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Robotics Software Engineering: A Perspective from the Service Robotics Domain (Summary)

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Abstract: We present our paper published in the proceedings of the ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering 2020.
Robots that support humans by performing useful tasks (a.k.a., service robots) are booming worldwide. In contrast to industrial robots, the development of service robots comes with severe software engineering challenges, since they require high levels of robustness and autonomy to operate in highly heterogeneous environments. As a domain with critical safety implications, service robotics faces a need for sound software development practices. In this paper, we present the first large-scale empirical study to assess the state of the art and practice of robotics software engineering. We conducted 18 semi-structured interviews with industrial practitioners working in 15 companies from 9 different countries and a survey with 156 respondents (from 26 countries) from the robotics domain. Our results provide a comprehensive picture of (i) the practices applied by robotics industrial and academic practitioners, including processes, paradigms, languages, tools, frameworks, and reuse practices, (ii) the distinguishing characteristics of robotics software engineering, and (iii) recurrent challenges usually faced, together with adopted solutions. The paper concludes by discussing observations, derived hypotheses, and proposed actions for researchers and practitioners.

Keywords: robotics; software engineering; interview study; questionnaire study

1 Introduction

Service robots are a rising robotics domain with broad applications in many fields, such as logistics, healthcare, telepresence, maintenance, domestic tasks, education, and entertainment. Service robots are robots that performs useful tasks for humans or equipment (excluding industry automation robots). Compared to industrial robotics, the service robotics domain is more challenging, since these robots usually operate in unconstrained environments, often populated by humans, requiring high degrees of robustness and autonomy.

Despite software playing an ever-increasing role in robotics, the current software engineering (SE) practices are perceived as insufficient, often leading to error-prone and hardly maintainable and evolvable software. Robotic systems are an advanced type of cyber-physical system

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(CPS), made up of an intricate blend of hardware, software, and environmental components. SE, despite its beneficial role in other CPS domains (e.g., automotive, aeronautics), has traditionally been considered an auxiliary concern of robotic system construction. A possible reason is that robots in factory automation have built-in proprietary controllers for repetitive tasks, therefore, allowing a simple programming style. The heavy lifting is in the domains of mechanics, electronics, and automatic control. In contrast, to achieve autonomy when interacting in highly heterogeneous environments, service robots are equipped with a large variability of functionalities for perception, control, planning, learning, and multimodal interaction with the human operator [Ga19]. The integration, customization, and evolution of these functionalities give rise to a large amount of complexity, the management of which is a challenging task. SE systematic practices could play a crucial role in the management of such complexity.

Systematic studies about the specific software development practices and tools applied in service robotics as well as the challenges faced by practitioners in this domain are currently lacking. Towards this goal, our paper [Ga20] assesses the current SE practices applied to the domain of service robotics, as well as its distinguishing characteristics and faced challenges. To collect data, we conducted 18 semi-structured interviews with industrial robotics experts working for 15 companies from 9 different countries. We accompany this study with an online survey, targeting industrial and academic practitioners in the robotics domain, from which we collect 156 responses. To the best of our knowledge, our study is the first with this ambition.

Highlights from our results include the following observations: We discovered that roboticists are predominantly focused on implementation and real-world testing, often favored over simulation. We learned that robotic control systems are typically developed as component-based systems, implemented by developers who may come from different backgrounds (e.g., mechanical, electrical, or software engineers). We also elicited the main characteristics of robotics SE, where the cyber-physical nature of robots and the variety of disciplines required to develop a complete robotic system were highlighted. These characteristics increase the complexity of robots' control software, calling for systematic practices as modeling and the usage of software architectures to improve the development process. Our respondents ranked challenges related to robustness and validation as most pressing, and typically address them by applying thorough testing processes. Based on our observations, we also identify research themes that deserve further investigation. We provide conjectures for why these themes are currently under-investigated and recommendations for both researchers and practitioners.

Literaturverzeichnis

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