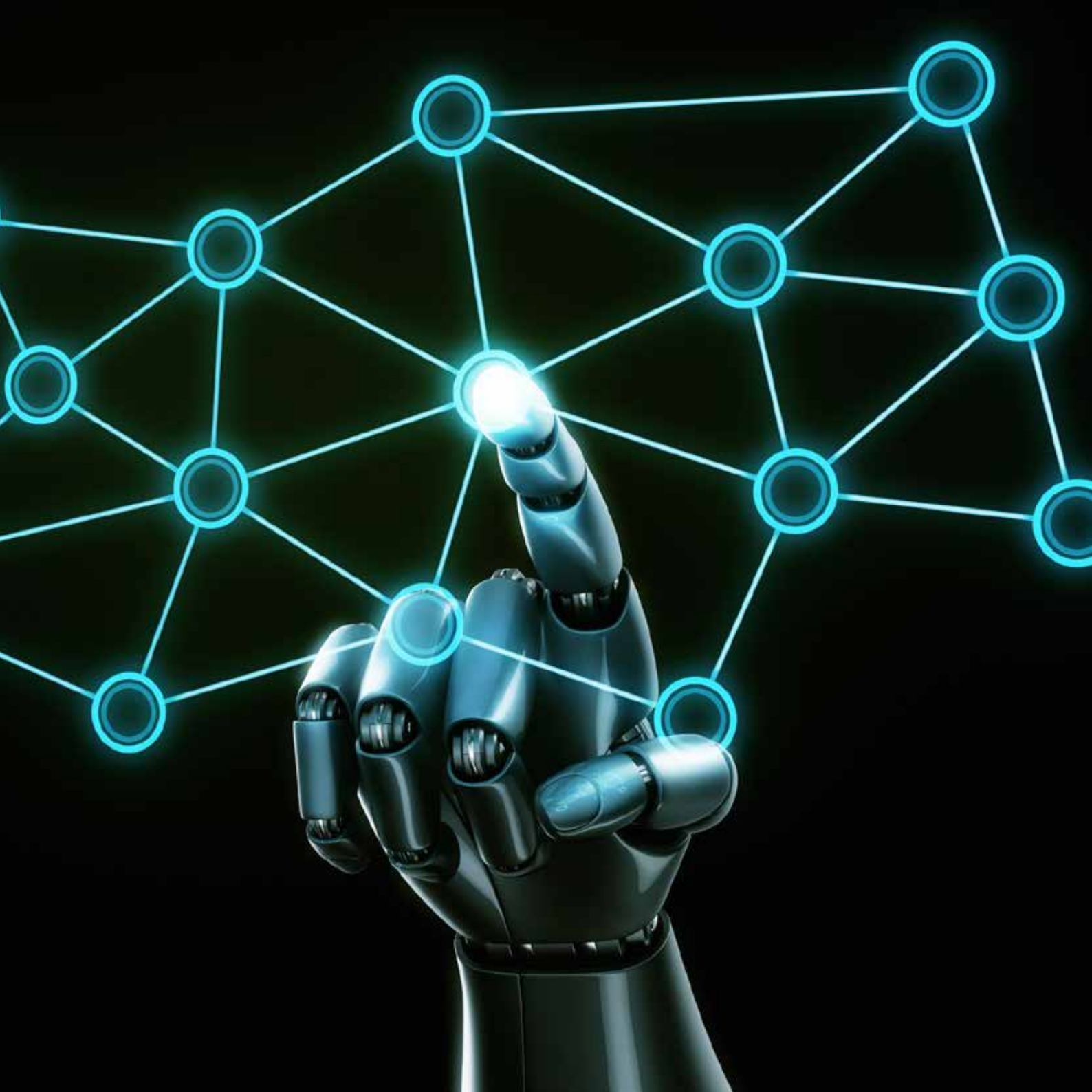
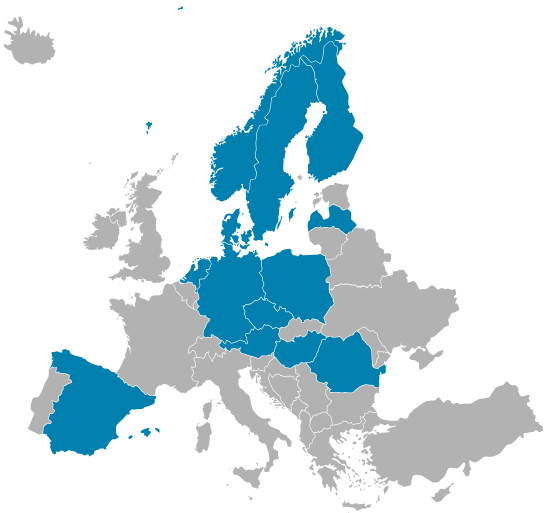


R5-COP
621447

Start date:	February 2014
Project duration (months):	36
Total investment:	€13.15 m
Number of participating organisations:	31
Number of countries:	13

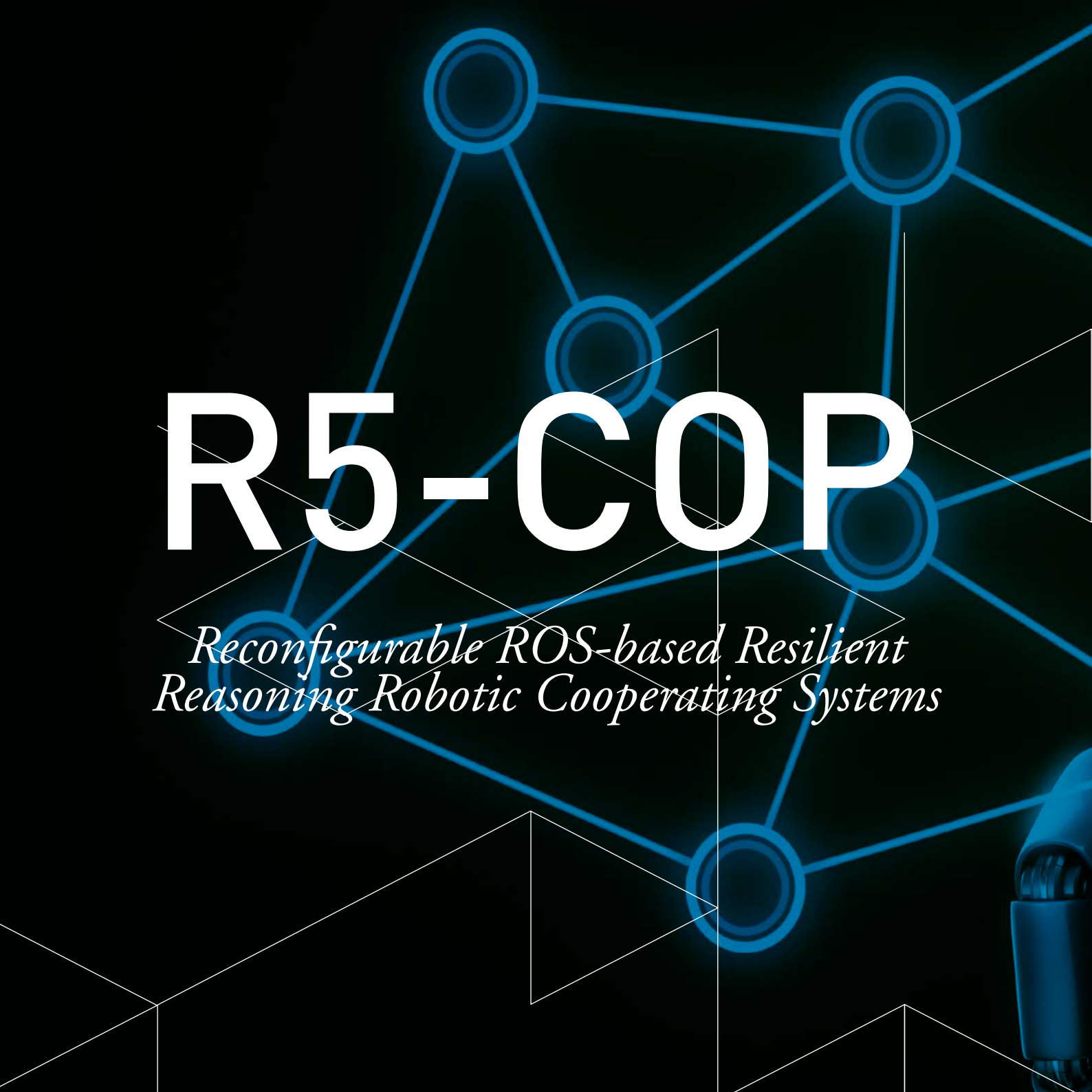
R5-COP focuses on agile manufacturing paradigms and specifically on modular robotic systems. Based on existing and newly developed methods for the formal modelling of hardware and software components, R5-COP will support model-based design, engineering, validation and fast commissioning. Using existing interface and middleware standards, R5-COP will be a strong facilitator of the integration of components from various suppliers.



MARKET INNOVATION AND IMPACT

The main objective of the R5-COP project is to provide the means for fast and flexible adaption of robots to quickly changing environments and conditions, and to enable safe and direct human-robot cooperation and interaction on an industrial scale. It aims to enable fast and flexible re-composition of software and hardware components of robotic systems, while ensuring robust and safe operation, through the modular design of components with formalised specifications and standardised interfaces. Standardised yet simple design and implementation of software components will be complemented by standardised yet flexible (re)configuration, using ontologies of configurable components for modelling hardware and modelling applications on an app or skill level. Dedicated verification and validation techniques will support component and system certification for safe human/robot cooperation, while dedicated use cases from industrial and service domains will identify, model, develop and evaluate key hardware and software components.

The focus on agile manufacturing paradigms, and specifically on modular robotic systems, will firstly identify and extend suitable existing methods and, where required, develop new ones to formally model hardware and software components. Using existing interface and middleware standards, such as ROS, will strongly facilitate the integration of components from various suppliers. Such a modular approach is not only flexible, but will also reduce design, setup and maintenance costs. Living labs will be employed to show the feasibility and capability in manufacturing and service demonstrator environments.


R5-COP
Reconfigurable ROS-based Resilient
Reasoning Robotic Cooperating Systems

Industrial robotic systems and recent developments in the area of service robots have opened a wide range of new application scenarios, especially where human/robot cooperation is required. However, the current state of the art still lacks suitable methods that enable easy adaption and reconfiguration of such systems, as it does not yet support straightforward and efficient engineering, set-up and deployment of them. →

The R5-COP project tackles these problems with a holistic approach, applied to various system levels.

PROJECT GOALS AND SRA CONTRIBUTION

R5-COP focuses on agile manufacturing paradigms and specifically on modular robotic systems. Based on existing and newly developed methods for formal modelling of hardware and software components, R5-COP will support model-based design, engineering, validation and fast commissioning. Using existing interface and middleware standards, R5-COP will strongly facilitate the integration of components from various suppliers.

R5-COP will be providing a platform and toolset containing methods, algorithms, prototypes and living lab solutions for cross-domain reusability, scalability and open interface standards for robotic and autonomous systems. It will contribute to the ARTEMIS Repository, by connecting to other ASP and AIPP initiatives, to ensure long-term sustainability and impact towards society. The key results of R5-COP will be demonstrated in a set of showcases, displaying high relevance to industrial and manufacturing issues and cross-domain applicability. Regarding interoperability, R5-COP will also contribute to establishing a standard for robust, reliable reconfigurable robot systems, using common interfaces in a certification and safety context, which entails conformity to both domain-specific and international domain-independent standards. By enabling the use of highly flexible robots in safety-critical (fenceless) environments, the project fosters a significant increase in market potential. The actual impact of R5-COP will be evaluated against its influences on the standards, scientific-technological viewpoints towards reconfiguration in SMEs and paradigm change towards using reliable, safe, and easily reconfigurable robotics.

PROJECT HISTORY AND FORMATION

To reach these ambitious goals, the R5-COP project builds upon the results of its ARTEMIS Call 2009 ancestor R3-COP, which particularly dealt with aspects of autonomous behaviour, most notably orientation and autonomous task-execution in a safe, resilient and fault-tolerant manner. In order to achieve wide applicability of the developed approaches, a software-modular approach was already employed, ensuring the successful application of core results in the project's wide variety of demonstrator platforms.

With R3-COP having successfully ended in October 2013, R5-COP – starting February 2014 for a 36-month period – picks up the modular approach and goes further, by introducing advanced flexibility. Featuring the use of the Robot Operating System (ROS) enables enhanced modularity, by the functionality being encapsulated in so-called ROS nodes (software modules) and ROS modules (hardware modules).

With 31 partners from 13 countries, R5-COP features an even bigger consortium than its predecessor. This is particularly noteworthy, given that R5-COP was struck with depletion of national funding in several partner countries, lowering the project's original planned budget by more than 42%. However, R5-COP was and is of the highest relevance, so a number of partners accepted participation at reduced, or even without, national funding. Where this led to vacancies within the project due to the accordingly reduced work effort, R5-COP was able to gain additional partners from other countries, not only filling these vacancies, but even taking over key roles within the project, hence furthermore emphasising the relevance of R5-COP's topics.

R5-COP INNOVATION AT A GLANCE

The European manufacturing industry faces increasing demand for high product variance, small product series, shorter production cycles and cost reduction. However, few robotic components are designed for easy adaptation and reuse. R5-COP focuses on agile manufacturing paradigms and specifically on modular robotic systems, to overcome the shortcomings

of the existing solutions. It starts by identifying and extending suitable existing methods and, where required, developing new ones to formally model hardware and software components. Since the flexible use of robots includes their close cooperation with humans, robustness and safety are crucial requirements, which will be assured by dedicated verification and validation methodologies. The formal specification framework will support component suppliers in efficiently verifying and certifying their modules. This project will help to identify and develop reconfigurable key hardware and software components, and to show the feasibility and capability of the approach in living labs in manufacturing and service demonstrator environments.

MAIN OBJECTIVES

The R5-COP project aims to provide the means for the fast and flexible adaption of robots to quickly changing environments and conditions, to enable safe and direct human/robot cooperation and interaction at industrial scale. To overcome the shortcomings of existing robotic solutions, it aims to enable fast and flexible re-composition of software and hardware components of robotic systems, and ensure their robust and safe operation through modular component design with formalised specifications and standardised interfaces. This will be complemented by standardised yet simple design and implementation of software components using ROS Industrial for software deployment and SDKs for software development. Standardised yet flexible (re)configuration will be achieved using the ontologies of configurable components for modelling hardware, and modelling applications on an app or skill level, while the use of advanced reconfigurable sensor systems modules will ensure robust perception. Component and system certification for safe human-robot cooperation will be assured by using dedicated V&V techniques and the identification, modelling, development and evaluation of key hardware and software components will employ dedicated use cases from industrial and service domains.

ARTEMIS SUB-PROGRAMMES

The R5-COP project addresses the ARTEMIS sub-programs ASP4 (“Embedded Systems for manufacturing and process automation”), ASP1 (“Methods and processes for safety-relevant embedded systems”), and ASP5 (“Computing platforms for embedded systems”).

In terms of ASP4, the sub-programme primarily addressed, it specifically relates to: improved methods and technologies for automation model life-cycle management; online real-time quality assurance of measurement data; robustness of sensor and actuator technology, e.g. calibration, energy harvesting, and disposability; automation system human-user interface context awareness and information timing; automated device configuration. Due to the delicate nature of robot and automation systems, there is strong focus on safety and security. Hence, the project also addresses core ASP1 topics, which are: requirement management; architecture modelling and exploration; analysis methods; component-based design, particularly building reliable systems out of unreliable components.

Technology-wise, it is closely tied to work in the field of ASP5, especially with respect to complex distributed heterogeneous systems supporting real-time awareness, safety protection and cyber-physical properties such as complex real-time sensor-data fusion. We aim to target ASP5’s main goal of enabling an increase of cross-domain re-use and interoperation, thus leading to lower costs of ownership and wider applicability.

Furthermore, R5-COP covers aspects of ASP8 with respect to human-centred design of human-machine interfaces, object recognition, scene analysis, real-time image processing and cognitive assistance. It is motivated by usage scenarios from ASP2, ASP3, and ASP6.

INITIAL PROJECT OUTCOME

One of the focal goals of R5-COP is "programming by demonstration". The concept that it proposes, as enabler of more flexible robotics, is the combination of imitation learning and reinforcement learning. Imitation learning is a method by which a robot learns new skills through human guidance and imitation. The purpose of imitation learning is to perform a task by generalising from observations. The power of imitation learning is that the robot is programmed in an intuitive way, while the insight of the teacher is incorporated in the execution of the task.

In this work, a combination of imitation and reinforcement learning is prepared for a grasping application in an industrial setting. The robot generalises movements from observations of human operators and optimises these for energy-efficiency and time using reinforcement learning. During the first months of the project, project partners Alten and TU Eindhoven presented initial ideas to a potential user, Philips Consumer Lifestyle, which adopted this as a serious use case to consider for future use in their shaver factory. One of the process steps in the production of a Philips consumer product is the painting of plastic parts. In the current situation, parts are placed manually on a painting carousel. There are several reasons why this process has not been automated yet: the parts are fragile and not easy to grasp, there are several different geometries, detailed visual inspection is required, and new parts are often introduced in the system. Using the proposed solution, the robot could directly learn an efficient grasping strategy from an operator, saving the time and expense of conventional reprogramming.

For the Vision and Robotics conference on 11-12 June 2014, co-organised with the RoboNED conference, in Veldhoven, Netherlands [1], project partner Alten prepared a workshop on the use of ROS Industrial (ROS-I) [2] . Its purpose was to introduce new users from industry to ROS-I, by means of a practical training. Furthermore, this event targeted potential users of the R5-COP project results, and informed them on its aims and objectives.

As one further example of ROS employment, the robotic platforms of project partner BUT are ready for running the latest ROS release (also known as Hydro Medusa). BUT is currently working on initial test bed set-ups for an indoor environment focused on house and workshop scenarios, with the goal of making the transfer of task solutions from simulation to real environment faster, easier and more effective.

[1] http://www.vision-robotics.nl

[2] http://wiki.ros.org/Industrial

Article written by Rainer Buchty, with additional input from Heico Sandee, Mark Geelen and Vítězslav Beran.

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