respond in the appropriate manner. This paper describes how inclusion of an instructional activity on temperament helps students understand the value of adding a human dimension to the design of devices and systems which interact with and assist users with their activities of daily living.

Motivation

The active learning intervention presented in this paper was implemented in Medical Robotics and Assistive Technologies, a popular elective course for senior level Biomedical Engineering (BME) students at Wentworth Institute. The course, designed and delivered by one of the authors, has been offered every summer for the past six years, with an enrollment ranging between twelve to twenty students per offering. The course consists of lectures, labs, and workshops, where students, individually and in groups, learn about and explore different aspects of robotics. The course covers traditional topics in robotics, including kinematics, sensors and actuators, navigation, planning, haptics, and modes of human-robot-interaction (HRI). One unique feature of the course is that it also covers design and implementation of assistive technologies. Whereas many universities offer courses in medical robotics, and some offer courses in assistive technology, few, if any, offer courses combining both medical robotics and assistive technologies. Even more so, such courses are typically offered at the graduate level. Our course provides an overview of these important topics to undergraduate BME students.

Incorporating assistive applications into the course, exposes students to human "stories" which deal with supporting people with cognitive and/or motor impairments, whether these are temporary due to injury or life long as a result of a condition or an event, such as stroke. In the process, students uncover important issues like privacy, data integrity, information security, risk, decision making, ethics, regulations, and social disparities in access to care and outcomes. Students find that exploration of these issues adds context and meaning to their training as biomedical engineers.

The Active Learning Activity

The key active learning intervention implemented in the course is a case study based on a thoughtful 2009 article by Jerome Gropman, entitled Robots that Care [3]. In this activity, all

students read and discuss not only the technical challenges involved in creating assistive robots, but also explore and reflect on how to implement and regulate the temperament of the robots. From discussion in class, the topic of temperament seemed to engage students, and that is what prompted this investigation.

The activity was delivered in two parts. In the first part, the entire cohort of nineteen students enrolled in the Summer of 2023 semester read and reflected on the article. In the second part, the students responded to a questionnaire posted on the learning management system. Many of the questions focus on technical and implementation aspects of assistive technologies, and those are not part of the discussion here. The two questions shown below are the ones used for the analysis presented here. They ask students to reflect on the role of temperament in the design and implementation of assistive robotics. The activity concluded with in-class sharing and discussion of the comments posted by the students.

> *How would you incorporate "temperament" into how a robot interacts with a human user?*
>
> *This article was published over ten years ago. What has happened since in terms of "robots that think?"*

Thematic Analysis Methodology

Thematic analysis was used to analyze the written reflections on the role of temperament in the design of robot assistants. Thematic analysis provides a way to systematically analyze qualitative data and is performed following a five-step process: data acclimation and familiarity, line-by-line coding, initial theme identification, further theme expression, and review of themes based on the complete data set [4-5]. The two authors reviewed the student responses and identified preliminary themes from this first round of thematic analysis. Following thematic analysis protocol, the two authors performed a secondary review independently, then combined similar themes, and performed another review of all sections using and consolidated their data into combined theme sets.

Results

Thematic analysis of data revealed two main themes, and they are summarized below in Table 1. Other themes developed from the coding schema included: make the robot less natural; allow users to program temperament; aid those with disabilities; and A.I. in daily life.

Table 1: Thematic analysis codes identified from student responses. Sample responses included.

Theme	Sample Responses
Theme 1: ***Temperament should conform to user's personality, mood and condition***	*Ex 1: "The robot would need to determine what kind of personality their patient had (e.g. introvert/extrovert) in order to appeal to their judgment and be open to treatment."* *Ex 2:"Incorporating temperament into a robot would help determine its personality and how it speaks to the patient, allowing each patient to "get along" with the robot helping them."* *Ex. 3: "Patients' personalities and outgoingness should be assessed to match them with a robot of a similar style for effective treatment."*

Theme 2: ***Artificial Intelligence as a way to adjust and regulate temperament***	*Ex 1: "In the past ten years, A.I. has improved significantly. The improvement in A.I. technology allows for these types of robots to have more human-like actions and responses."* *Ex 2: Today, critical thinking is possible through AI, and robots can make independent decisions to adjust their actions based on previous experience. As robots become more sentient, their ability to complete complex tasks like caregiving will improve.* *Ex 3: AI is now prevalent within our society, and used in countless ways for a multitude of purposes.*

Discussion

The first theme derived from analysis of the responses indicates that students recognized the importance of temperament in the design and implementation of assistive technologies. Some students went beyond noting that temperament should not be fixed, but rather, should conform to the personality, condition, mood, and reaction of the user. The second theme brings out the role of artificial intelligence (AI), and how it can be the mechanism by which temperament is regulated in assistive robotics. Although not a direct focus of this paper, AI should be important in future work. This is something that we plan exploring further during the next offering of the course.

Another important insight noted by a few students is that temperament should be adjusted just to the point where robots behave "human," but *"not too human."* Some students pointed out that these systems should be easily recognizable as non-human in more ways than just physical appearance. This alludes to the powerful notion of the "uncanny valley" in the design of intelligent systems, first formulated by Mashiro Mori in the early 1970s [6].

> *"[Mori] hypothesized that a person's response to a humanlike robot would abruptly shift from empathy to revulsion as it approached, but failed to attain, a lifelike appearance. This descent into eeriness is known as the uncanny valley."*

Whereas the robotics course which served as the setting for this activity is mostly technical in nature, and focused on implementation of various robotics systems, brief exposure to the human aspect of temperament, was enough for students to internalize, and have an appreciation for the humanistic aspects of robotics (and technology in general). Since BME deals with human life and wellbeing, the approach implemented here, can be applied to other BME courses, The humanistic aspects of this course are, and should be an integral part of BME courses. The implementation here could be scaled to take the form of a lecture period followed by an active learning activity and discussion.

Conclusion

The paper is a first step in addressing how students recognize temperament as a vital element in the implementation design and implementation of robotic systems which interact with humans for assistive purposes. Thematic analysis provided meaningful insights into how students view the design of assistive technologies, and how temperament plays a predominant role in the use of assistive technologies. Features of human behavior, such as temperament, should be applied to other biomedical engineering courses to provide context on how medical devices and systems are used by humans, and how the systems need to respond. These results provide evidence that looking at temperament can add humanistic skills to BME student's education.

IRB Statement on Data Usage
The data utilized in this study was anonymized and aggregated and was deemed as "exempt" by the university's IRB committee.

References

[1] Feldman, U., Larsen, C.N., Parmonova, E., Theobald, D., "Innovations in Medical Robotics: Surgery, Logistics, Disinfection, and Telepresence," Chapter 8, in 'Patient-Centered Healthcare Technology: The Way to Better Health' edited by Goldschmidt, L. & Relova, IET Books, (2021) doi:10.1049/PBHE017E_ch8

[2] Karpov, V.' "Robot's Temperament." *Biologically Inspired Cognitive Architectures* 7, (2014): 76-86, https://www.sciencedirect.com/science/article/pii/S2212683X13000972.

[3] Groopman, J., "Robots That Care," The New Yorker*,* vol. 85, *(35),* pp. 66, 2009.

[4] Douglas, E. P., "Beyond the interpretive: Finding meaning in qualitative data." Columbus, Ohio: *ASEE Conferences.* doi:10.18260/1-2—27658, 2017.

[5] Case, J. M. and Light, G., "Emerging Methodologies in Engineering Education Research," *Journal of Engineering Education,* vol. 100, *(1),* pp. 186-210, 2011.

[6] Mori, Masahiro and Karl F. Macdorman. "The Uncanny Valley: The Original Essay by Masahiro Mori-IEEE Spectrum." (2017).