Software Variability in Service Robots (Summary)

Sergio García
Chalmers | Gothenburg University, SE

Daniel Strüber
Chalmers | Gothenburg University, SE
Radboud University, Nijmegen, NL

Davide Brugali
University of Bergamo, IT

Alessandro Di Fava
PAL Robotics, ES

Patrizio Pelliccione
Gran Sasso Science Institute (GSSI), IT

Thorsten Berger
Ruhr University Bochum, DE
Chalmers | Gothenburg University, SE

CCS CONCEPTS

• **Computer systems organization** → Robotics.

KEYWORDS

Autonomous and (self-)adaptive systems, service robots, variability, robotics software engineering

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1 SUMMARY

We present "Software Variability in Service Robotics" published in the Journal of Empirical Software Engineering (EMSE) in 2023 [2].

Engineering robotics software systems [1] is a booming discipline, with recent breakthroughs in AI that improve robots' capabilities to emulate human perception and intelligence, while operating in environments that are potentially unsafe or even hostile to humans. A trend are service robots—autonomous, mobile robots that can address meaningful tasks. For example, consider a disinfection robot for hospital rooms, which was developed during the COVID-19 pandemic by one of the subject companies of this paper. Service robotics presents a much more sophisticated challenge for software engineering than traditional, factory-automation type robots, due to several drivers of variability that inherently need to be reflected in software, and lead to variability management issues.

In our journal article [2] we survey the state-of-the-art and state-of-practice in software variability in service robotics. We present and triangulate the results from a systematic literature review and an interview suite conducted with eleven practitioners from three subject companies. The paper extends a previous workshop paper [3] that did not yet include the SLR and only two interviews.

We now summarize the results for our three research questions. The paper adds details within 38 observations, each paired with actionable recommendations for researchers and practitioners.

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RQ1: What are the drivers of variability in the service robotics domain? We identified three main classes of drivers: First, *environment*—to ensure robustness, service robots must be able to cope with different scenarios and map models, events, specific features of the environment (e.g., outdoors vs. indoors), and the inclusion of humans and uncertainty. Second, *hardware*—hardware variability arises from offered services, robotic capabilities, embodiment, and variying customer requirements. Third, *mission*—to support the specification of the desired goals of the robot, robotic software engineers need to account for variability in the expertise of the human operator, the means of human-robot interaction, and means to deal with both expected and unexpected events.

RQ2: What variability management practices—in particular, strategies and mechanisms—are applied by the companies to address the drivers of variability? To simplify variability management and software integration while keeping a sufficient level of customization to boost efficiency and effectiveness in operation, the abstraction level in robotics software needs to be raised. Planning and realizing variability for specific requirements and implementing robust abstractions permit robotic applications to operate robustly in dynamic environments, which are often only partially known and controllable. To this end, our companies use a number of mechanisms, some based on formalisms used to specify robotic behavior, such as finite-state machines and behavior trees [4].

RQ3: What challenges do service robotics companies face when managing variability? We identified the challenges our practitioners face when managing variability for service robots, and discuss their impact on our companies' development processes. Crucially, to foster software reuse, the service robotics domain will greatly benefit from having software components—decoupled from hardware—with harmonized and standardized interfaces, and organized in an ecosystem shared among various companies.

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