Towards system development processes for robotic applications

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ABSTRACT

The number of robotic applications that are being developed is increasing exponentially both in industry and academia. However, those applications do not have common system development process, what leads to the necessity of starting projects from scratch for most of the robot developers.

In this PhD project, we aim to produce a set of processes and architectural models and methods to be used by developers in order to improve reusability and modularity in robotic applications. In order to validate our results we make use of a set of service robots that will be employed for different case studies.

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1 INTRODUCTION

Service robots are invading human lives. They are increasingly used in environments such as houses, airports, hospitals, and offices for performing navigation, transportation, and manipulation tasks. The World Robotic Survey [5] estimated 35 million indoor service robots to be sold by 2018, accumulating a sales value of $12 billion since 2015. The global sales of household and personal robots is expected to grow by 23.5% per year [8]. This increase is accompanied with huge progress in robot technology, especially in image processing, planning, control, and collaboration. Software engineering is key to sustaining this new technology.

A robot typically performs specialized tasks; however, some tasks are highly complex and require a team of robots, whose capabilities (e.g., perception, manipulation, and actuation) are coordinated and supervised. Such teams also need to adapt to changes, such as of the environment, of the desired tasks, or of the robot (e.g., hardware failures). These demands drive the complexity of robot control software relying on appropriate software architectures. To tackle this complexity, we need to rethink design processes [6] by properly managing system integration and raising the abstraction levels, addressing qualities like evolvability [7], configurability [4], scalability, power consumption, and dependability.

The PhD project presented in this paper is involved in the Co4Robots [1] European project. Being part of this project allow us not only to formulate but also to validate our research questions in real-world scenarios.

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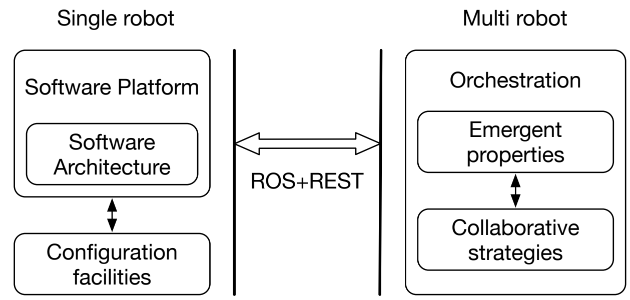

Figure 1: Overview of this PhD project.

Figure 1 depicts an overview of the work being developed for this project. There is an evident difference between two different approaches in robotic practices, that is when the robotic application puts to work an unique robot or a team of them. This division also splits the research schedule of this project in terms of time, as explained in the following. The "Single robot" subdivision of the overview represents the work already achieved and work in progress to be achieved in the near future. This subdivision contains the block of the *Software Architecture*, which is at the same time contained in the *Software Platform* block. The last mentioned block represents an additional layer for integrating the tools developed by researchers. Our platform must also be able to be customized by means of *configuration facilities*, which provide the required tools for configuring the basic platform both at design and run-time.

On the other hand, the future work that will be tackled once the single robot contents are already addresses is group in the subdivision of "Multi robot". The main expected outcome of this subdivision is to achieve the orchestration of a deployed team of potentially heterogeneous robots. In order to do so, issues as *Emergent properties* [2, 3] and selecting the most suitable *Collaborative strategy* Sergio ►*needed citation*◄ must be addressed.

Research Questions. In this project we divide robot applications between single-robot and multi-robot approaches. For this reason, we state the following research questions:

- RQ1 Which are the software engineering practices for single and multi-robotic systems?
- RQ2 Which are the applicable strategies to manage an heterogeneous robotic application?

Contributions. Our contributions are listed in the following:

1. Definition of a software architecture able to support a robotic team
2. Validation of the architecture in a real-world scenario
3. Implementation of a software platform where all the algorithms and tools developed can be plugged in

(4) Definition of configuration mechanisms to enable *start-up configuration* and *run-time configuration*
(5) Integration of an approach based on ROS+REST for the internal communication between robots
(6) Development of orchestration algorithms based on:
    (a) Response to emergent properties
    (b) Selection of collaborative strategies

Organization. In Section **??**, we introduce different works with a similar scope and position our research. Section **??** describes the research approach of the current work. Then, the next sections present the current state of our work in Section 2, future work and planned directions in Section **??** and it concludes with Section **??** with final remarks.

2 CURRENT STATUS

Currently, our main focus lays on the RQ1, learning, defining and differencing between software engineering practices regarding single-robot and multi-robot systems. Our software architecture, Self-adaptive dEcentralised Robotic Architecture (SERA) is already defined. As its name indicates, it supports a real-time decentralized robot coordination to accomplish missions with teams of robots. Furthermore, it is self-adaptive, responding to different changes by computing new strategies to achieve the desired goals. SERA was already tested during an Integration Meeting of the project, where it demonstrate that can support the performance of a robot achieving different complex missions —i.e. collaborative transportation with an human being, autonomous driving in a dynamic environment.

The aforementioned architecture follows the component-based style, so the main robotic functionalities are encapsulated in different modules or "components". All this components are developed abstracting the communication capabilities since we rely on the interfaces defined in the architecture. It not only significantly reduces the complexity of the code but also triggers the modularity of our system making possible exchanging the components that conform our architecture.

Since the components of our architecture are exchangeable our next step is to define configuration facilities in order to allow the customization of the robotic application during design-time or its self-adaptation at run-time. Sergio ►*cita a rosplug lib?*◄

Finally, the communication approach based on ROS+REST is already implemented, allowing the famous robotic middleware to share information between different robots in a decentralized way using services.

REFERENCES

[1] Co4Robots. 2017. Co4Robots. http://www.co4robots.eu/. (2017).
[2] Francesco Luca De Angelis and Giovanna Di Marzo Serugendo. 2015. *Logic Fragments: A Coordination Model Based on Logic Inference.* Springer International Publishing, Cham, 35–48. https://doi.org/10.1007/978-3-319-19282-6_3
[3] Francesco Luca De Angelis and Giovanna Di Marzo Serugendo. 2016. *Logic Fragments: Coordinating Entities with Logic Programs.* Springer International Publishing, Cham, 589–604. https://doi.org/10.1007/978-3-319-47166-2_41
[4] Nadia Gamez and Lidia Fuentes. 2013. Architectural evolution of FamiWare using cardinality-based feature models. *Information and Software Technology* 55, 3 (2013), 563–580.
[5] IFR. 2016. World Robotic Survey. https://ifr.org/ifr-press-releases/news/world-robotics-survey-service-robots-are-conquering-the-world-. (2016).
[6] E. A. Lee. 2008. Cyber Physical Systems: Design Challenges. In *ISORC*.
[7] Jennifer Pérez, Nour Ali, Jose A. Carsí, Isidro Ramos, Bárbara Álvarez, Pedro Sánchez, and Juan A. Pastor. 2008. Integrating aspects in software architectures: PRISMA applied to robotic tele-operated systems. *Information and Software Technology* 50, 9 (2008), 969 – 990. https://doi.org/10.1016/j.infsof.2007.08.007
[8] Colleen Sheng. 2016. Global Domestic Service Robots Market âĂŞ Size and Trends to 2020. https://www.alliedmarketresearch.com/robotics-technology-market. (2016).