University of Pittsburgh | School of Computing and Information

Proposal Defense

Doctor of Philosophy in Information Science

"**A Bidirectional Communication Framework for Task Goal Alignment in Human–Robot Interaction**" by **Lesong Jia**

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Committee:

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Abstract:
As motion planning and control continue to advance, robots are becoming increasingly capable of executing a wide range of tasks. However, achieving effective human–robot communication that ensures task goal alignment before execution remains a critical challenge for integrating robots into everyday life. This work aims to develop a user-centered, bidirectional communication framework that enables robots to interpret users' natural instructions while keeping users aware of the robot's understanding and planned actions. The framework comprises three interconnected components: feedforward communication, which guides users in formulating clear instructions to robots; multimodal instruction understanding, which recognizes and interprets users' natural inputs; and interactive feedback communication, which clarifies ambiguous instructions and explains the robot's planned actions. To develop this framework, the proposed research will begin with semi-structured interviews with potential users to understand their preferences regarding how instructions are delivered and how robots convey information. This will help establish a user-centered foundation for the overall framework design. Building on this foundation, the research proceeds in two complementary directions. The first focuses on the human-to-robot communication. Users' natural multimodal behaviors during instruction delivery will be collected and analyzed to develop an instruction-understanding model grounded in large language models for robots. This will help enhance recognition and interpretation accuracy. The second examines the robot-to-human communication. Quantitative user studies will be conducted to compare feedforward and feedback information presentation strategies that vary in content, density, and modality. The results will help establish design guidelines for feedforward and feedback interfaces that enhance effectiveness, trust, and user experience. Together, these efforts will advance embodied intelligence toward more fluent and trustworthy human–robot collaboration.