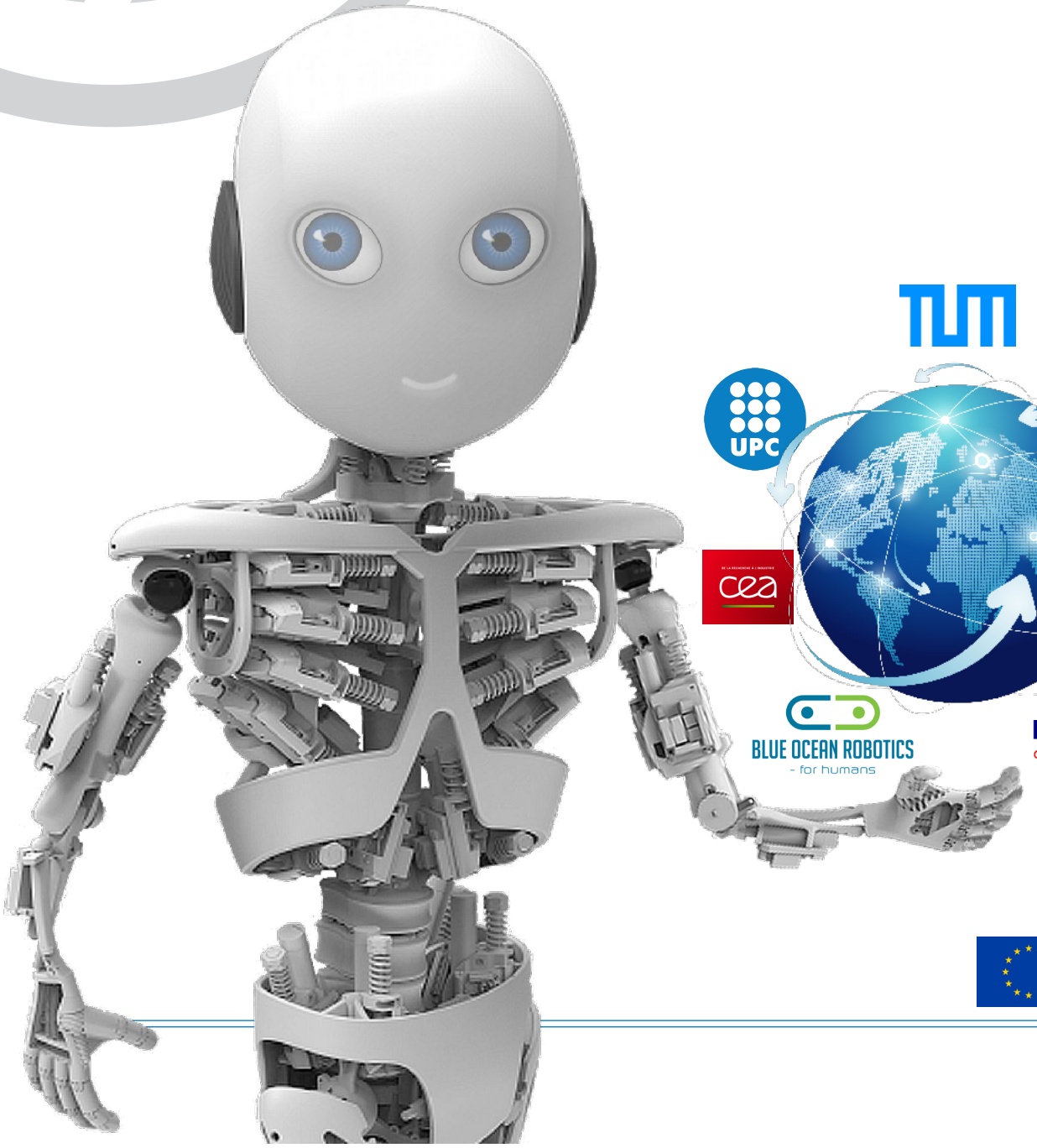
ECHORD++

The European Coordination Hub for Open Robotics Development

OVERVIEW OF THE EXPERIMENTS



SEVENTH FRAMEWORK PROGRAMME

INTRODUCTION

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ECHORD++ coordinator

Professor of Computer Science

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Department of Informatics
Technische Universität München

Europe has a long tradition of outstanding research and manufacturing in robotics. However, finding common ground between manufacturers and the research community has proven difficult in the past. Defining the future direction of robotics research is the real challenge.

To promote the fast uptake of robotics technology, the European-funded ECHORD project (European Clearing House for Open Robotics Development, 2009-2013) introduced a unique instrument to the landscape of European funding: The "experiments" – small joint academia-industry projects. With a **funding of 300.000 € per experiment** and a **runtime of 12 to 18 months**, this flexible new instrument made it easy to tackle the industry's burning technology needs. Allowing for cooperation between partners without the restrictions of EU-funded projects in terms of nationality (as long as the eligibility criteria of FP7 were respected), ECHORD facilitated the introduction of robotics technology into industry in more than 50 cases. More importantly, it filled a gap in the funding scheme of the European Commission – it can be regarded as the pilot of the „cascading funding model" introduced with Horizon 2020.

ECHORD++ (The European Coordination Hub for Open Robotics Development) will further stimulate the interaction between robot manufacturers, researchers and users. This goal will be achieved by implementing three different instruments: **the Experiments, Public end-user Driven Technological Innovation (PDTI) and the Robotics Innovation Facilities (RIF)**.

ECHORD++ once more targets some of the major barriers preventing the boost of robotics technology. The lack of testing facilities has been identified as one of the major handicaps of robotics. Particularly Small and Medium Enterprises (SMEs) or young start-ups cannot afford the technology needed to test the feasibility of new robotics technology. The RIFs provide free access to state-of-the-art robotics technology as well as the necessary support in terms of hardware and software expertise, legal advice, assessment of market potential for novel technology, etc. The RIFs offer a unique chance to try out new business ideas and make the field test with innovative technology **without running any financial risks**.

PDTI intends to motivate a user group with a tremendous leverage on the market: the public sector which can act as a **powerful first buyer for robotics technology**. Public bodies often have specific requirements for the products they use. ECHORD++ offers to both – the technology developers and the public authorities – the chance to closely interact with each other during the conception and development of the solution. This is to make sure that the product meets the requirements of the target group, technically and price-wise.

Continuing the tradition of ECHORD, 31 experiments are funded under ECHORD++. It is with great pride that we present this brochure, which provides **an overview of all experiments** that have been selected for funding from 251 submitted proposals, and which demonstrates the wealth of research conducted under the umbrella of ECHORD++.

ECHORD++ aims at creating new knowledge through advancing the state of the art and by developing novel technology from which new products may be derived. The intent is to act as a pioneer in new ways of community building for robotics and market creation.

Alois Knoll

Prof. Dr.-Ing. habil. Alois Knoll / ECHORD++ coordinator

STATEMENTS FROM ECHORD++ PARTNERS

„ECHORD++ enables a close cooperation between industry and academia with product focused experiments in small consortia. Through ECHORD++ a strong network of robotics specialists in academia and industry allows us to get in touch with the newest robotics technology.

The participation in ECHORD++ with a strong academic partner combines AGCO's knowledge in agricultural applications with state-of-the-art robotics research. This approach has the potential to bring robotics technology even closer to agricultural applications."

AGCO GmbH

„ECHORD++ gives us the opportunity to pursue interesting, focused advance development topics together with academic and international partners in areas where immediate commercial potential is still a couple of years away.

By these means, SMEs get the chance to pursue highly innovative topics and foster their collaborative network beyond day-to-day business."

ArtiMinds Robotics GmbH

„Participation in ECHORD++ is going to allow us to collaborate with the University of Modena and Reggio Emilia to develop new robotic solutions. This research activity would never take off without such a European support.

Being part of ECHORD++ will allow us to exchange information and experiences with other project participants, all of them being key players from their industry and academic world.

Additionally, comparing and getting inspired by different scientific and technical fields is certainly going to be the fuel for searching new solutions to be implemented for our business."

Corghi SpA

"ECHORD++ provides the opportunity to develop and test innovative machinery, which is of substantial importance for SMEs like us to maintain competitiveness.

The project is a good chance for the continuation of our several years long trustful cooperation with the University of Bremen."

Strauss Verpackungsmaschinen GmbH

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PUBLIC END-USER DRIVEN TECHNOLOGICAL INNOVATION (PDTI)

Public bodies often have specific requirements for the products they use. By acting as technologically demanding first buyers, public procurers can drive innovation from the demand side and promote the transfer of robotic technology to the market. The Public end-user Driven Technological Innovation (PDTI) scheme in **ECHORD++ offers research and development consortia the possibility to develop robots according to the needs of public bodies**. Healthcare and Urban Robotics have been identified as scenarios for which different public bodies have submitted their technology needs. Out of this pool, a panel of experts has selected two challenges: „Innovative technology for Comprehensive Geriatric Assessment (CGA)" in the Healthcare scenario and „Robots for the Inspection and Clearance of the Sewer Network in Cities" in Urban Robotics.

With the **financial support of ECHORD++** the consortia will develop the required technology in three competitive phases:

1. System design (duration 6 months, 3 consortia per scenario)
2. Prototyping (12 months, 2 consortia per scenario)
3. Small-scale test series (12 months, 2 consortia per scenario)

Innovative technology for Comprehensive Geriatric Assessment (CGA)

The Comprehensive Geriatric Assessment (CGA) is a diagnostic instrument designed to collect data on the medical, psychosocial and functional resources and problems of elderly patients. The information gathered is used to create an overall plan for treatment and follow-up.

Currently, CGA is performed by social and clinical professionals involved in the care of elderly people: physiotherapists, occupational therapists, nurses, social workers, psychologists, medical doctors, etc. Utilizing robotic technology to conduct geriatric tests will reduce the time medical professionals have to spend with purely mechanistic tasks (like documentation). Thus, they will gain time to developed individualized care plans for their patients. The possibility to assess and record the cognitive and physical status of a patient increases transparency and objectivity of the assessment. The interim results of the technology development will be evaluated in a geriatric hospital under natural circumstances.

Innovative technology for sewer inspection

Sewer inspections require many humans to work in risky and unhealthy conditions. Introducing a robotics solution in this process aims at reducing the labour risks, improving the precision of sewer inspections and optimizing sewer cleaning resources of the city, not only in terms of economic expenses but also in terms of water required for the cleaning process and of machinery needed.

The aspired solution should determine the state of the sewer in order to identify segments where the sewer's functionality has been reduced either by sediments or by structural defects. Other required functionalities of the technology include sewer monitoring and collecting samples of water, air and sediments.

ROBOTICS INNOVATION FACILITIES (RIF)

Robotics Innovation Facilities (RIFs) offer access to high-tech robotic equipment and expertise, the RIFs are open labs which provide state-of-the-art robotic hardware and software, as well as scientific and technical support. Anticipating market trends, the RIFs cover a wide range of application areas including agriculture, healthcare, logistics, and manufacturing.

The facilities offer their users the possibility to **improve processes**, to **investigate new products and services** and to **improve personal skills**. RIF users can try out new technology ideas and explore new, smart solutions.
Every company, institution, research organisation, etc. is eligible for a RIF engagement. **Users can come from all areas**, no matter how "unexposed" to robotics they were before.

An outstanding fact is that benefiting from the RIF comes at **zero risk**: a RIF engagement is not only **free of charge**, the RIFs also **safeguard your intellectual property**. The physical facilities are located at three of the ECHORD++ core consortium members' premises in the United Kingdom, France and Italy. Applying for a stay at the RIFs is easy and non-bureaucratic.

Realize your potential and accelerate your innovations to the marketplace – with the ECHORD++ RIFs.

RIF United Kingdom

Due to its longstanding contacts with partners from industry, the RIF located at the Bristol Robotics Lab (BRL) can provide support for applications geared to **cognitive workers and manufacturing**. The RIF in Bristol is particularly capable of supporting SMEs.

RIF France

The French RIF is run by the Institute for Smart Digital Systems of CEA (Commission for Atomic Energy and Alternative Energies) in Paris-Saclay. The key competence areas of this RIF are centered around **interactive robotics and manufacturing, logistics and transport**. Due to the longstanding experience with healthcare projects, CEA can also provide expertise in the area of **healthcare robotics** (surgery, assistive and rehabilitation robotics).

RIF Italy

Located at SSSA (Scuola Superiore Sant' Anna) in Pisa-Peccioli, the RIF offers a huge variety of testing facilities to try out **indoor and outdoor robotics, robotic technology for agricultural and logistics applications as well as medical robotics**.

RIF proposal submission is easy!

For more information go to **www.echord.eu/rif**

INDUSTRIAL COMPANIES INVOLVED IN ECHORD++ EXPERIMENTS

+ AGCO GmbH
+ Ansaldo NES
+ ArtiMinds Robotics GmbH
+ avular
+ C. Wright & Son Gedney Ltd.
+ Carl Cloos Schweißtechnik GmbH
+ CDD Ltd.
+ CHRU Brest
+ CM Labs
+ Corghi S.p.A
+ Eca Robotics
+ Ekymed S.p.A
+ Elettric80
+ Eurecat
+ Fabrica 136 Srl
+ Fastenica Srl
+ Flexible Robotic Solutions BVBA
+ Génération Robots Sarl
+ Humanware Srl
+ Idelt SL
+ Idrogenet Srl
+ IEMA Srl
+ Imer International SpA
+ INGRO Maquinaria
+ INSTEAD Technologies SL
+ IT+Robotics
+ Loccioni Group
+ Marsi Bionics SL
+ MOOG GmbH
+ Pilz GmbH & Co. KG
+ PreGel SpA
+ Refind technologies
+ RioTinto
+ RoboTech Srl
+ Robotnik SLL
+ ROBOX motion control
+ Scape Technologies A/S
+ Shadow Robot Company Ltd.
+ Stena Recycling
+ Strauss Verpackungsmaschinen GmbH
+ Vitirover SAS

ACADEMIC PARTNERS INVOLVED IN ECHORD++ EXPERIMENTS

+ Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC)
+ ATB Leibniz-Institut für Agrartechnik und Bioökonomie
+ Bielefeld University
+ CAR - Centro de Automática y Robótica (Universidad Politécnica de Madrid)
+ ceit - Centro de Estudios e Investigaciones Técnicas
+ Consiglio Nazionale delle Ricerche (CNR)
+ Czech Technical University in Prague
+ Danish Technological Institute
+ Dipartimento di Ingenieria dell' Informazione (DII)
+ Ecole Polytechnique Fédérale de Lausanne (EPFL)
+ Eingenössische Technische Hochschule Zürich (ETHZ)
+ Fraunhofer Gesellschaft / Fraunhofer IFF
+ Fundación Tekniker
+ Fundación tecnova
+ Hochschule Ulm
+ Hospital Sant Joan de Déu
+ Information Technologies Institute (iti)
+ Icelandic Institute for Intelligent Machines (IIIM)
+ Istituto di Scienze e Tecnologie della Cognizione (ISTC)
+ Istituto Italiano di Tecnologie (iit)
+ Karlsruher Institut für Technologie (KIT)
+ Katholieke Universiteit Leuven
+ Politecnico di Milano 1863
+ Sapienza Università di Roma
+ Seconda Università degli Studi di Napoli
+ SURO National Radiation Protection Institut (CZ)
+ Telecom Bretagne Institut Mines-Télécom
+ Universidad Miguel Hernández de Elche
+ Università degli studi di Modena e Reggio Emilia (UNIMORE)
+ Università degli Studi di Genova
+ Università di Bologna
+ Universität Bremen
+ University of Ljubljana
+ Wageningen University & Research

2F - FLOORING FELLOW

Runtime: May 1, 2015 - October 31, 2016

2F - FLOORING FELLOW

The Flooring Fellow (2F) experiment aims at introducing robotics in construction yards by developing a co-working robot for a specific function related to floor building: grout removing and floor cleaning with acid. The 2F approach starts from consolidated research and industry know-how in mobile robotics and construction equipment to design and develop a standard mobile robot endowed with tools commonly used in the building site sector to perform the requested task. The ultimate goal of the 2F experiment is to develop a new product for the building sector that will be introduced to the market one year after the experiment finishes.

The 2F robot's mobile base will be provided with a sponge system and a mechanism to apply proper sponge pressure. The system will be powered by a lithium battery, avoiding the use of heavy power cables, and the battery pack will be extractable and portable. Navigation sensors, an embedded control system and Robot Operating System (ROS)-based navigation software will give the robot a proper level of autonomy.

The system will also be provided with both autonomous and manual control mode: a user interface for tablet and smartphone will be developed for configuration, set up and control of the robot.

The use of 2F will have a direct impact on the entire working cycle related to flooring realization. It will decrease the risk of an electric shock for construction workers and expose them to less noise and vibration than current machinery. In total, the labour time needed for floor building will be reduced as well.

+ **Imer International SpA**, Italy *(Coordinator)*
+ **ROBOTECH srl**, Italy

www.echord.eu/experiments/3dssc

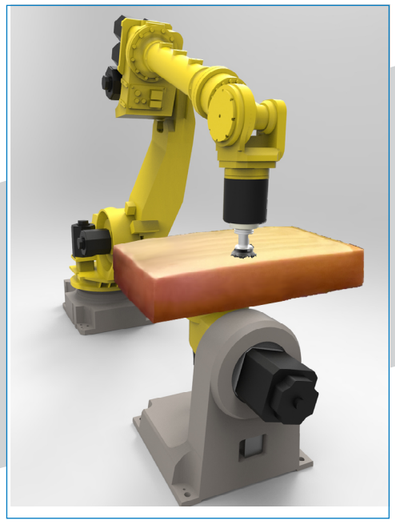
IMER GROUP

ROBOTECH

ECHORD++

3DSSC

Runtime: May 1, 2015 - October 31, 2016



3D Smart Sense and Control

This experiment addresses a real-life industrial application involving mechanical surface treatment of products or work pieces with different shapes. A typical example, encountered in the food industry, is to remove the coating from blocks of cheese with a shaving or planing tool. Automation of these tasks is desired because of labor cost, labor conditions, and the demand for further reduction of material losses which, for some applications, represent a high cost.

To automate this process with a performance comparable to the one achieved by human workers, the prototype will be based on cheap, fast and robust 3D sensing using a limited number of laser distance sensors, which are used to generate trajectories with minimal material loss for coating removal.

3DSSC aims at developing a working prototype and deployable software. Although the experiment focuses on an application in the food industry, applications in other industries will benefit from the results of this experiment. Particularly processes involving the treatment and finishing of complex surfaces like polishing, grinding, planing or deburring will profit from 3DSSC's results, thanks to the generic sensing and system architecture and the systematic software engineering approach.

+ **Flexible Robotic Solutions**, Belgium *(Coordinator)*
+ **Katholieke Universiteit Leuven**, Belgium

www.echord.eu/experiments/2f

FRS FLEXIBLE ROBOTIC SOLUTIONS

KATHOLIEKE UNIVERSITEIT LEUVEN

AAWSBE1

Runtime: September 1, 2016 - February 28, 2018

Adaptive Automated WEEE Sorting 1: Battery Extraction

Legislation regarding recycling – both to preserve resources and to reduce hazardous waste – puts strong requirements onto waste handling. The AAWSBE1 experiment aims to sort batteries inside Waste Electrical and Electronic Equipment (WEEE). It will detect potential battery-containing items from residuals in a WEEE small electronics stream, as well as presort battery streams for more efficient recycling of the batteries.

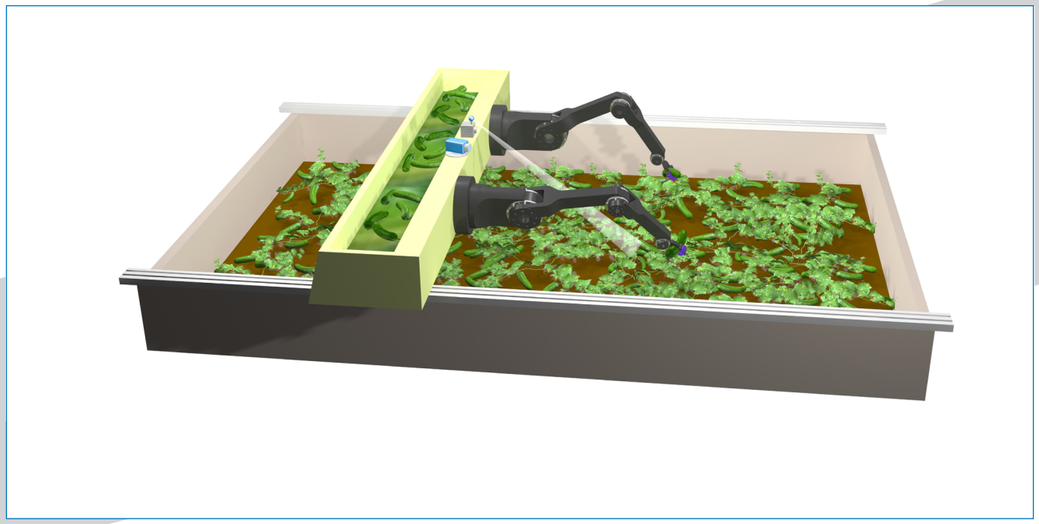
The AAWSBE1 system will be adaptive, responding to e.g. new items appearing, changes in item value, both successful and failed picks, conveyor movements and settling. It will be designed to work as an individual sorting station in a line, with either manual or robot sorting stations, capable of either working alone or of integration into a cognitive factory.

+ **Danish Technological Institute (DTI)**, Denmark *(Coordinator)*
+ **Refind Technologies**, Sweden
+ **Stena Recycling**, Sweden

www.echord.eu/experiments/aawsbe1

CATCH

Runtime: September 1, 2016 - February 28, 2018



Cucumber Gathering – Green Field Experiments

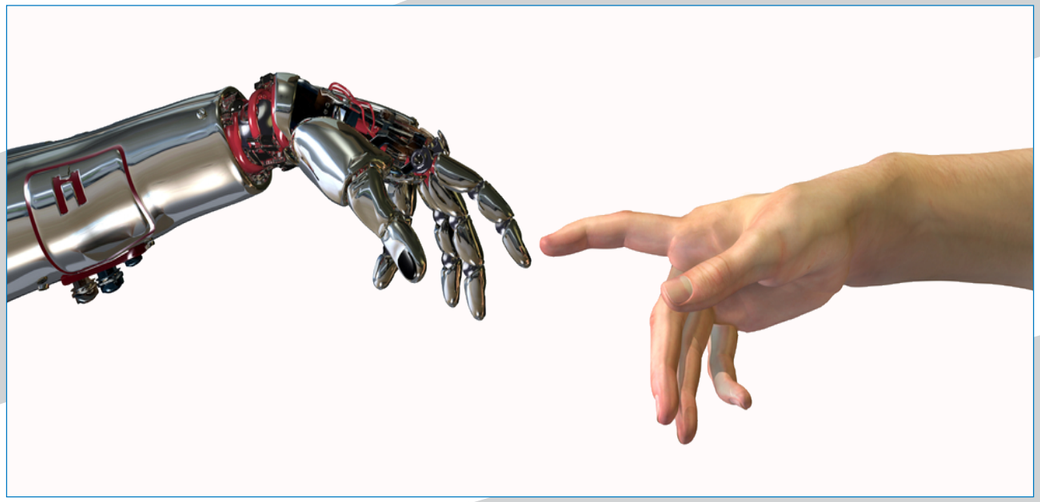
The CATCH experiment explores novel, lightweight, modular and cheap, nevertheless robust multi-arm robotic systems, built of standardised components, providing economic basis and use cases for agricultural applications. It aims at developing a flexible, cost-efficient and reconfigurable/scalable hortibotic outdoor solution for automated harvesting in challenging natural conditions by addressing critical problems, such as fruit perception and fast picking actions. The use case of outdoor cucumber harvesting has been selected taking into account the need from relevant end-users, the technological challenges, as well as the economic impact in various European regions.

+ **IPK Fraunhofer**, Germany *(Coordinator)*
+ **CSIC-UPM Centre for Automation and Robotics**, Spain
+ **Leibniz-Institut für Agrartechnik und Bioökonomie Potsdam-Bornim e.V. (ATB) Technik im Gartenbau**, Germany

www.echord.eu/experiments/catch

COCOMAPS

Runtime: September 1, 2016 - February 28, 2018



Collaborative Cognitive Maps

The experiment CoCoMaps uses an expanded version of the existing Cognitive Map Architecture implemented on Honda's ASIMO robot in an environment with more complex tasks than already attempted. This will allow the robot to interact in more complex ways, in particular, to simultaneously interact with another robot and more than one person at a time. Thus, the project aims for a group of 2 robots and 2 humans. These systems will enable social interactions that can coexist with the robots' attention to – and completion of – practical tasks in the workplace. A particular focus is on human detection and tracking algorithms and on an improved dialogue system.

The principal components of the dialogue system, as targeted in this demonstration, have been validated piece-wise in laboratory settings, and some subsystems have been demonstrated to work in combination; a finally unified, fully integrated whole remains to be demonstrated and is thus targeted here. Deployment in a single robot has performed well, whereas the whole remains to be demonstrated in simulation.

The aim of the project is :

+ Improve natural human-robot communication & collaboration
+ Working together on task specification and completion
+ Based on real-time dialogue skills
+ Cognitive model of turn-taking, knowledge and goals information
+ Task-oriented coordination of multi-party task completion
+ Using conversational dialogue to obtain and convey information

+ **CMLabs- Communicative Machines**, United Kingdom
+ **IIIM – Icelandic Institute for Intelligent Machines**, Iceland

www.echord.eu/experiments/cocomaps

COHROS

Runtime: January 1, 2015 - June 30, 2016

Cooperative Programming for Highly Redundant Robot Systems

Nowadays, robotic systems are used for industrial applications like welding, grinding or varnishing of large work pieces. The robots in question are highly redundant systems with up to 10 or more degrees of freedom, which allows these robots multiple configurations and a wide range of possible movements. Such systems are used in the industrial production of, for example, earthmoving equipment, agricultural machines or automobiles. However, programming these systems is tedious, costly and needs highly specialized expertise, which is an important factor to achieve a reasonable return on investment for automation.

Current programming is mostly based on recording of a large number of key-frames that are obtained by manual operation of the robotic system. This is typically done by domain experts that are neither roboticists or mechanical engineers. To develop an application in a typical complex welding scenario, up to several thousands of such key-frame postures are collected in a tedious step-by-step procedure.

The experiment CoHRoS intends to develop a practical and robust method for assistive teaching, meaning the robot will learn and generalize from few demonstrations provided by the programmer. The results will redefine and advance the state-of-the-art programming for highly redundant (high degree of freedom) robot systems. The experiment will contribute in adapting and advancing methods to structure interactive programming for those systems where it is not easily possible that a human is performing the motions which the robot then has to repeat.

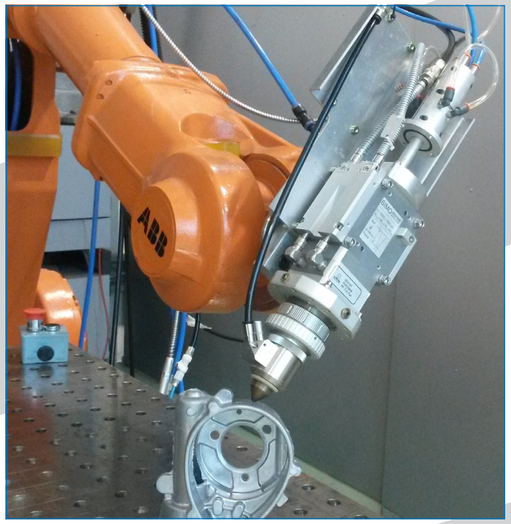
The project will benchmark success of the developed method based on a real, marketable application provided by Carl Cloos Schweißtechnik GmbH, a leading welding robot systems producer and application developer.

+ **Bielefeld University**, Germany *(Coordinator);* Cor-Lab
+ **Carl Cloos Schweißtechnik GmbH**, Germany

www.echord.eu/experiments/cohros

DEBUR

Runtime: May 1, 2015 - October 31, 2016



Automated robotic system for laser deburring of complex 3D shape parts

Die casting is a manufacturing process used for producing large volumes of parts of light alloys, such as aluminium, zinc or magnesium alloys. Among the finishing operations, the deburring process is a key step, whereby raised edges or small, unwanted pieces of materials attached to the part are eliminated.

With the currently used cutting press machines the cutting sometimes is imprecise, therefore it is necessary to include other steps in the finishing of the parts. These steps like in spection, review and manual deburring and sanding with abrasive tools make the deburring stage more costly. Furthermore, the need to manufacture cutting dies and tools for the various possible shapes of the parts as well as the wear that these cutting tools suffer after several production cycles produce further costs.

The DEBUR experiment is dedicated to the design and set up of an automated robotic station for laser deburring of metal castings of three-dimensional, high-quality, complex parts. In particular, it is intended to develop a flexible, low-maintenance and environmentally friendly prototype, able to improve the quality, cost and cycle time of finishing operations of aluminium-injected components.

+ **Fundación Tekniker**, Spain *(Coordinator)*
+ **Idelt SL**, Spain

www.echord.eu/experiments/debur

IK4 TEKNIKER Research Alliance

IDELT Prototype Engineering

DEXBUDDY

Runtime: January 1, 2015 - June 30, 2016

Dexterous Robotic Co-Worker

DexBuddy will show overall cost reduction in automotive manufacturing tasks by using a flexible gripping device in combination with advanced intuitive programming.

DexBuddy is an ambitious system integration experiment to test the feasibility of easily programmable dexterous robotic co-workers performing highly dexterous tasks in real industrial scenarios – specifically, cable manipulation tasks in manufacturing, bringing together key skills from 4 partners to produce a novel system.

DexBuddy will combine an innovative hardware prototype (Shadow's new Hand Lite dexterous hand) and an innovative software product (ArtiMinds's software suite enhanced to integrate dexterous hands) with KIT's vision know-how to produce a novel robotic solution (integrated by the experts from Loccioni Group) for industrial automation challenges based on real customer demand.

DexBuddy will demonstrate how the power of visual 3D-perception as well as flexible online motion planning and control can be leveraged in domains with high task complexity, beyond simple bin picking. Currently, such application areas are inaccessible to robotics because of the complexity of defining motion planning and control task descriptions for specific applications as well as the flexibility limitations of standard grippers. Pushing the flexibility of industrial robots further towards the ability of human workers will allow for improved coexistence and collaboration of robots and human workers. Automation and skilled manual labour will be more seamlessly combined.

DexBuddy will help to unlock novel automation applications for European manufacturing, integrating robots tightly with skilled manual labour, reducing costs and increasing productivity by making flexible re-commissioning accessible for medium-skilled workers.

+ **ArtiMinds Robotics GmbH**, Germany *(Coordinator)*
+ **Karlsruher Institut für Technologie (KIT)**, Germany
+ **Loccioni Group,** Italy
+ **Shadow Robot Company Ltd.**, United Kindom

www.echord.eu/experiments/dexbuddy

ARTIMINDS ROBOTICS

LOCCIONI

KIT Karlsruhe Institute of Technology

Shadow Robot Company

DUALARMWORKER

Runtime: June 1, 2016 - November 30, 2017

Dual-arm robot closed kinematics chain motion planning for flexible industrial components assembly

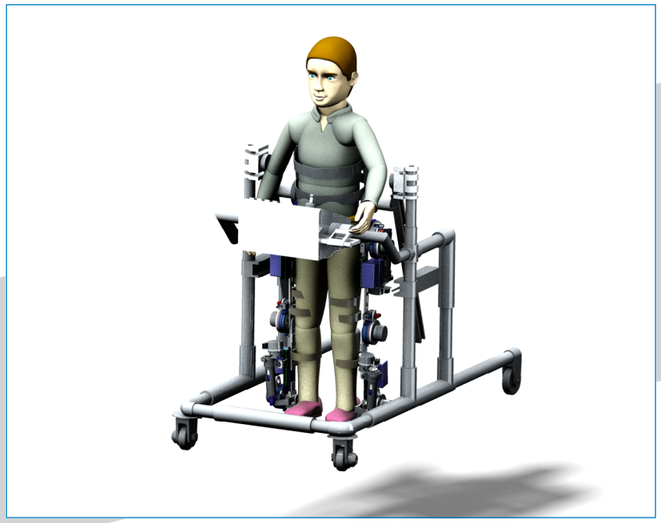
Humans can manipulate things using two hands in an easy way due to great joint flexibility, advanced tactile sensitivity and the ability of sliding the objects on their hands to naturally find the optimal grasp and movement configurations. Actual robots are much more primitive using these kinds of sensory skills. When a robot grasps one object with one arm, the object is rigidly attached to the arm and it can move and place it with fabulous precision and strength but it cannot slide the object and re-grasp it to find better joint configurations depending on the movement. When a dual-arm robot grasps an object with two arms, the process to find an optimal joint configurations becomes a very challenging job. DUALARMWORKER will target and solve this key issue to the real use of dual-arm robots in assembly operations: the planning and execution of complex closed kinematics chain dual-arm motion, constrained not only by the manipulation of parts that require both hands to be held and manipulated but also by the production station environment with low accessibility and static/dynamic obstacles. No industrial software or open source library available today allows these capabilities.

+ **LAAS – CNRS**, France *(Coordinator)*
+ **Tecnalia**, Spain
+ **AIRBUS**, Spain

www.echord.eu/experiments/dualarmworker

EXOTRAINER

Runtime: May 1, 2015 - Ocober 31, 2016



Clinical Evaluation of Gait Training with Exoskeleton for Children with Spinal Muscular Atrophy

EXOTrainer introduces wearable gait exoskeletons for the therapy of children affected by Spinal Muscular Atrophy (SMA). SMA is caused by a genetic defect, the disease manifests in various degrees of severity, which all have in common progressive muscle wasting and mobility impairment.

Although it is a rare disease, SMA is the most common genetic cause of infant death. There is still no known cure for SMA, treatments mainly focus on maintaining the physical state of the patient, as well as on attempting to delay the onset of side effects like a deformation of the spine and the loss of range of motion. Walking is the key to retard the evolution of these side effects and EXOTrainer is expected to provide an improved therapy approach through wearable gait exoskeletons.

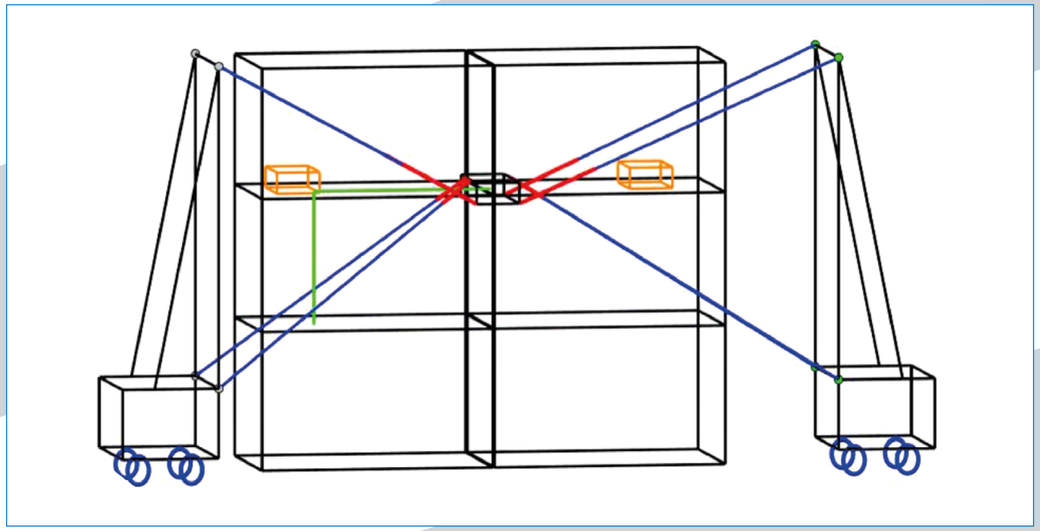
EXOTrainer builds on available technology, addressing children as a new target group, particularly because current commercial devices are targeted to adult paraplegics. EXOTrainer will improve the quality of life of children affected by SMA and increase their life expectancy. The new therapy can potentially relieve each family of up to 25.000 € spent on welfare costs per year. It may even reduce expenditures of the healthcare systems through an improved and personalized therapy.

+ **Consejo Superior de Investigaciones Científicas (CSIC)**, Spain *(Coordinator)*
+ **Hospital Sant Joan de Déu**, Spain
+ **Marsi Bionics**, Spain

www.echord.eu/experiments/exotrainer

FASTKIT

Runtime: September 1, 2016 - February 28, 2018



Collaborative and mobile cable driven parallel robot for logistics

The objective of project FASTKIT is to provide a low cost and versatile robotic solution for logistics using a unique combination of mobile robots and Cable-Driven Parallel Robot (CDPR). The FASTKIT prototype addresses an industrial need for fast picking and kitting operations in existing storage facilities while being simple to install, maintaining existing infrastructures and covering large areas.

For the past 5 years, automated technical solutions for picking have been emerging in the areas of production or logistics. The Fastkit robot presents a new technical solution that could help to bring more flexibility and versatility compared to existing solutions.

Innovative features of the project:

+ Reconfigurability (depending on warehouse/ factory) and flexibility (height, payload, speed)
+ Lightweight and robust structure
+ Low investment cost
+ Mobile CDPR

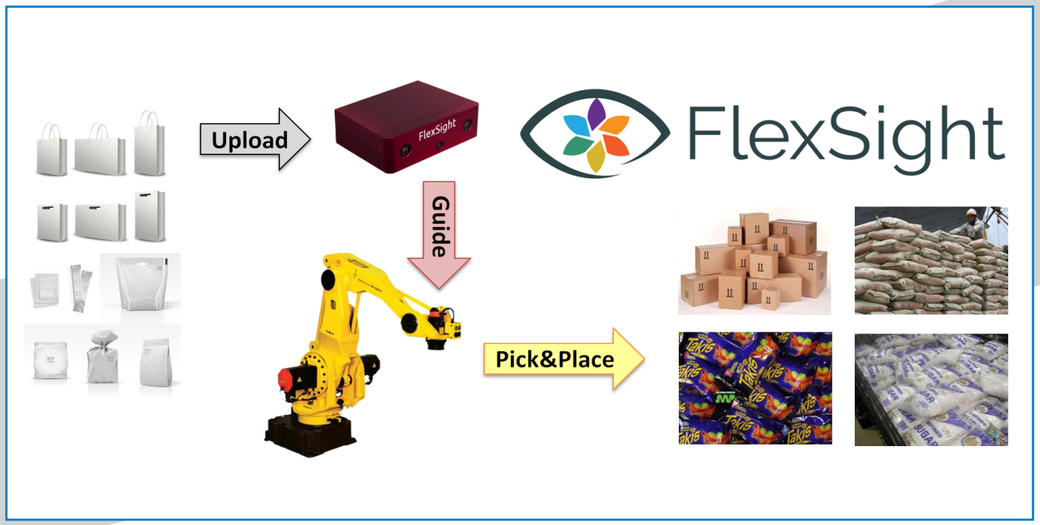
FASTKIT targets industries in the logistics industry but also enables intra-logistics operations within the retail automotive or aeronautics industries, where kitting bins have to be prepared. In fact bin picking algorithm and specific manipulators effector have to be developed for the automation of kit preparation. In order for the FASTKIT solution to be viable on the market, it would have to be adaptive to the needs of several industries.

+ **IRT Jules Verne,** France *(Coordinator)*
+ **CNRS**, France

www.echord.eu/experiments/fastkit

FLEXSIGHT

Runtime: September 1, 2016 - February 28, 2018



Flexible and Accurate Recognition and Localisation System of Deformable Objects for Pick&Place Robots

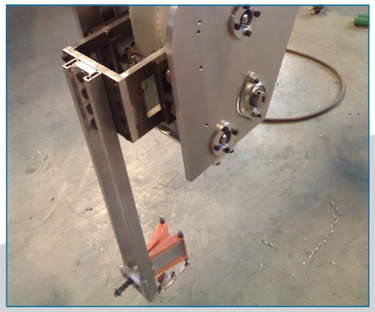
The FlexSight experiment aims to provide a robotic solution for the “pick&place” class of applications with rigid and deformable objects. The project focuses on building a prototype smart camera – the FlexSight Sensor (FSS) – which can be integrated in the chassis of an existing robot to empower it with detection and localisation capabilities. The main objectives of the FlexSight experiment are: (1) Enable a robot to perceive a large and widespread class of rigid and deformable objects in an accurate and reliable way, with a particular emphasis on the computational speed of the whole system. (2) Implement a prototype of a compact industrial sensor (the FlexSight Sensor, FSS), that integrates all the required sensing and processing needed to run the detection and localization algorithms inside a robust and small chassis. (3) Integrate the FSS within a working system that will be tested in several industrial and logistic use cases.year. It may even reduce expenditures of the healthcare systems through an improved and personalized therapy.

+ **Sapienza University of Rome**, Italy *(Coordinator)*
+ **Robox S.p.A. Roberto Montorsi**, Italy
+ **IT+Robotics S.r.l.**, Italy

www.echord.eu/experiments/flexsight

GAROTICS

Runtime: May 1, 2015 - October 31, 2016



Green asparagus harvesting robotic system

Due to lower harvesting costs, there is an increasing trend towards the production of green asparagus. Today harvesting is done by seasonal workers, however, the increasing labour costs and the lack of available labour supply forces farmers to optimize the harvesting process and to introduce harvesting aids.

Usually one worker is needed per hectare and season, putting the harvesting cost to approximately € 0.7/kg, which presents about one third of the total production cost. With automated harvesting the availability of labour force would play a less important role and make the harvesting much more flexible and cost efficient.

While for the cultivation of green asparagus the degree of automation is quite high, automation of harvesting is still an unsolved challenge. Several approaches for automated machines have been made, but none of the known automated harvester can guarantee a picking rate and quality like manual labour. This is mainly because of the difficulty and the complexity of the asparagus detection.

GARotics will improve the automatic harvesting systems for green asparagus by enhancing the quality of the asparagus detection and by increasing the detection rate as well as the harvesting rate. Furthermore, GARotics will present a new gripping mechanism with three robotic arms. In addition, data are collected to support the yield forecast and planning of the next harvest run.

+ **Strauss Verpackungsmaschinen GmbH**, Germany *(Coordinator)*
+ **C. Wright & Son Gedney Ltd.**, United Kingdom
+ **Universität Bremen**, Germany; BCM

www.echord.eu/experiments/garotics

GRAPE

ECHORD++

Runtime: September 1, 2016 - February 28, 2018

GRAPE
Ground Robot for vineyArd monitoring and ProtEction

Ground Robot for vineyArd Monitoring and ProtEction

Precision agriculture practices are the most effective way to significantly reduce the negative environmental impact of farming due to over-application of chemicals, while still producing enough food to satisfy a growing demand. The introduction of advanced sensing capabilities allows monitoring at plant level, spotting problems before they spread. Furthermore, introducing farming robots, chemicals can be applied with honeybee precision, pesticides and fungicides can be used only when needed and in the smallest necessary amount, or even be substituted by less impacting techniques (e.g., mechanical instead of chemical thinning, biological control instead of chemical pesticides).

The adoption of such an innovative concept in vineyard farming entails the automation of many tasks, ranging from green pruning and bunch-tip thinning, to precise spraying of chemicals and water, to plant monitoring and protection using integrated biological techniques.

GRAPE project (Ground Robot for vineyArd monitoring and ProtEction) aims at creating the enabling technologies to allow agricultural service companies and equipment providers to develop vineyard robots that can increase the cost effectiveness of their products with respect to traditional practices. In particular, the project addresses the market of instruments for biological control by developing the tools required to execute (semi) autonomous vineyard monitoring and farming tasks with Unmanned Ground Vehicles (UGVs) and, therefore, reducing the environmental impact with respect to traditional chemical control.

+ **Fundació Eurecat**, Spain *(Coordinator)*
+ **Politecnico di Milano**, Italy
+ **Vitirover SAS**, France

www.echord.eu/experiments/grape

HOMEREHAB

Runtime: June 1, 2016 - November 30, 2017

Development of Robotic Technology for Post-Stroke Home Tele-Rehabilitation

Rehabilitation can help hemiparetic patients to learn new ways of using and moving their weak arms and legs. With immediate therapy it is also possible that people who suffer from hemiparesis may eventually regain movement. However, reductions in healthcare reimbursement place constant demands on rehabilitation specialists to reduce the cost of care and improve productivity. Service providers have responded by shortening the length of patient hospitalisation.

The HOMEREHAB project will develop a new tele-rehabilitation robotic system for delivering therapy to stroke patients at home. It will research on the complex trade-off between robotic design requirements for in home systems and the performance required for optimal rehabilitation therapies, which current commercial systems designed for laboratories and hospitals do not take into account. Additionally, the new home scenario also demands for the smart monitoring of the patient's physiological state, and the adaptation of the rehabilitation therapy for an optimal service.

+ **Universidad Miguel Hernández de Elche (UMH)**, Spain *(Coordinator)*
+ **CEIT – Centro de Estudios e Investigaciones**, Spain
+ **Instead Technologies**, Spain

www.echord.eu/experiments/homerehab

HYQREAL

Runtime: September 1, 2016 - February 28, 2018

HyQ-REAL: from the research lab to the real world

Disaster response and other tasks in dangerous and dirty environments can put human operators at risk. Today's remote-controlled vehicles with wheels and tracks have limited use in such missions due to their reduced mobility on rough terrain. In the wake of recent disasters (e.g. Fukushima power plants) we have witnessed how tracked robots can struggle and eventually get stuck in unstructured environments, such as stairs with rubble. A new generation of all-terrain vehicles, with legs instead of wheels and tracks, is finally reaching performance levels that show superior mobility on rough terrain.

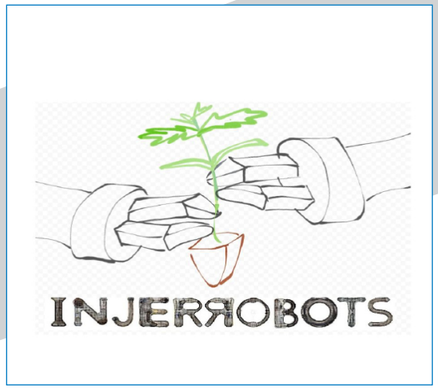
The HyQ-REAL experiment will bring IIT's new quadruped robot HyQ2Max from the laboratory to the real world applications. HyQ2Max is an improved version of HyQ, a robot that has demonstrated a wide repertoire of indoor/outdoor motions ranging from running and jumping to careful walking over rough terrain. In this experiment IIT will team up with MOOG, the world-leader in reliable, high-performance actuation systems for aerospace and motorsport. Besides ruggedizing the robot against impacts, dust and rainwater, IIT will develop control algorithms for self-righting and intelligent teleoperation. MOOG will develop a compact battery-powered hydraulic system to provide HyQ2Max with power-autonomy. MOOG will also further develop their TRL-4 Integrated Servo Actuators (ISA) and bring them onto the market. ISAs will be used to upgrade HyQ2Max with highly reliable and efficient hydraulic actuators. Field testing the new vehicle will be the main focus towards the end of the experiment.

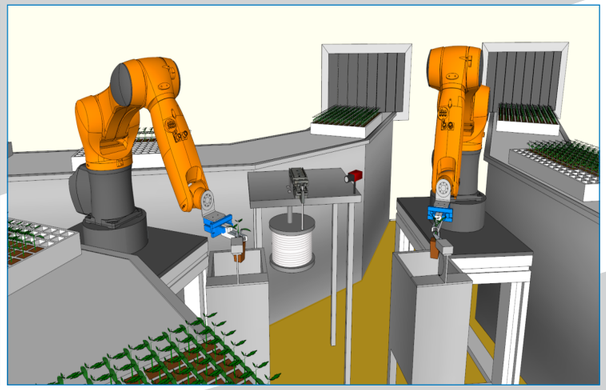
+ **Istituto Italiano di Tecnologia (IIT) – Advanced Robotics**, Italy *(Coordinator)*
+ **Moog Controls Ltd.**, United Kingdom

www.echord.eu/experiments/hyqreal

INJEROBOTS

Runtime: June1, 2016 - November 30, 2017





Universal Robotic System for Grafting of Seedling

Grafting in horticultural seedling industry is a common handmade practice, with the objective to achieve a stronger and more productive plant. Currently, grafting of seedlings is a very important part of the horticultural production industry in Europe, accounting for solanaceae (tomato, pepper and eggplant) market up to 38% of world production, with more than 200 Million grafted plans annually, and for cucurbitaceae (watermelon, melon and cucumber) market up to 47% of world production, with more than 120 million of grafted plants annually.

INJER-ЯOBOTS goal is to perform a universal and flexible robotic system for grafting of horticultural seedlings, based on the cooperative work of two anthropomorphic robots supported by artificial vision, and external devices. The key strategy of this approach is based on two main concepts: (1) the application of grafting techniques over several species with a single robotic system, which allows for the reduction of downtimes between commercial seasons, and (2) the precise control of the grafting process taking advantage of the precision and repeatability of commercial robotic arms.

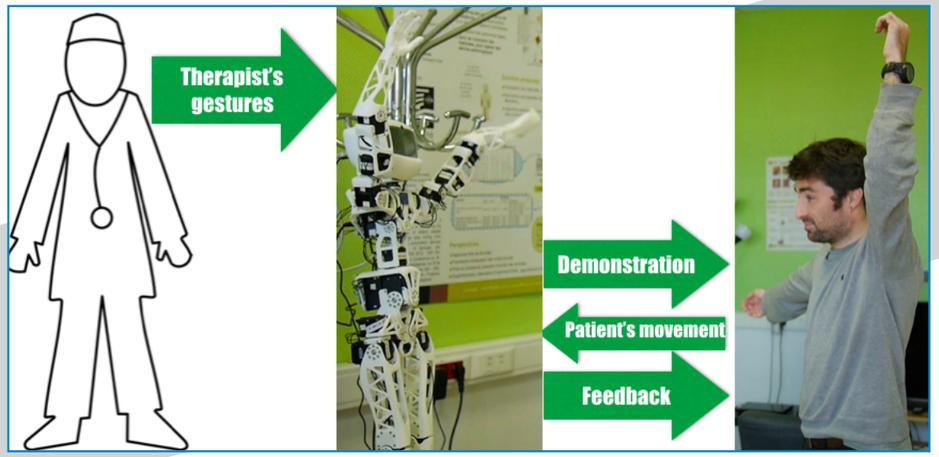
INJER-ЯOBOTS will attempt to solve a horticultural problem introducing equipment, techniques and work practices that had not been applied previously for grafting seedlings, generating results in equipment evolved with respect to existing systems and that responds to needs of plant nurseries and farmers.

+ **CT TECNOVA**, Spain *(Coordinator)*
+ **Robotnik Automation S.L.L.**, Spain
+ **Ingro Maquinaria**, Spain

www.echord.eu/experiments/injerobots

KERAAL

Runtime: September 1, 2016 - February 28, 2018



Kinesiotherapy and Rehabilitation for Assisted Ambient Living

Low back pain is a leading cause disabling people. It particularly affects the elderly, whose proportion in European societies keeps rising, incurring growing concern about healthcare. Assistive technology in general and assistive robotics in particular may help to address the increasing need for healthcare. In particular, it can help people with musculoskeletal conditions that need keeping mobility of joints and increase of muscle force and coordination. In this context, we propose to develop a robot coach for rehabilitation exercises. The goal is to increase the time patients spend exercising, by alleviating the lack of time a physiotherapist can spend monitoring a patient. With this perspective, our project will develop a robot coach capable of demonstrating rehabilitation exercises to patients, watch a patient carry out the exercise and give him feedback so as to improve his performance and encourage him.

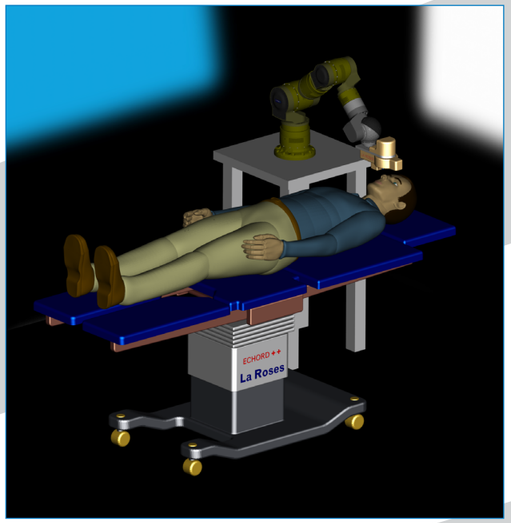
Our consortium made up of roboticists and doctors will address both the technological and the medical aspects of this project.

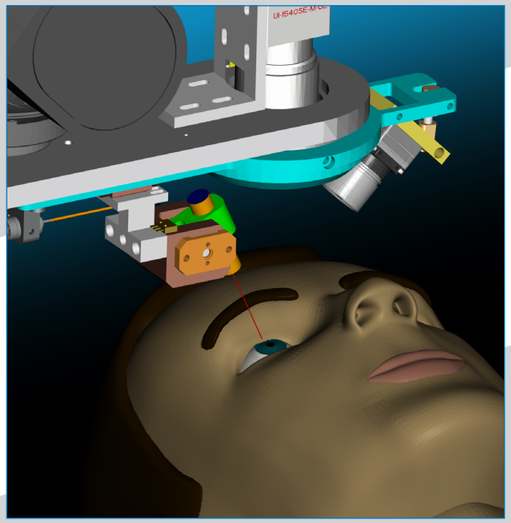
+ **Telecom Bretagne**, France *(Coordinator)*
+ **Génération Robots**, France
+ **CHRU Brest – Centre Hospitalier Régional et Universitaire de Brest**, France

www.echord.eu/experiments/keraal

LA-ROSES

Runtime: January 1, 2015 - June 30, 2016





Laser Assisted Robotic Surgery of the anterior Eye Segment

The objective of LA-ROSES is to develop a vision guided robotic platform for all-laser corneal transplantation (keratoplasty). In laser assisted keratoplasty the transplanted tissue is currently secured with the use of needles and stitches. This standard suturing procedure can be related to post-surgery complications such as postoperative astigmatism, dislocation of the transplanted tissue, or inflammatory reactions. As an alternative, the laser welding of the cornea has been recently proposed and clinically tested. The main limit of this laser suturing procedure is the required manual dexterity: the surgeon has to properly align and move the light source, keeping the correct orientation and distance from the target in order to focus the laser beam in the wound.

At the end of the LA-ROSES experiment a robotic console will be realized including a robotic arm equipped with a so-called „end effector", a device at the end of the robotic arm designed to deliver laser light to the welding site in the eye. Furthermore, the console will be equipped with an integrated vision system.

The experiment originates from a clear medical demand in order to improve the efficacy of at least 20 different surgical procedures. The experiment consortium estimates an increase of procedure precision and efficacy of around 100-150%. The knowledge acquired in this project will have an impact on several industrial projects using a robot for positioning medical devices. Application areas include neurosurgery, urology, spinal surgery and eye surgery.

+ **Ekymed SpA**, Italy *(Coordinator)*
+ **Consiglio Nazionale Delle Ricerche (CNR) - Institute of Applied Physics**, Italy: IFAC
+ **Fastenica, Srl**, Italy

www.echord.eu/experiments/laroses

LINARM++

Runtime: May 1, 2015 - October 31, 2016

Affordable and Advanced LINear device for ARM rehabilitation

LINarm++ is a multisensory and multimodal device for neuromuscular rehabilitation of the upper limb, designed to enable enriched rehabilitation treatment in both clinical and home environments. Originating from LINarm, an existing low-cost variable-stiffness rehabilitation device, it will expand its functionalities by integrating additional modules in order to augment application scenarios and applicable clinical techniques.

The newly developed system will focus on the following aspects: the integration of a wearable neuromuscular electrical stimulation system, a virtual rehabilitation scenario, a low-cost unobtrusive sensory system integrated in the device handle, a low-cost wearable sensory system and a patient model for adapting training task parameters.

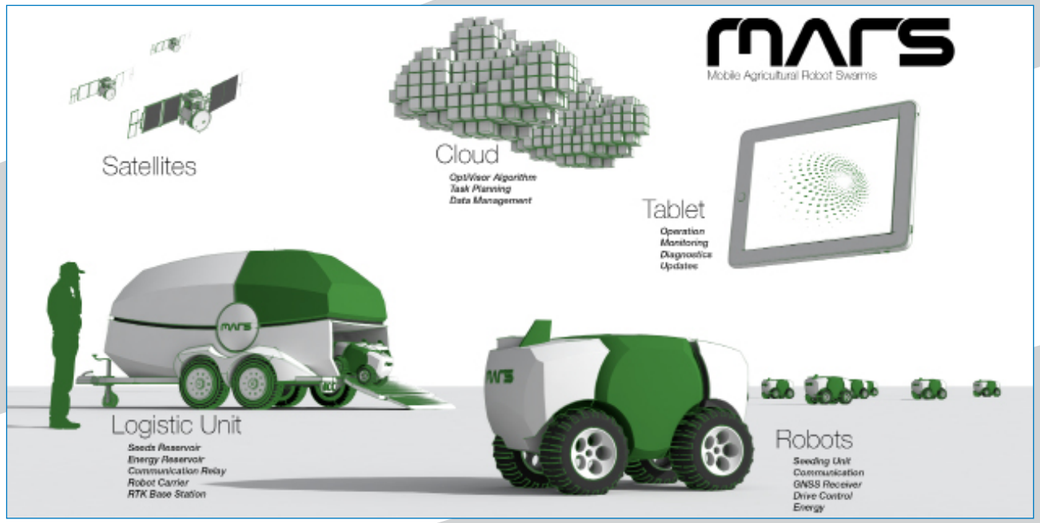
LINarm++ will also monitor the user behaviour during each single session and its evolution throughout the entire training period. The result will be a modular, integrated and affordable rehabilitation device, enabling a biomechanical, neurological and physiological-based training of patients, including innovative features currently unavailable within off-the-shelf rehabilitation devices. The price range will make it suitable for the home healthcare market.

+ **Consiglio Nazionale Delle Ricerche (CNR) - Institute of Industrial Technologies and Automation**, Italy *(Coordinator)*
+ **Ecole Polytechnique Fédérale de Lausanne (EPFL)**, Switzerland
+ **Idrogenet Srl**, Italy
+ **University of Ljubljana**, Slovenia

www.echord.eu/experiments/linarmplusplus

MARS

Runtime: May 1, 2015 - October 31, 2016



Mobile Agricultural Robot Swarms

The MARS experiment aims at the development of small and stream-lined mobile agricultural robot units to fuel a paradigm shift in farming practices. The concept addresses looming challenges of today's large and constantly growing tractor-implement combinations with mainly three aspects. First: to optimize plant specific precision farming, leading to reduced input of seeds, fertilizers and pesticides and to increased yields. Second: to reduce the massive soil compaction as well as energy consumption of heavy machinery. Third: to meet the increasing demand for flexible to use, highly automated and simple to operate systems, anticipating challenges arising from climate change as well as shortage of skilled labour.

The robots will cooperate as a group, similar to swarm principles. MARS will focus on the seeding process for corn performed by two robots as an example. The key strategy of this approach is on the one hand the radical reduction of weight and size compared to conventional farming equipment which also allows for a fundamental simplification of safety tasks. On the other hand it is the essential simplification compared to known agricultural robot prototypes, especially by minimized use of on-board sensors. This will be realized by transferring control algorithms, process optimizing and supervising intelligence to cloud services and utilizing precise GPS-Real Time Kinematic technology. All these measures are intended to lead to a significant cost reduction of the overall system paving the way towards robots as a true alternative in the agricultural domain.

+ **AGCO GmbH**, Germany *(Coordinator)*
+ **Hochschule Ulm**, Germany

www.echord.eu/experiments/mars

MAX-ES

Runtime: September 1, 2016 - February 28, 2018

An Embedded Software for Autonomous Industrial Vehicles

The experiment MAX-ES aims to develop, implement and test a navigation software for delivery robots in an industrial environment, with the objective to integrate fully autonomous unmanned vehicles in an industrial process. This raises some very challenging problems such as the robustness of the navigation for indoor and outdoor operations and the safety of goods and people.

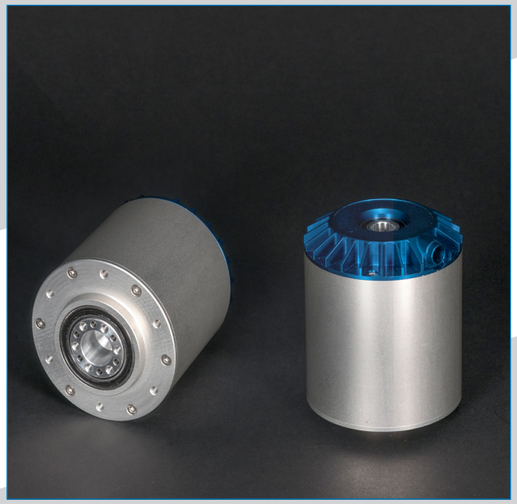
MAX-ES is the first of its kind involving a robot for handling and delivering heavy loads in a realistic situation alongside other vehicles and pedestrians. In addition, MAX-ES will demonstrate the feasibility of implementing an autonomous form of logistic in an existing plant, without guiding infrastructures while staying in the existing road network.

+ **ECA Robotics**, France *(Coordinator)*
+ **Rio Tinto**, France

www.echord.eu/experiments/max-es

MODUL

Runtime: May 1, 2015 - October 31, 2016



Modular Drive Units for Legged Locomotion

First, MODUL focuses on developing a so-called series elastic actuation (SEA) unit which will be modular and highly integrated by including electric motor, gearbox, sensors and control electronics. Furthermore, it will provide a simple mechanical and electrical interface to enable its straightforward integration into the customers application. Due to a sophisticated sealing concept, the module will be suited for outdoor operation.

The main benefit of the unit is its ability to control the torque used and its robustness against impacts. The envisaged product can be used in many existing, but possibly also new applications that call for a robust mechanism with comparably high torque at low speeds, e.g. for the propulsion system of wheeled, tracked and legged systems, but also to build ‚soft' robotic arms that are robust against collisions with the environment and that could potentially be used to safely work together with humans.

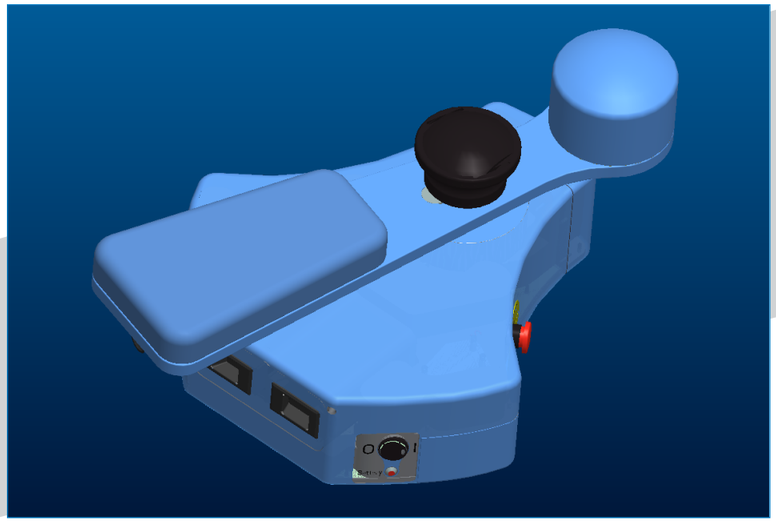
The second target is to develop a modular, four-legged, energy-efficient multi-purpose transporter, simple to operate, maintain and upgrade, with a high relative payload (50% of body weight) and speed. Immediate target groups of this system are academic and industrial research labs. Future customers might include operators of power plants and chemical/petrochemical facilities using the robot for inspection and surveillance. Further applications on rough terrain and in harsh environment, such as search and rescue missions in disaster areas or in context of service robots are envisaged.

+ **Eingenössische Technische Hochschule Zürich (ETHZ)**, Switzerland *(Coordinator)*
+ **CDD Ltd.**, Greece

www.echord.eu/experiments/modul

MOTORE++

Runtime: January 1, 2015 - June 30, 2016



A new Rehabilitation Robot for the upper Limb: Refinement and experimental Trials

The goal of this experiment is to continue the development of a rehabilitation robot named MOTORE to restore upper limb functionality.

Quantity, duration, content, and intensity of training sessions are important variables in the recovery of motor skills for patients suffering from the effects of cardiovascular diseases like a stroke. Due to the repeatability, flexibility and precision of robots, robotic rehabilitation is a growing practice in hospitals, useful to personalize therapies with goal-oriented tasks. However, a shortcoming of most of the existing devices is their high price, the bulky layout and the large power consumption.

MOTORE++ will improve the existing MOTORE rehabilitation device by improving the system to the level which is required for commercialization: it will work without any links or wire and be small enough to be easily carried and as such be suitable for in-home rehabilitation. A proprietary software will be developed with several exercises and a wide range of exercise parameters. Moreover, a patient database will permit the customization of the therapy.

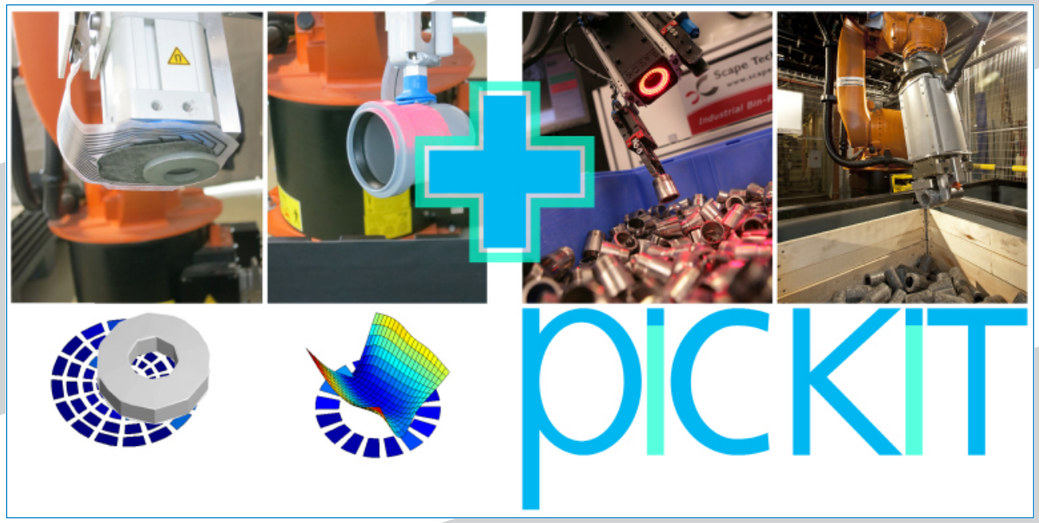
The commercial application of this technological development will allow to build smaller and lighter robotic systems, which are able to interact with patients in hospitals, in retirement homes or are even suitable for in-home therapy. The improved prototype will be tested in home-based rehabilitation sessions.

+ **Humanware Srl**, Italy *(Coordinator)*
+ **Fabrica 136 Srl**, Italy
+ **RoboTech Srl**, Italy

www.echord.eu/experiments/motoreplusplus

PICKIT

Runtime: January 1, 2015 - June 30, 2016



Multi-modal bin-picking for new industrial tasks

Randomly stored material in bins is the most cost-effective and flexible supply form, especially when using it in material transfer automation. In these cases, the process of gripping single parts out of a bin is usually carried out by utilizing bin-picking technology that combines vision sensors, grippers and software for image processing and process planning to enable a robot to execute the gripping process automatically. Bin-picking technology has become more reliable in the last few years and as a result is recently available in a variety of products. However, there are still ongoing challenges in bin-picking, as objects with certain surfaces cannot be processed in a reliable manner due to inadequate optical sensor input. Furthermore, the position of the gripped object cannot be monitored and controlled appropriately.

The pickit experiment enables a commercially-available vision-based bin-picking system to handle a variety of objects. A tactile sensor which can be attached to any desirable gripper is introduced as an add-on to a commercial off-the-shelf bin-picking solution to overcome limitations of current bin-picking systems. This innovative combination of two different technologies achieves a step change in bin-picking applications by reducing the cycle time up to 36%, detecting collisions and even part loss, while carrying a part. Furthermore the pickit system is able to determine the part pose in the gripper and can even extract small object features. Evaluation of the tactile sensor information also makes it possible to accurately place parts. The use of tactile sensing opens up new applications featuring bin-picking, even making the system applicable for objects with challenging surfaces as well.

The Fraunhofer IFF, a German institute for applied robotics research, is the partner responsible for contributing the tactile sensors and integrating the systems together with Scape Technologies, a Danish company specialized in commercial bin-picking systems for industrial use.

+ **Fraunhofer IFF**, Germany *(Coordinator)*
+ **Scape Technologies A/S**, Denmark

www.echord.eu/experiments/pickit

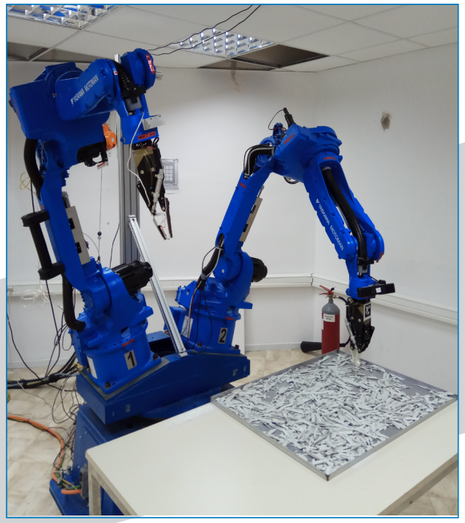
Fraunhofer IFF

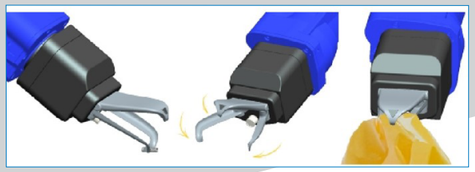
Scape technologies

ECHORD++

RADIOROSO

Runtime: September 1, 2016 - February 28, 2018





Radioactive Waste Robotic Sorter

The scope of RadioRoSo is decommissioning operations performed in nuclear waste storage facilities. A significant amount of old and undocumented nuclear waste is buried underground in unused mines in several countries. Many of these facilities, created as far as 50 years ago, pose a safety and environmental risk, and thus several countries have started or considering the decommissioning of this waste in safer facilities. The main challenge is sorting the waste according to radioactivity level and compressibility, to achieve efficient storage in modern and safer facilities.

Decommissioning is a complex and expensive process. Large industrial cells are manufactured around the storage silos. Sorting is done manually by using mechanical master-slave manipulators. The process is very slow and tiring for the workers, thus requiring short shifts, a high number of workers and along training. The overall costs are huge.

The experiment will demonstrate that this job may be done by robots autonomously, much faster and with significantly lower cost. State-of-the-art machine vision, robotic manipulation and grasping will be employed to solve this real-world task. A special gripper will be prototyped to address the mid-level radioactivity conditions in the sorting cell.

+ **Center for Research and Technology Hellas**, Greece *(Coordinator)*
+ **ANSALDO – Nuclear Engineering Services Ltd.**, UK
+ **National Radiation Protection Institute**, Czech Republic
+ **Universita degli Studi di Genova**, Italy
+ **Czech Technical University**, Czech Republic

www.echord.eu/experiments/radioroso

iti Information Technologies Institute

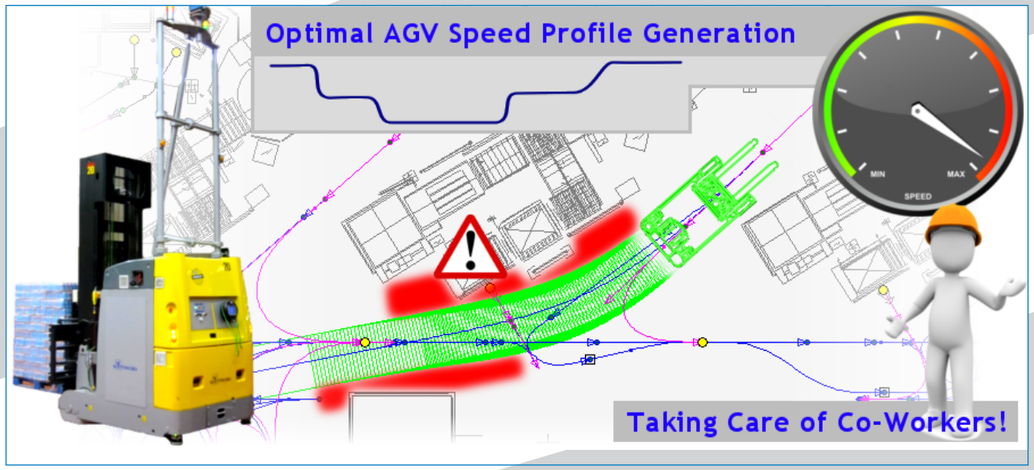
ANSALDO NES Ansaldo Energia Group

SÚRO

CZECH TECHNICAL UNIVERSITY IN PRAGUE

SAFERUN

Runtime: June 1, 2016 - November 30, 2018



Secure and fast real-time planner for autonomous vehicles

The SAFERUN experiment aims at developing and implementing a new planning methodology for Laser Guided Vehicles (LGV). Such vehicles, which are largely used in industrial environments for the autonomous transportation of huge loads, share their workspace with several independent agents, like other LGVs or humans. For efficiency, but also for safety reason, LGVs move along pre-specified path segments. This implies that they can not skip unexpected obstacles placed along their route: collisions are normally avoided through the execution of emergency stops. The drawback of this approach is that, in the absence of a thorough study, collisions can only be avoided by greatly reducing the average vehicle speeds: evidently, the plant productivity is negatively affected by such commonly used strategy.

The new planning method proposed for the SAFERUN project aims at improving the safety standards in LGV plants – such to preserve the physical integrity of human coworkers – by simultaneously increasing the plant productivity. This goal will be reached by providing the LGVs with autonomous velocity planning capabilities, thus making them reactive with respect to unexpected events. The velocity references will be obtained by solving, at run-time, a constrained nonlinear optimisation problem in which, for the first time ever, constraints deriving from safety concerns are directly accounted for. The project was conceived not only in terms of the design of new plants, but also having in mind the modernisation of existing ones, which safety standards and productivity performances would be consequently increased.

The project descends from a collaboration between the Dip. di Ingegneria dell'Informazione of the University of Parma, the Elettric80 company, a worldwide known producer of LGV vehicles, and the PreGel company, which warehouse will be used for testing the novel navigation system.

+ **University of Parma**, Italy *(Coordinator)*
+ **PreGel S.p.A.**, Italy
+ **Elettric 80 SpA**, Italy

www.echord.eu/experiments/saferun

DIPARTIMENTO DI INGEGNERIA DELL' INFORMAZIONE

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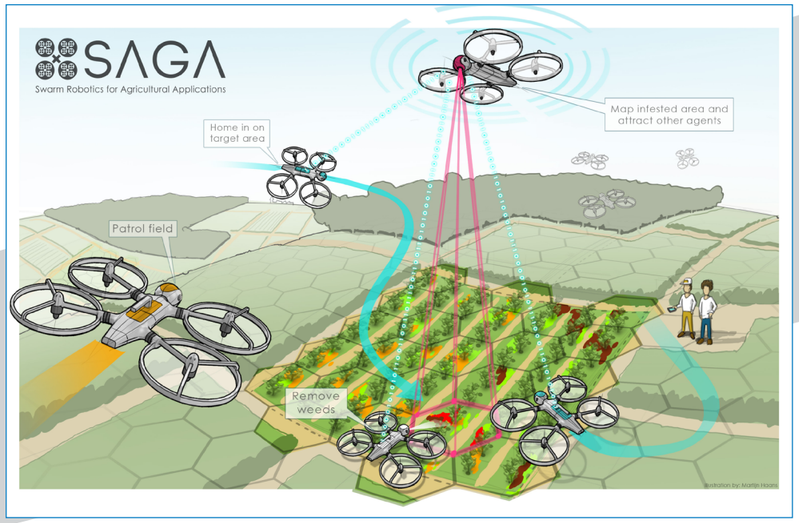
SAGA

Runtime: June 1, 2016 - November 30, 2018



Swarm Robotics for Agricultural Applications

The goal of the experiment is to prove the applicability of swarm robotics to precision farming. The application of swarm intelligence principles to agricultural robotics can lead to disruptive innovation, thanks to the parallel operation of multiple robots and their cooperation. The experiment aims at demonstrating such advantages and comparing them with the current state of the art within the context of a monitoring/mapping scenario.

By exploiting swarm robotics principles, a group of small unmanned aerial vehicles (UAVs) will be deployed to collectively monitor a sugar beet field and cooperatively map the presence of volunteer potatoes, which are a major threat as they spread diseases (e.g., late blight) and facilitate harmful soil nematodes. Hence, it is very important to precisely map the presence of volunteer potatoes to facilitate weed control procedures. In particular, it is very important to determine when to perform weeding on which parts of the farm land (sometimes spanning hundreds of hectares). Currently, this planning task requires repetitive and labor intensive monitoring.

An existing multi-rotor UAV will be enhanced with on-board camera and vision processing, radio communication systems and suitable protocols to support safe swarm operations. Online, on-board processing is key for weed detection, as the UAV needs to fly close to the plants to obtain images of sufficient quality, and this should be done only when there is some evidence of weed to reduce flight time and energy expenditures.

The experiment will develop robust on-board vision routines capable of supporting local navigation and discerning weeds from cultivated plants. Collectively, the robots will build a map of the field with semantic tags associated with different areas, so as to convey precise information about the presence and amount of weed in the different parts of the field. This will facilitate optimal spatiotemporal planning of weeding operations and autonomous precision weed removal in the future.

+ **Istituto di Scienze e Tecnologie della Cognizione (ISTC)**, Italy *(Coordinator)*
+ **Avular B.V.**, Netherlands
+ **Wageningen University & Research**, Netherlands

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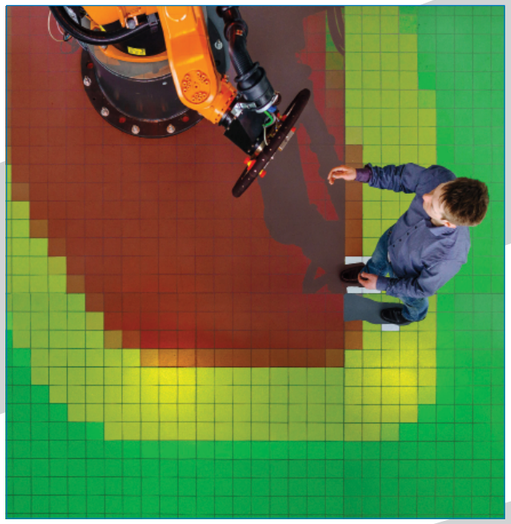
SAPARO

Runtime: January 1, 2015 - June 30, 2016



Safe Human-Robot Cooperation with high payload Robots in industrial Applications

Safety is of uttermost importance in human-robot collaboration, especially where high payload robots for industrial applications are involved. Building on the results of previous projects (including the EXECELL experiment of the first ECHORD programme), the SAPARO experiment proposes a novel solution for safeguarding collaborative human-robot workplaces. The objective of the experiment is to combine a pressure-sensitive tactile floor, detecting the position of the human worker, with a projection system, visualizing safety relevant information like the dynamic boundaries of the safety zones by appropriate colors.

In contrast to current fenceless safeguarding technologies such as laser scanners and camera-based workspace monitoring, which have static safety zones, the proposed safety system will provide dynamic safety zones that are based on current joint positions and velocities of the robot and will offer a maximum of free space to the user at any time. As this system will allow both co-existence as well as certain degree of collaboration between humans and robots, it acts as a baseline technology for eventual use with other systems to allow for a deeper level of collaboration with force limiting approach.

The project partners Pilz GmbH & Co.KG and Fraunhofer IFF are leading institutions in safety and human-robot cooperation with trendsetting developments and technologies and wide experience in this field.

+ **Fraunhofer IFF**, Germany *(Coordinator)*
+ **Pilz GmbH & Co. KG**, Germany

www.echord.eu/experiments/saparo

TIREBOT

Runtime: May 1, 2015 - October 31, 2016

A TIRE workshop roBOTic assistant

In Europe there are about 278.8 million cars and trucks traveling every day and, considering only routine maintenance, about 332.2 million tires need to be replaced every year. Most of the tire servicing operations require dismounting the wheel from the vehicle, taking it to a tire changer machine for extracting/inserting the tire, and consequently to a wheel balancer machine, for balancing the wheel and then re-mounting the processed wheel on the vehicle. Nowadays, the operator needs to manually handle and transport the wheels from the car lift to the machines and back. These manual operations are time consuming and tiring and detrimental for the operator and, consequently, the efficiency of the tire processing task is low and the quality of the working condition of the operator can be definitively improved.

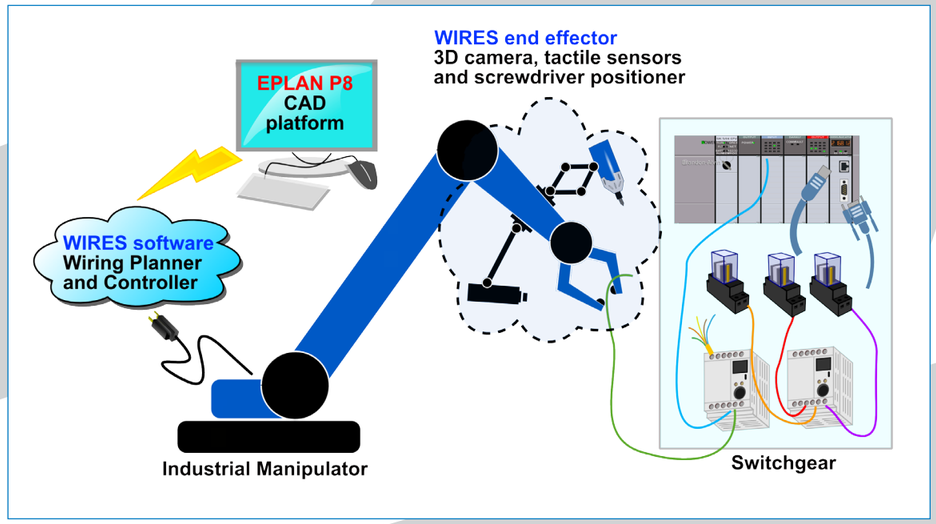
In the TIREBOT experiment, the ARSControl lab of the University of Modena and Reggio Emilia, and Corghi S.p.A., a leading company in the production of equipment for wheel servicing, aim at introducing robotics in tire workshops for improving the tire processing. The goal of this experiment is to develop TIREBOT, a mobile robotic assistant that takes care of transporting wheels among car lifts, tire changers and wheel balancers, and that helps the operator to handle the wheels. In this way, both the time wasted for the manual transportation and the fatigue due to heavy wheels handling will decrease and, consequently, both the efficiency of the work and the quality of the working conditions will increase.

+ **Università degli studi di Modena e Reggio Emilia (UNIMORE)**, Italy *(Coordinator)*
+ **Corghi SpA**, Italy

www.echord.eu/experiments/tirebot

WIRES

Runtime: September 1, 2016 - February 28, 2018



Wiring Robotic System for Switchgears

The experiment aims to improve production quality of switchgears by automatising the wiring process, which is currently handled manually. The experiment will contribute in software as well as hardware (grippers) in order to come up with a robotic solution for wiring. The main challenge is to develop a new gripper with tactile sensors which can handle deformable objects such as wires and simultaneously operate on screw/clip type connection points.

For the gripper, UNIBO will use an existing industrial parallel gripper and equip it with tactile sensors provided by SUN. UNIBO will also mount a 3-degree of freedom (DOF) screw driver positioner and a 3D camera on the gripper. IEMA will develop a software package that utilizes CAD data of the mechanical switch gear to optimise wiring sequence and plan the robot trajectories.

All the technologies developed within the WIRES experiment aim at reducing the time for switchgear wiring and at improving the product quality. The foreseen reduction of the wiring time is about 40% with respect to the overall wiring time, due to the fact that at least part of the overall wiring process can be executed by the automatic system also overnight. It is clear that the achievement of these objectives will have a very strong impact on product cost and company income.

+ **Università di Bologna**, Italy *(Coordinator)*
+ **DIII – Seconda Università di Napoli**, Italy
+ **I.E.M.A. s.r.l.**, Italy

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