

## **Research Title:**

# **Teleoperation Interfaces for Last-Mile Delivery Robots**

## **Primary Investigator:**

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As e-commerce rapidly expands, the challenges associated with delivery are becoming more evident. Increased traffic, environmental concerns, and rising customer expectations have intensified the complexities of the delivery process. Customers now expect faster deliveries within tighter time windows, which adds pressure to last-mile logistics—a crucial but expensive stage of the delivery chain. Fully autonomous last-mile delivery robots (LMDRs) present a promising, sustainable solution to streamline deliveries. However, despite their advanced autonomy, it is widely recognized that in the near future, these robots operating in urban settings will frequently encounter situations that exceed their capabilities. This research investigates how to design the teleoperation interface for remote human operators, allowing them to effectively manage multiple delivery robots at once.

After a thorough literature review, we conducted interviews with local and international industry stakeholders in the ecosystem. The interviews were systematically analyzed using thematic analysis, summarizing the main challenges in LMDR operation. We then conducted a task analysis to better understand the remote operator's tasks. In the third year, we conducted a participatory design study to develop command menus for last-mile delivery robot teleoperation interfaces. The study was designed to elicit and develop a command language that can be used to remotely control an LMDR. In these workshops, we mapped remote operator tasks across intervention scenarios and organized commands using the card sorting technique. Participants identified 35 distinct tasks and 76 teleoperation commands across 12 scenarios, with moderate consensus on essential commands and their categorization. The findings provide insights for designing intuitive command menus for last-mile delivery robots. Finally, using this command language, as well as the insights gained from the interview study and the task analysis, we developed a design prototype for a remote operator's interface.