IMPACT

SMART ASSEMBLY ROBOT WITH ADVANCED FUNCTIONALITIES (SARAFUN)

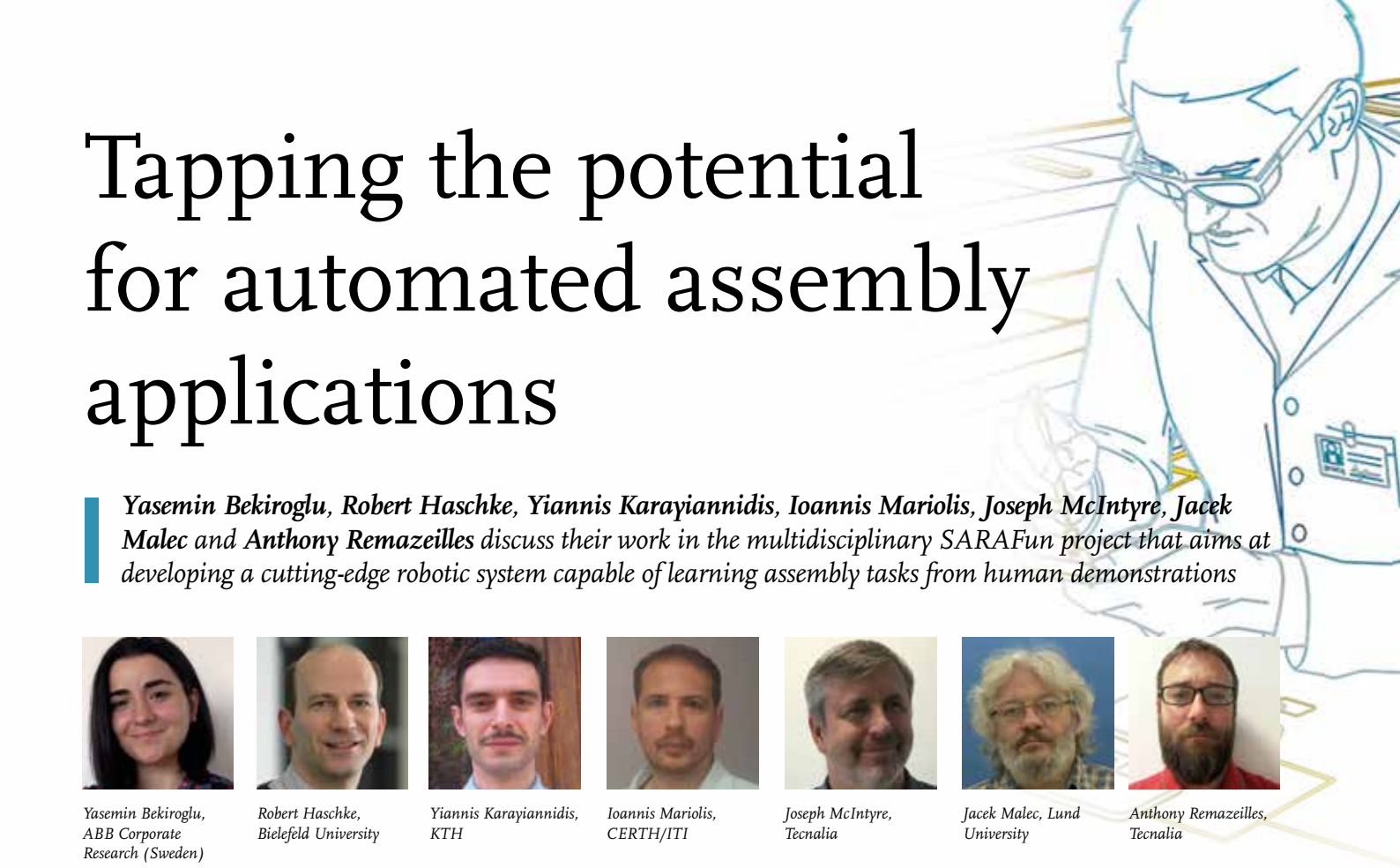
SARAFun

ABB

This project is funded by the European Union

HTTP://H2020SARAFUN.EU/

Tapping the potential for automated assembly applications



***Yasemin Bekiroglu, Robert Haschke, Yiannis Karayiannidis, Ioannis Mariolis, Joseph McIntyre, Jacek Malec** and **Anthony Remazeilles** discuss their work in the multidisciplinary SARAFun project that aims at developing a cutting-edge robotic system capable of learning assembly tasks from human demonstrations*

Yasemin Bekiroglu, ABB Corporate Research (Sweden)

Robert Haschke, Bielefeld University

Yiannis Karayiannidis, KTH

Ioannis Mariolis, CERTH/ITI

Joseph McIntyre, Tecnalia

Jacek Malec, Lund University

Anthony Remazeilles, Tecnalia

The project is divided into seven different Work Packages (WPs). What does WP2: Framework Design, Requirements and Human Studies Feedback involve?

JMcI: WP2 encompasses two main aspects of the SARAFun project. One was extremely practical. In a project such as this, with diverse players, it is important to remain focused on a common goal and it is important that all the pieces fit together at the end. Most of the tasks are related to defining the vision of what will be the SARAFun system at the end of the project in specific terms of end user requirements, system specifications and the human-machine interface that an operator would use to interact with the SARAFun robot. It includes common tools for representing task knowledge in a common framework for use within the SARAFun architecture.

AR: A unique aspect of WP2 is the inclusion of human studies within the SARAFun robotics research programme. SARAFun aims to teach a robot to perform assembly operations by simple observation; a trained operator would demonstrate the assembly task and the SARAFun system will automatically generate motor programs to drive the robot without the need for writing complex code. Understanding how humans perform assembly operations is pertinent in two ways for the success of the project. First, humans are adept at assembly and very robust. By understanding the control policies adopted by humans to perform these tasks, one can hope to generate better control policies for the robot in a bio-inspired approach. Second, in order for the robot to 'understand' what is being demonstrated, it is extremely helpful if the robot already 'understands' what kinds of operations the human may be performing. Thus, the measurement and analysis of human assembly activities can provide key information to inform on how robots can learn to perform assembly tasks just by watching a human.

Can you briefly summarise your research goals at Bielefeld University and describe your contributions to the project?

RH: At Bielefeld University we are striving to understand human manipulation skills and replicate them with dexterous robot hands. To this end, we cover a large variety of disciplines, including human studies, tactile sensors development, controller development (particularly tactile servoing), vision, machine learning and high-level reasoning, as well as systems integration. Within the SARAFun project we contribute with our expertise on tactile sensing and grasp planning. Namely, we proposed force sensors to enable slip detection for the YuMi hands and we develop an integrated framework for simultaneous grasp planning and fingertip shape optimization. Furthermore we are working on autonomous learning methods to improve robustness of grasp execution.

What role is KTH Royal Institute of Technology taking in SARAFun?

YK: KTH is responsible for leading WP5 of the project, which aims at designing control and estimation algorithms for bimanual two-part assembly under uncertainties. The main types of assembly considered in the WP are folding assembly and assembly via insertion and deformation. We are developing techniques that allow a bimanual robot to use its two arms employed with appropriately designed grippers by other partners in order to perform the assembly by using force-torque measurements or estimates. We have also investigated how behaviour trees, a high level control structure, can be used to execute and monitor assembly tasks.

Can you share a little about the role of Lund University in the project and the expertise it brings to the consortium?

JM: Lund University, with its expertise on force-based control of industrial robots and knowledge based instruction of industrial robots, plays an important role providing theoretical and practical tools for achieving the SARAFun goals. Force estimation is crucial to providing information to the system about the state of the assembly process. Lund University has developed a sensorless methodology for force estimation and extended it for the YuMi robot within the framework of WP5. Force estimation and force-based control are also of utmost

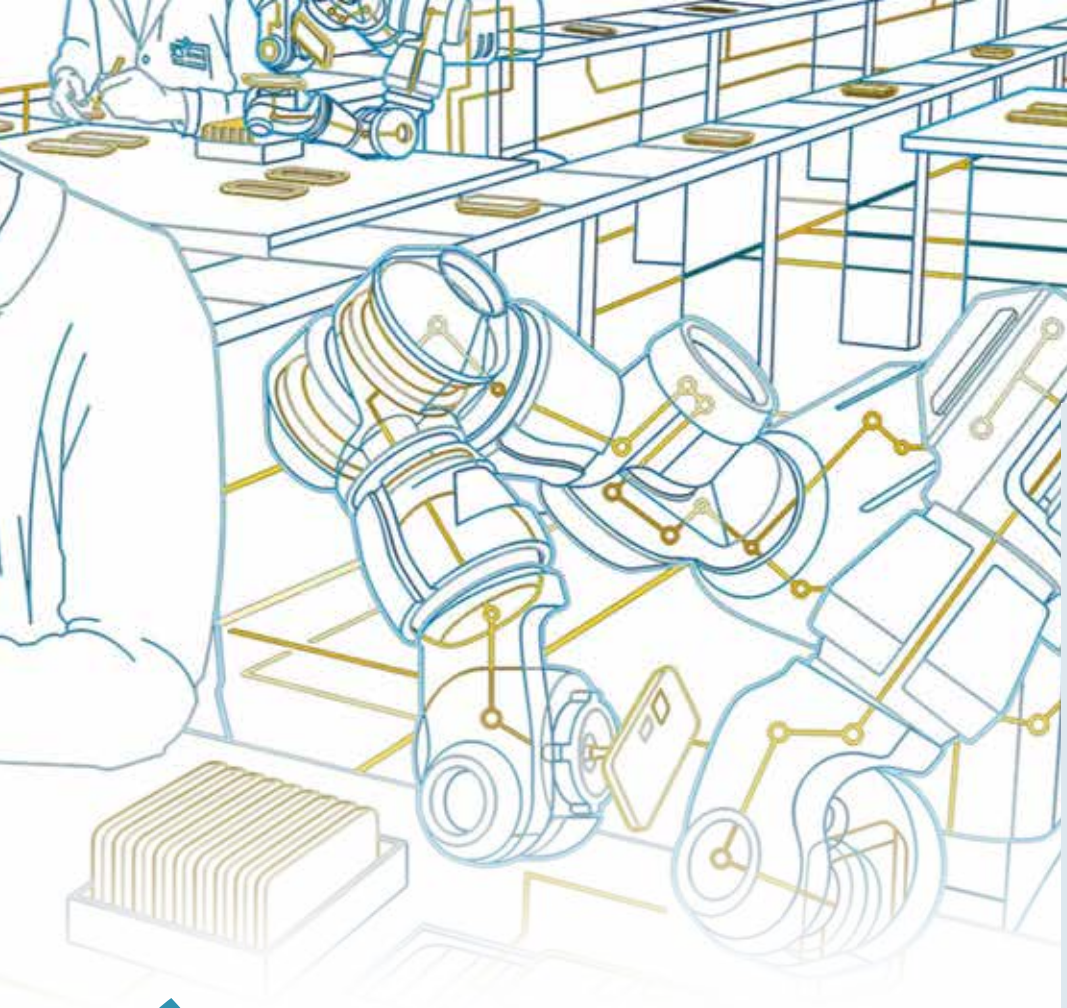


ABB has developed YuMi, a collaborative assembly robot that is expected to reduce integration costs significantly by offering a standardised hardware setup and simple fitting of the robot into existing workplaces

importance for 'leadthrough' (kinaesthetic) feedback necessary for development of an executable robot program within the limited time-frame. The knowledge base containing robot skills is called the Knowledge Integration Framework, which is used for reasoning about human demonstrations and for generating corresponding robot programs.

CERTH/ITI is responsible for two of the SARAFun WPs. Can you talk briefly about these and their aims?

IM: In the Teaching by Demonstration WP the necessary methods for enabling the robot to learn a new assembly from human demonstration are researched. Within this WP methods for reliable on-line motion generation are also developed, whereas graph representations for different contacts during assembly are formulated. CERTH/ITI is also responsible for the integration of SARAFun components into the ABB YuMi robot. The robotic platform has been installed into our robotics lab and the majority of the developed components have been integrated and tested. As part of the system's evaluation, live demonstrations of the system's capabilities are performed. A folding assembly scenario for two parts was demonstrated to EU reviewers during month 21 of the SARAFun project, whereas a more elaborate demonstration, including an insertion by deformation assembly, will be demonstrated by the end of the project.

With the project entering its final year, what are the key tasks you will be focusing on?

YB: We have successfully completed several demonstrations – a full integration where a human user shows a folding assembly task and our YuMi is able to mimic the same task using the designed system components, such as the human-robot interaction (HRI) interface, grasp planning, force control and also slippage detection, during our first review. In the second part of the project, we will focus on teaching bimanual assembly tasks, and components such as motion and force control for both arms, (self-)collision avoidance, physical HRI for learning by doing.

Project Insights

FUNDING

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 644938

PARTNERS

ABB Corporate Research (Sweden) • Centre for Research and Technology, Hellas/Information Technologies Institute (Greece) • KTH Royal Institute of Technology (Sweden) • Bielefeld University (Germany) • Lund University (Sweden) • Tecnalia (Spain)

CONTACT

Yasemin Bekiroglu
Project Coordinator

E: yasemin.bekiroglu@se.abb.com
W: http://h2020sarafun.eu/

PROJECT COORDINATOR BIO

Dr Yasemin Bekiroglu holds a PhD in Computer Science from KTH Royal Institute of Technology, Sweden. She conducted postdoctoral research there and at the University of Birmingham, UK, from 2012 to 2016. Bekiroglu was involved in several European projects including CogX, eSMCs, RoboHow and RoMaNs before joining ABB Corporate Research (Sweden) in 2016. Her research interests include robotics, computer vision and machine learning.

This project is funded by the European Union

Impact Objectives

- Enable a non-expert user to integrate a new bimanual assembly task on a collaborative robot in less than a day.
- Augment the robot with cutting-edge sensory, cognitive, and reasoning abilities required to learn, plan, and execute an assembly task.
- Develop a robot that is capable of learning and executing assembly tasks in a humanlike manner.

Teaching robots to learn for themselves

*The **Smart Assembly Robot with Advanced FUNctionalities (SARAFun)** project has been formed to enable non-expert users to easily and simply integrate a new bimanual task into a robotic system. The project's findings could significantly change the use of robots in the workplace enabling more efficient integration*

The 21st century has ushered in an era where humans are increasingly reliant on robots to perform a variety of tasks. For years now, robots have been used on production lines, for example assembling cars. However, despite the widespread success of industrial robots, automatic assembly still suffers from the time it takes to program and reprogram robots. In addition, it has proved difficult to find a means of integrating robots into the workplace where conditions do not necessarily repeat, causing unstructured variability. The field remains an area of untapped potential.

REDUCING INTEGRATION COSTS

To respond to these challenges, in early 2015 the highly innovative SARAFun project was established and funded through the EU's Horizon 2020 programme. It aims at empowering industrial robots with perception, learning, and reasoning abilities, providing tools to automate robot program generation and design of task-specific hardware. The main focus of the research is to enable robots to be trained and prepared for work on a new assembly task in less than a day. If this were achieved, it would significantly change industrial manufacturing and encourage a re-evaluation of assembly manufacturing in which robots can be used to lower costs and increase efficiency for products with relatively limited manufacturing runs or constantly evolving product designs.

This hugely collaborative endeavour, now in its final year, is being coordinated by Yasemin Bekiroglu from ABB Corporate Research in Sweden, and has already seen some notable successes. 'ABB has developed YuMi, a collaborative assembly robot that is expected to reduce integration costs significantly by offering a standardised hardware setup and simple fitting of the robot into existing workplaces' explains Bekiroglu. 'However, internal pilot testing has shown that integration time of new assembly tasks with YuMi, using a traditional programming approach remains long.' The team's next step is to conduct additional research towards enabling a complete integration of a new assembly task in a single day.

COLLABORATION AND INSPIRATION

To achieve its aims, SARAFun is composed of a team of researchers that have been gathered from ABB Corporate Research (Sweden) and leading academic partners and research institutes, including the Centre for Research and Technology Hellas/Information Technologies Institute, KTH Royal Institute of Technology, Bielefeld University, Lund University and Spain-based Tecnalia. The project has been divided into seven distinct Work Packages (WPs), to which the partners bring their specific expertise. As coordinator and the only industrial partner, ABB Corporate Research (Sweden) oversees all the WPs and maintains focus on real-life problems and solutions for manufacturing.

A key focus is on studying how human assembly workers learn and perform assembly tasks. By understanding this the researchers will then be able to model and transfer assembly skills. From there, the robot will learn assembly tasks, such as insertion or folding, through observing the task being performed by a human instructor. After analysing the demonstrated task, the robot will generate and execute its own assembly program. Based on the human instructor's feedback, the robot will be able to progressively improve its performance during execution in terms of speed and robustness. Ultimately, it is hoped that the YuMi robot will one day be capable of learning and executing assembly tasks in a humanlike manner.