Research Statement

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The focus of my research in the computer sciences is Human Computer Interaction and my particular interest lies in the area of autonomous systems. This area is immensely interdisciplinary by nature--which is a major factor that has attracted me research interest in this direction--and is influenced by interface design theory, human psychology, as well as team dynamics. It was my original dual interests in studio arts and the computer sciences that combined into a pursuit of visual programming as a National Science Foundation researcher as an undergraduate at Cornell University. That led me to pursue graduate work in visualization at Brown University which led me to user interface work, user experience design, and user behavior research, in industry and my dissertation under Mark Billinghurst at the University of Canterbury investigating how human interface technology affected the formation of cognitive maps. This evolved into my current work with Human Machine Teaming and autonomous systems, from interaction with robots to self-driving cars. Within this space, there are three different directions I am following: (1) Understanding the factors that govern how users perceive and consequently interact with autonomous systems, (2) Creating interactive systems with behaviors that encourage more thoughtful interaction by users with autonomous systems, and (3) Investigating how user behavior with technologies affects interaction with autonomous systems in the real world.

Factors in Perception and Interaction with Autonomous Computer Systems

In my current research into Human Machine Teaming, I am concentrating on how human perception of machine teammates may be affected by the relationship formed between the human user and the robot teammate. While substantial work has been undertaken to understand trust-based relationship a human may have for a robot, relatively little work has been undertaken in the area of an empathic-based relationship and how it may impact upon collective human-robot performance. Work to date has focused on the possibility of inducing empathy in humans for their robot companions (see Darling, K., Nandy, P., & Breazeal, C. (2015); and Seo, S. H., Geiskkovitch, D., Nakane, M., King, C., & Young, J. E. (2015)) but those studies have been limited to the detection of induced empathy. Things get interesting when one looks at the consequences: Would empathy for a machine teammate affect human actions to the point that the ultimate success or failure of a mission be impacted? To gain insights into how people act differently as a result of empathic concerns for their robot companions, I designed an experiment to collect measures of decision consequences based upon induced empathy. The self-assessed surveys and simple measure of decision time did not seem to be a sufficient enough metric for the richer set of actions and consequences I wanted to measure and so I created a simulated mission where a virtual robot companion suffered damage every time it aided the user. I implemented it as a game-like simulation and logged the decision time and frequency of requested and accepted assistance from the robot. In this way, I was able to introduce a measure for the behavioral differences--and the associated consequences--between users presented with a robot that was viewed as a teammate against users presented with a robot viewed as a tool. Preliminary results suggest that user empathy would indeed limit their usage of a robot companion sustaining damage on their behalf but also that users would work harder to compensate for the reduced help rather than accept the diminished results. Such findings can have a direct impact in how HMT scenarios should be designed and how effective they may be given the potential relationship between the human and the machine. Manuscripts reporting the results are under review by ACM's Computer Human Interaction and APA's Technology, Mind, and Society.

Encouraging More Thoughtful Users

While the quantifying of HMT performance based on empathic perception may offer new insights, the treatment of computers with a certain degree of human perspective is not new and is rooted in the Computer are Social Actors Theory (see Nass, C., Steuer, J., & Tauber, E. R. (1994)) which proposes that we naturally anthropomorphize objects and so we will tend to treat them with a certain level of humanness. How such behavior can be harnessed, however, is a challenge. There is evidence that users may relate more with--and therefore have greater patience for--systems that exhibit human-like flaws (see, for example, Biswas, M., & Murray, J. (2017); and Salem, M., Eyssel, F., Rohlfing, K., Kopp, S., & Joublin, F. (2013)). Tying this to my current work with HMTs and the simulation platform, I am extending the simulation system to accommodate a model for exhibiting more human-like behavior in order to encourage empathy from human companions that may lead to more meaningful and thoughtful interaction and, in the case of robots, stronger relationships. In contrast to work where the capabilities of the computational systems are reduced or made faulty in order to introduce flaws in the system, I prefer to avoid curtailing compute power and so I seek to increase the scope of the problem space rather than deliberating mishandling existing situations in order to mimic human imperfections. Using a neural network Bayesian combination (see Simpson, E., Roberts, S., Psorakis, I., & Smith, A. (2013)), the simulation system will present potentially overlapping solutions in a manner that exhibits the dilemma of the machine in order to elicit greater empathy from the user, as suggested by the observations (see Zannato, D., Goslin, J., Patacchiola, M., & Cangelosi, A. (2017)). Such an effort can help us to identify the right amount of computational ambition to use with a suitable boundary for the domain of operation so that an ideal balance can be struck to optimize the relationship between human and machine teammates with respect to shared tasks.

Behavior with Autonomous Technologies

Designing a robot brain to be human-like in its limitations is a fascinating challenge but, in the realm of human computer interaction, it is when real users are interacting with the actual system that the rubber meets the road. In contrast to the simulation work I am undertaking, I am also investigating the real world tests of people interacting autonomous vehicles for the first time. While the notion of self-driving cars has been firmly integrated into the popular mindset, it has yet to be fully integrated into everyday life. Given the higher risk of operating a physical vehicle compared to, say, a laptop, the initial encounter can a critical one for properly understanding and suitably calibrating the user experience. As a counterpart to my HMT work in a simulated setting, the Tesla studies are designed to collect empirical data on how users feel and behave when control is relinquished to an autonomous vehicle that can literally kill people if something goes awry. How users generally interact with technology will be a highly relevant factor and my doctoral work classifying users based upon their usage pattern (see Wen, J., Helton, W. S., & Billinghurst, M. (2013)). With autonomous systems straddling the space between smart tools and self-deterministic entities, how users generally perceive interaction with others in a computer mediated setting will be relevant and I will build upon my work examining the surprisingly large discrepancies between what users perceive to be their ability to interact with others with how they actually behave in reality (see Wen, J., & Ünlüer, A. (2015)).

While HMT is my current focus, I am also interesting in expanding my research areas which has evolved from mobile pedestrian navigation tools to cooperative photography to human-robot interaction. With human interface technologies as a common thread, I intend to extend my work in new directions as well as continue my effort in areas I have already established. As an example, separate from my work in HMT, I am interested in exploring the use of machine learning to integrate user gaze in order to synchronize the display of musical scores for users who are occupied playing instruments and so unable to physically turn pages without interrupting their primary activity. Although there is a broad range of topics from which to pursue research, they all share the common thread of applying HCI foundations to the frontiers of computational systems which makes the field a continually refreshing and fascinating one for me.

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