

Robot in the Loop: An Ethnography-Based Approach to Robotics and Reinforcement Learning to Support On-Site Construction Work

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Abstract

Construction is one of the world's largest and least automated industries, relying on the cooperation of multiple people with diverse skillsets in labor intensive, physical tasks. Since the 1980s, attempts to introduce robots into construction contexts have mostly focused on automating discrete tasks or monitoring site activities. In this paper, by contrast, we show how robots might be designed to adaptively support the cooperative work of construction teams. Following an indicative review of the state of the art in construction robotics, the paper shows how a detailed ethnographic study of construction workers shaped the design, development, and evaluation of a robot able to assist a team of carpentry workers by delivering tools and hardware during the installation of formwork panels. The resulting prototype is a building companion rover guided by state-of-the-art deep reinforcement learning (DRL) methods and an innovative social navigation stack. Through quantitative and qualitative evaluations in both lab settings and in a construction site, we show how the rover can support carpentry workers taking their specific workflow into account. By documenting these technical and conceptual contributions, we hope to bring "robotically-supported construction" into focus as a domain of interest for the construction robotics community.

Keywords: Construction Robotics, Human-Robot Interaction, Reinforcement Learning, Ethnographic Study

Declarations

Competing Interests: The authors have no competing interests to declare that are relevant to the content of this article.

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Data Availability Statement: Access to the ethnographic data that support the findings of this study is limited by Carnegie Mellon University's Office of Research Integrity and Compliance (ORIC). However, an anonymized dataset recording the authors' observations of construction tasks can be made available by the authors upon reasonable request and with the permission of CMU's Office of Research Integrity and Compliance (ORIC). In addition, a dataset created during the evaluation of the robotically-supported workflows can be made available by the authors upon reasonable request.

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