Know Thyself: Self-aware Computing for Scaling Autonomous Personalization in Health and Robotics

Research Statement

Jasmine Berry, Ph.D.

The advent of Large Language Models such as ChatGPT and Bard sparked a call to action from a select group of researchers and brain-related technologists within the AI community; specifically to be cautious of the rapidly-growing architecture complexity and unexpected emergent behavior in AI systems. Self-aware computing, an area of research that once laid dormant due to the difficulty in examining the epistemological nature of the mind, is now gaining long overdue attention. Self-aware computing refers to systems that are capable of adapting to changing environments and conditions, potentially even predicting future needs or problems, and adjusting their behavior accordingly. One of the significant challenges in this field is making machines and agents more contextually aware of the surrounding variables. This awareness not only enhances how they perform in specific situations but also how they interact with humans and adapt to dynamic environments. For everyday consumer products, like smartphones and productivity apps, the aim is to develop agents capable of providing the appropriate support in any given context. Early evidence indicates self-aware computing has fundamental implications for practical applications in 1) Precision Medicine and Health, 2) Quantified Self, and 3) autonomous robotic systems.

Addressing the algorithmic processing needed in both personalized healthcare and human-robot interaction (HRI) through the lens of self-aware computing in autonomous systems presents a multifaceted challenge. The core problem we are tackling involves integrating the realms of artificial intelligence, robotics, and precision health to develop systems that autonomously gain diagnostic knowledge of themselves (with minimal human pre-programming) to subsequently become better equipped to understand and adapt to individual needs of others. The ultimate goal is to enable autonomous systems not only to make explainable decisions based on a vast array of parameters like health data, but also to incorporate an understanding of individual/user identities and preferences into these decisions.

The reason this problem hasn't been fully solved yet lies in the complexity of human health and the various sophisticated levels of personalization required for the innumerable classes of autonomous systems. Traditional prescriptive and diagnostic models in healthcare often follow a standardized approach, which falls short in addressing the unique aspects of each individual's fitness. My approach involves an interdisciplinary strategy, combining insights from computer science, robotics, cognitive science, psychology, neuroscience, and healthcare. We hypothesize that self-modeling and Theory of Mind processes can be adapted to health and HRI applications from the construction of 1) an artificial self (i.e., simulated internal model) that emulates a neuromechanical sensorimotor body representation (Berry & Valero-Cuevas 2020), 2) modeling edge potentials of local evidence and pairwise compatibility based on personal expectations of latent and observed variables (Desingh et al. 2019), and 3) more computationally efficient algorithms to build from the Markov Random Fields and Factor graph models. The intellectual merit of this proposal addresses two main challenges listed in Yang et al.'s (2018) report on Grand Challenges of Science Robotics: 1) building an artificial theory of mind to assist with robot-human social interactions and 2) bio-inspired robots that couple sensation and action based on natural processes to maintain autonomy in novel environments.

Among the hardest problems to solve is prompting explainable decision making while balancing the need for comprehensive data collection with privacy and consent. There's also the technical challenge of creating models innovative enough to accurately interpret the vast and varied forms of health data, from genomic information to lifestyle habits. Another major hurdle is ensuring that these systems are accessible, equitable, and device-agnostic, avoiding the creation of general usability across domains Lastly, there is the challenge of building trust among users - patients and healthcare providers alike - in these advanced, autonomous systems. Success in this research endeavor hinges on not just technological innovation but also on navigating complex ethical, social, and practical challenges.