Trust, Comfort, and Communication: Human Machine Interface Testing with Virtual Reality Robot

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ABSTRACT

Would you feel safe and comfortable working side by side on a task with a robot? Researchers conducted Human Machine Interface (HMI) Testing for a proposed new robot as an additional team member for a warehouse facility. The overall purpose of this project was to explore how to build human/robot trust, robot communication, human expectations from robot behaviour, and how to measure the positive or negative effects relating to trust as we test HMI variables.

Because of the size and weight of the robot, Virtual Reality (VR) was used to simulate the warehouse environment to test the VR robot. The researchers created four VR sessions to test the new robot and obtained the reactions and responses of 10 participants. Most participants did not have a significant change in their trust in robots' baseline responses. Participants showed overall trust in robots and their comfort and trust in working with the new proposed robot and the new robot's capabilities. Participant comments about suggested further robot improvements were gathered and accompanied the results.

The researchers discovered that the HMI testing for the robot was more about defining the borders of comfort rather than trust. Additionally, researchers discovered to first deal with the psychology of trust and comfort, then concentrate on robot indicators. Additional HMI Testing using VR is planned for the proposed changes for the new robot and future new robots and contemporary design and development features.

KEYWORDS

Robot team members, workplace robots, virtual reality robot

Introduction

Imagine going to work, and one of your team members is a giant robot. Would you feel comfortable moving through your workday with your team robot and other large robots passing around you or in front or behind you? Would you trust and understand the robot's behaviour and intentions during an encounter, interaction, or work task?

A fundamental role in a human's trust formation is the predictability of a system that plays a fundamental role in a human's trust formation (Lee and Moray, 1994). However, with advanced technologies, it has become increasingly more difficult for humans f to know every working and technical detail of their teammate robot. According to Ribeiro et al. (2016), humans base their trust on limited perceptions of the machine partner and make decisions accordingly.

Perception is critical for human decision-making. However, a perception bias may occur now and then, which may ultimately compromise the quality of human decision-making (Dietvorst et al., 2015). According to Woods et al. 1994, the human is susceptible to bias. The attribution bias is one of the most well-known forms of perception bias in which people tend to neglect their own faults but attribute them to others, especially machines (Lee and Moray 1992). Humans are much less tolerant of mistakes made by machines than by themselves. Humans are much less tolerant of mistakes made by machines than by themselves (Muir. 1994).

According to Muir (1996, 1994), humans overrode the machine if they had higher confidence in themselves than their trust in the machine. However, this conclusion is subjective and difficult to measure or compare with trust. There is still limited knowledge of the quantitative relationship between perception, trust, and decision (Yu et al., 2019.

Today there are a variety of robots in the workplace. Unhelkar et al. (2014), Gleeson et al. (2013), Knight (2013) researched introducing co-workers into factories and, Graf et al. (2004) provide insight on in-home robot helpers. Fong et al. (2013), Diftler et al. (2011), Bualat et al. (2015) discuss the development of robotic assistants for astronauts onboard the International Space Station (ISS). Transportation (Smith, 2019), and many other industries, often utilize robots to perform tasks because the robot capabilities are better suited for the functional allocated task than their human counterparts. Some job tasks require human and robot interaction.

Method

Researchers conducted Human Machine Interface (HMI) Testing for a proposed new robot (potentially working on tasks and interfacing directly with humans) as an additional team member for a manufacturing facility. The overall purpose of this project was to address the following questions:

- How do we build trust between users and the robot?
- How does the robot communicate its intent to users?
- What do users intuitively expect from the robot in terms of behaviour?
- How can we measure the positive or negative effects relating to trust as we test HMI variables?

Researchers created storyboards and a series of scenarios for software engineers (See Figure 1) to gather participant input on the proposed new robot design features, communication abilities, and perceived comfort and safety through observation, participant interviews, and a series of survey questionnaires. The introduction, four sessions, and follow-up for each participant was one hour.

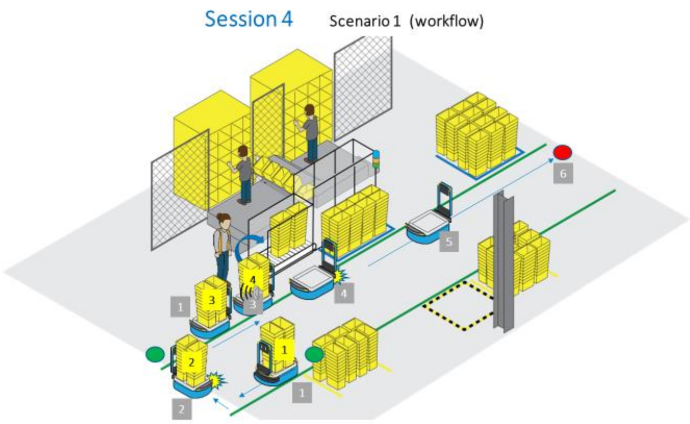

Figure 1: Example of Storyboard for software engineers.

The researchers prepared an extensive survey, based on works by Schaefer (2016) and Charalambous et al. (See Figure 2); Lee and Moray (1992), using the Merritt et al. Scale (2011), a 5-point Likert-type scale that assesses a user's trust in an automated system; Madsen & Gregor (2000), Human-Computer Trust. The Human-Computer Trust (HCT) Questionnaire is a 25-item subjective measure of "cognition-based" and "affective-based" trust. Körber et al. (2015), German TiA Scale 19 items on a Likert-type rating scale with subscales for reliability and competence, familiarity, trust, understanding, and developers' intention.

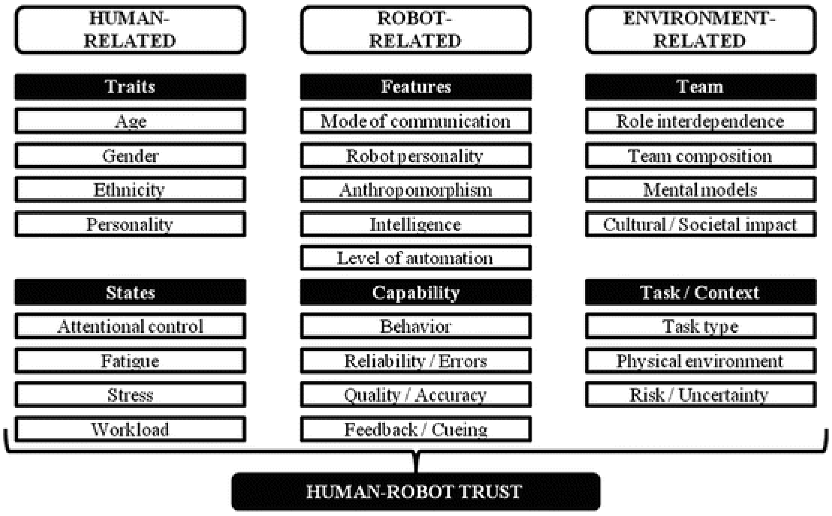

Figure 1: Categories used for a Scale to Evaluate Trust in Industrial Human-robot Collaboration (Schaefer, 2016).

The survey included several workload questions to assess the interaction task in Session 4. Ososky et al. (2014) and Hou et al. (2011) state that it is critical to measure the impact transparency information has on workload. Operator overload is a high-consequence problem that can be reduced with display designs that prioritize features to minimize visual clutter.

This HMI Testing was conducted in a virtual reality (VR) environment with a VR robot. Participants evaluated the VR robot in a VR environment simulated real-world use conditions.

Ten participants (adults) were recruited for the HMI VR Testing that was for two days. The participants worked one of three shifts for a warehouse. There were four sessions containing several scenarios in each session. At the beginning of session one, the researchers established a baseline with participants regarding their trust in robots and their comfort level through a one-on-one survey /interview.

Participants were instructed on how to put on and take off the VR headset. What sensations they might experience during their sessions in the virtual reality environment and what to do if the VR headset experienced technical difficulties, and what to do if they experienced uncomfortable sensations during the VR experience and wished to stop and remove the headset before the scenarios were finished for a session.

The researchers conducted four VR sessions to assess the proposed new VR robot's communication indicators, intent, likeability, and perceived safety. The researchers recorded objective and subjective data regarding participants' physical, psychological, and emotional reactions to the proposed new VR robot throughout the four sessions.

After the interactive VR sessions, researchers asked the initial trust and comfort baseline questions again. Participants were asked about the tasks completed with the new VR robot, their trust and comfort of robots in the workplace, and as a team member.

Results

The HMI Testing obtained the reactions and responses of 10 participants. 8/10 did not have a significant change in their trust in robots baseline responses. 9/10 participants showed overall trust in robots and their comfort and trust in working with the new proposed robot and the new robot's capabilities. Participant comments about suggested further robot improvements were gathered and accompanied the results.

How do we build trust between users and the robot?

The researchers discovered that the HMI testing was more about defining the borders of comfort rather than trust. There were large robots in the workplace already, although they had not worked with a robot or had a robot on their work team.

The workplace culture was tribally crossed with a sports club fan mentality. Participants were loyal to each other and the company; they were incredibly supportive and took care of one another as a team. However, if someone did not pull their weight, the team members told them they were letting down the team. Participants stated that they trusted the company and therefore felt that the company would only introduce a robot they could trust and work with productively and safely and would not put an employee in harm’s way.

How does the robot communicate its intent to users?

During the sessions, the VR robot would sometimes appear behind, in front, or cross in front of the participants. The researchers began with some fundamental indicators on the robot that mirrored the participants' mental model of a car. As the sessions progressed, the indicators became more sophisticated with sound, eyes on the robot, and gesture and movement. The participants reacted positively to robot communication indicators that were most familiar to them and were startled but not fearful by those that were not.

Motion or gesture was the number one indicator that alerted participants that the robot was in the environment. Additionally, participants noticed social cues before the robot approached, not during the interaction. When the robot was at a distance, the participants saw indicators and perceived the robot much sooner than the researchers had anticipated.

What do users intuitively expect from the robot in terms of behaviour?

Participants expected the robot to stop if it came too close and trusted it to move around an object or person safely. They expected an indication of the robot's intent, much like two people walking down the street and nodding at each other or looking in the direction of arrival to a destination. During Session four, participants expected the robot to know what the common task was and to be part of the team. After the robot teamwork interaction, most participants could see the feasibility of the robot being a team member.

How can we measure the positive or negative effects relating to trust as we test HMI variables?

Although researchers had developed a baseline process with an in-depth survey, observations, and interviews, the results from the first test were a shotgun spread (too many variables, very qualitative), and later tests were more specific to variables. As it turned out, the trust baseline survey and interview were more about exploring the effectiveness of trust rather than moving it from one point to the other.

Limitations

Participants evaluated the VR robot in a VR environment that simulated real-world use conditions and environment. All robot interaction was in VR, and no actual robot was used in this HMI Testing. It was not anticipated that the VR environment and VR headset would interfere with the testing objectives. Still, all instances of moderator intervention were noted and analyzed for impact on results.

Conclusion

This study investigated participant trust, comfort, responses, and reactions to VR robot communications and indicators in a VR environment. The HMI Testing obtained the physical reactions and verbal responses of 10 participants. Participant comments about suggested new robot improvements were gathered and accompanied the results.

This was the first time researchers had used VR for testing HMI for robot testing. During the preparation and later the testing, researchers discovered too many variables, and the feedback was primarily qualitative. For future testing, the researchers determined they would first address trust and comfort (psychology) and then concentrate on robot indicators for subsequent tests. Later tests were more specific to variables.

During the observation, researchers noticed the participant body language changes were correlated with the trust follow-up questions, and the responses would border more on comfort than trust. The workplace environment/culture was against institutional trust in a general baseline of trust in industrial settings for robots xxx. The participants trusted the company would not send in a robot as a team member that would hurt them. During the first session, participants tended to assess the robot early, from a distance, long before approaching. Additionally, the body language changed when the robot got closer or adjusted course; most participants wanted to trust the robot.

According to Yu et al. (2019), trust in a robot teammate is based on how the machine is designed, perceived, interacted with, and detected via the user decisions and perceptions.

The results generated from this HMI Test informed designers and engineers what worked and what did not work for the proposed new robot. Additional HMI Testing using VR is planned for the proposed changes for the new robot and future new robots and contemporary design and development features.

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