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European Commission

CORDIS Results Pack on artificial intelligence and industry

A thematic collection of innovative EU-funded research results

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Advanced innovation for European manufacturing

Research and Innovation

Contents

Editorial

Advanced innovation for European manufacturing

AI and advanced robotics are opening new horizons in all sectors of industry, in terms of both developing novel manufacturing techniques, as well as revising the interaction between human workers and automated tools. This new Results Pack presents the results of 14 innovative Horizon 2020 projects reshaping AI and industry.

Industry is the backbone of the European economy, providing employment and welfare across the continent. Between 2009 and 2019, industry constantly accounted for around 20 % of the EU's GDP.

However, European industry faces important challenges: an increasingly complex globalised economy, being exposed to a fast-changing geopolitical landscape and being vulnerable to setbacks in long value chains.

As economies aim for sustained post-COVID recoveries, industry needs to innovate in a way that is in line with the priorities of the European Commission, in particular the priorities laid out by the European Green Deal, a Europe Fit for the Digital Age and an Economy that Works for People.

Harnessing the benefits of AI

Industry 5.0 provides a coherent vision for such a future industry focused on human centricity, sustainability and resilience. It emphasises integrating social and environmental priorities into technological innovation, and shifting the focus from shareholder value to stakeholder value.

And it promises the creation of a new symbiotic environment between a workforce comprising both human operators and increasingly autonomous and intelligent machines. This transition will rely in no small part on the application of advanced digital technologies, including AI.

The infusion of AI processes into manufacturing offers many benefits. It will fuel the development of novel industrial processes for both existing and emerging industries, enhanced production efficiencies with less downtime, and a redefinition of the role of industry workers as they collaborate with and supervise AI-powered co-workers. The use of AI and augmented reality techniques in factories promises to make human roles less hazardous, less monotonous and less physically exhausting.

Supporting the spread of AI in European manufacturing

Europe is already one of the world's major leaders in the development of AI, but there is still much work to be done to adapt European industry to these new technologies and opportunities.

The European Commission is dedicated to enhancing Europe's leadership in the field of AI, an area of strategic importance and a crucial source of future economic growth. The 2018 Communication 'Artificial Intelligence for Europe' emphasises the importance of AI in European manufacturing, reflected in the EUR 1.5 billion for AI research provided in the Horizon 2020 programme.

In April 2021 the Commission put forward proposals for a legislative framework to boost excellence and trust in AI, the successful implementation of which will safeguard individual rights and provide Europe with a crucial competitive advantage in AI regulation.

And the Commission's 2020 Industrial Strategy was updated in May 2021 to reflect the impact of COVID-19, and empower SMEs and start-ups to adopt the twin green and digital transitions, making European industry more competitive globally.

This CORDIS Results Pack showcases 14 trailblazing projects that are shaping the future with AI technologies designed to support and boost industry and manufacturing across a range of objectives.

Advanced AI offers intuitive robots that can anticipate human actions

Intelligent robots have the potential to complement human ingenuity, skill and muscle power in the workplace. To capitalise on this, an EU-funded project has developed predictive models that give robots greater insight into human behaviour.

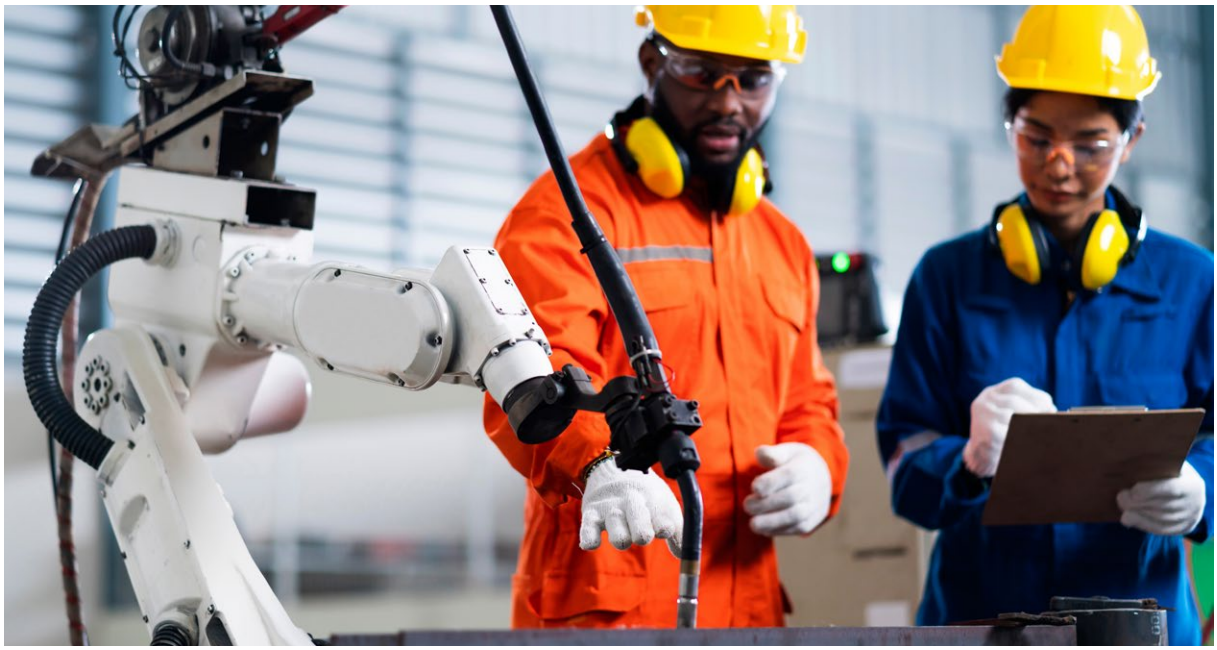
Robots play an increasingly important role in industrial manufacturing through precision engineering and helping manufacturers achieve production efficiencies. Critical to the inclusion of robots in the workspace of course is the welfare and safety of human workers.

This concern has led to a reconceptualisation of robots as active working partners. Rather than replace workers, robots are there to complement and boost human expertise.

"Physical-human robot interaction has become a key technology with huge potential to benefit industry as well as society," notes An.Dy (Advancing Anticipatory Behaviors in Dyadic Human-Robot Collaboration) project coordinator Francesco Nori from the Italian Institute of Technology. "An important element to this is endowing robots with the ability to react to unpredictable behaviour or unintentional contact."

Predictive behaviour models

The fundamental assumption of the EU-funded An.Dy project was that physical collaboration requires robots to better understand and predict what their human partner is doing. To achieve this, the project sought to bring human-robot collaboration up to the next level.



"Data related to human movement, heart rate, blood pressure, temperature and other factors can be gathered from wearable devices," explains Nori. "Analysis of this data can help machines 'learn' how to predict intentions, and to anticipate human actions."

The project team began by observing how robots and humans on the assembly line interact. From these findings, a database of robot-human interactions was built. This data was then used to develop the An.Dy Suit, a wearable overall that tracks motion and, importantly, records physical pressure and forces. The suit is similar to the sort of performance capture suits used in moviemaking.

Vast amounts of motion data were gathered from workers carrying out various physical tasks, such as automotive assembly. This led to the development of new predictive models of human dynamic behaviour. It is these models that could now revolutionise robot-human workspaces.

We are now able to provide robots with entirely new levels of awareness about human intentions and ergonomics.

"Through measuring and modelling human whole-body dynamics, we are now able to provide robots with entirely new levels of awareness about human intentions and ergonomics," adds Nori.

One unforeseen application came along during the COVID-19 pandemic. The project team was able to develop a prototype smart-band that can monitor distances between people, and sends an alert when the wearer's body temperature exceeds 37.5 °C. Researchers are currently working on a second prototype, which they hope to bring to market.

Future human-robot collaborations

These breakthroughs underline the potential that improved human-robot collaborations could bring. In the short term, this is perhaps most notable in manufacturing, the core focus of the An.Dy project.

Intelligent exoskeletons could anticipate human intentions in real-time, aiding tasks such as heavy lifting. An advanced collaborative robot could also tailor its speed and sensitivity to suit the physical characteristics of a particular worker, who might be engaged in manoeuvring a complex mechanical part into place.

"Exoskeletons capable of supporting heavy-duty workers could play a key role in boosting Europe's competitiveness," notes Nori. "Productivity improvements can be achieved through more flexible and effective production processes. Our vision is that the strength and ingenuity of humans and robots can be optimally combined."

Reducing the physical stress on workers could help to minimise injuries and thus reduce healthcare and compensation costs. There are also opportunities in assisted living that could be exploited. Robots capable of anticipating the needs of users could help elderly people to live autonomously for longer, through aiding everyday tasks such as walking and lifting objects.

PROJECT
An.Dy – Advancing Anticipatory Behaviors in Dyadic Human-Robot Collaboration

COORDINATED BY
Italian Institute of Technology in Italy

FUNDED UNDER
Horizon 2020-LEIT-ICT

CORDIS FACTSHEET
cordis.europa.eu/project/id/731540

PROJECT WEBSITE
andy-project.eu

Synthetic skin gives industrial robots a feel for human co-workers

Human-robot collaborative workspaces along the production line could increase productivity and lead to better working conditions. An EU-funded project has sought to make this concept a reality by focusing on safety, communication and flexibility.

A wide range of businesses are looking to shorten production cycles, including those in the automotive, manufacturing, chemical, pharmaceutical and food industries. A common aim is to deliver cost-efficiencies and bring products to market quicker, while ensuring this is done with respect to workers' rights and needs, as outlined in the Industry 5.0 framework. AI-enabled collaborative robots are one way to achieve this.

"Robots capable of working in a collaborative way with humans have even more potential to increase production efficiencies," notes Zoe Doulgeri, a professor from the Automation and Robotics Laboratory at Aristotle University of Thessaloniki in Greece, and project coordinator of CoLLaboratE (Co-production CeLL performing Human-Robot Collaborative AssEmbly).

She continues: "Consider a situation where a human worker is able to demonstrate to a robot how to assemble new parts in just a few minutes. The robot is able to learn from the demonstration and adapt to changes in the environment so that it can really assist workers in their daily tasks. Our vision is of a future where humans and machines can collaborate effectively and flexibly in a shared workspace."

Robot-human workspaces

The key objective of the EU-funded CoLLaboratE project was to develop industrial robots that can not only learn from humans, but also work alongside them safely.

"We wanted to ensure that non-experts would be able to teach robots assembly tasks," Doulgeri explains. "To achieve this, we developed different ways of teaching. These include visual demonstration by observing the worker performing the assembly, physical guidance (i.e. the worker takes the robot by the hand and leads it through the task), and augmented reality via a mobile app."

In terms of human safety, the project team developed software that ensures AI machines are fully aware of the presence of human co-workers on the production line, avoiding collisions while staying compliant, adaptive and accurate. "For example, we developed a new robotic skin that not only detects contact with objects, but can discriminate the type of contact," explains Doulgeri. "Using deep learning, the robot can detect voluntary contacts of the human from involuntary and react appropriately in a safe manner."

With the robot having learned the task from demonstration, the project team created methods to bring AI and adaptive control into play so that the robot can autonomously improve itself and adapt to different scenarios. For example, the robot can share the load with a worker during collaborative handling of different objects. The robots are able to recognise the gestures of workers, and translate these into actions.

The robots are able to recognise the gestures of workers, and translate these into actions.

In addition to these technical developments, the project team also paid attention to the social aspects of having AI robots on the production line. "The acceptance of robots by workers is of key importance," says Doulgeri. "We therefore worked to ensure good communication between robots and humans, in order to build trust."

Wide industry potential

Doulgeri expects that the advances made during the CoLLaboratE project will eventually lead to the increased adoption of collaborative robots in industry. She points out that in addition to the straightforward gains of increased productivity, working conditions of employees can be improved. More physically demanding and repetitive tasks can be delegated to robotic partners within the envisioned human-robot workspace.

Potential end users of CoLLaboratE technology include automotive, aircraft and home appliance manufacturers. Many industries have already identified the potential of collaborative robotics, and are taking steps toward integrating the results of the CoLLaboratE project in their assembly lines.

"We aim to not only access big industries, but also provide assistance to SMEs that have small-batch manufacturing," adds Doulgeri. "They can also benefit from the flexibility offered by CoLLaboratE."

To finance the commercialisation of the project's research results and scale up production, the project team is considering the possibility of a joint venture. Private and public funding is currently being sought. "Through this model, further development and testing can be conducted in an operational environment," says Doulgeri.

PROJECT
CoLLaboratE – Co-production CeLL performing Human-Robot Collaborative AssEmbly

COORDINATED BY
Aristotle University of Thessaloniki in Greece

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/820767

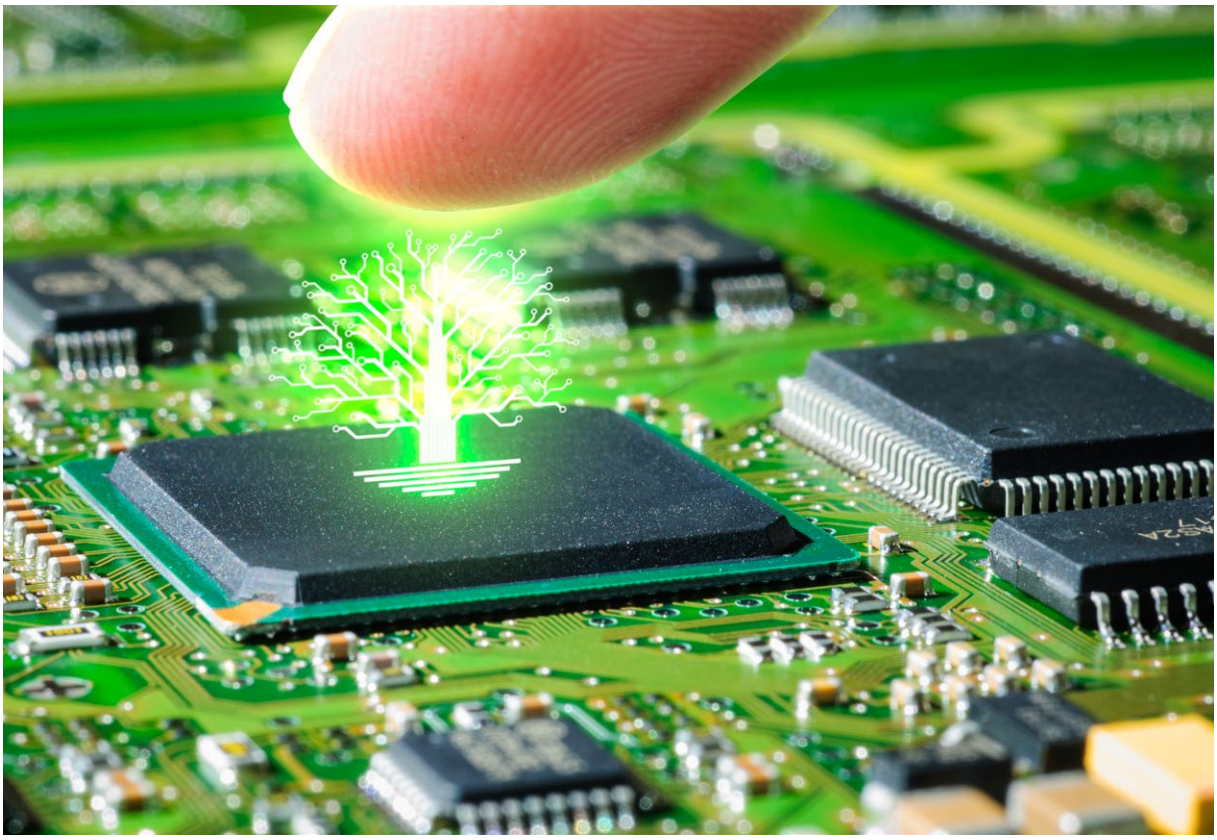
PROJECT WEBSITE
collaborate-project.eu

More computing, less energy

Today's data centres have an efficiency problem – much of their energy is used not to process data, but to keep the servers cool. A new server architecture under development by the EU-funded COMPUSAPIEN project could solve this.

As the digital revolution continues to accelerate, so too does our demand for more computing power. Unfortunately, current semiconductor technology is energy-inefficient, meaning so too are the servers and cloud technologies that depend on them. In fact, as much as 40 % of a server's energy is used just to keep it cool.

"This problem is aggravated by the fact that the complex design of the modern server results in a high operating temperature," says David Atienza Alonso, who heads the Embedded Systems Laboratory (ESL) at the Swiss Federal Institute of Technology Lausanne (EPFL). "As a result, servers cannot be operated at their full potential without the risk of overheating and system failures."



To tackle this problem, the EU has issued several policies addressing the increasing energy consumption of data centres, including the JRC EU Code for Data Centres. According to Atienza Alonso, meeting the goals of these policies requires an overhaul of computing server architecture and the metrics used to measure their efficiency – which is exactly what the COMPUSAPIEN (Computing Server Architecture with Joint Power and Cooling Integration at the Nanoscale) project aims to do.

The project intends to completely revise the current computing server architecture to drastically improve its energy efficiency and that of the data centres it serves.

"The project intends to completely revise the current computing server architecture to drastically improve its energy efficiency and that of the data centres it serves," explains Atienza Alonso, who serves as the project's principal investigator.

Cooling conundrum

At the heart of the project, which is supported by the European Research Council, is a disruptive, 3D architecture that can overcome the worst-case power and cooling issues that have plagued servers. What makes this design so unique is its use of a heterogeneous, many-core architecture template with an integrated on-chip microfluidic fuel cell network, which allows the server to simultaneously provide both cooling and power.

According to Atienza Alonso, this design represents the ultimate solution to the server cooling conundrum. "This integrated, 3D cooling approach, which uses tiny microfluidic channels to both cool servers and convert heat into electricity, has proved to be very effective," he says. "This guarantees that 3D many-core server chips built with the latest nanometre-scale process technologies will not overheat and stop working."

A greener cloud

Atienza Alonso estimates that the new 3D heterogeneous computing architecture template, which recycles the energy spent in cooling with the integrated micro-fluidic cell array (FCA) channels, could recover 30-40 % of the energy typically consumed by data centres. With more gains expected when the FCA technology is improved in the future, the energy consumption (and environmental impact) of a data centre will be drastically reduced, with more computing being done using the same amount of energy.

"Thanks to integration of new optimised computing architectures and accelerators, the next generation of workloads on the cloud (e.g., deep learning) can be executed much more efficiently," adds Atienza Alonso. "As a result, servers in data centres can serve many more applications using much less energy, thus dramatically reducing the carbon footprint of the IT and cloud computing sector."

PROJECT
COMPUSAPIEN – Computing Server Architecture with Joint Power and Cooling Integration at the Nanoscale

HOSTED BY
Swiss Federal Institute of Technology Lausanne in Switzerland

FUNDED UNDER
Horizon 2020-ERC

CORDIS FACTSHEET
cordis.europa.eu/project/id/725657

PROJECT WEBSITE
bit.ly/COMPUSAPIEN

Bridging the AI knowledge gap between Europe and Japan

To advance the use of AI in the manufacturing sector, the EU-Japan.AI project is supporting greater collaboration between East and West.

Artificial intelligence is revolutionising the manufacturing sector. By integrating AI with other advanced technologies and systems, Europe's manufacturing sector has already achieved unprecedented levels of adaptability, efficiency and robustness.

Yet leveraging AI's full potential will require partnerships, knowledge exchange and international cooperation, says Damir Haskovic, project coordinator of the EU-funded project EU-Japan.AI (Advancing Collaboration and Exchange of Knowledge Between the EU and Japan for AI-Driven Innovation

in Manufacturing) and researcher at the independent innovation organisation MINDS & SPARKS in Austria.

The EU-Japan.AI project is helping to facilitate this type of cooperation. "While there are good industrial links between Japan and some European countries, such as Germany and the United Kingdom, knowledge of Japanese manufacturing practices is limited in most other countries," explains Haskovic. "Similarly, while Japanese stakeholders are aware of major European countries' activities, their knowledge of smaller and medium-sized states is very limited."

We are confident our platform will grow into a vibrant online community.

To bridge this gap, the project aims to develop a platform-based approach to connect relevant stakeholders from the EU and Japan and support knowledge exchange on innovative AI applications for manufacturing. "The end goal is to establish and stimulate long-term cooperation in areas relevant to AI-driven innovation in manufacturing and digital industries," adds Haskovic.

Several early challenges

Launched in January 2021, the project has faced several early challenges, many of which relate to the COVID-19 pandemic. Travel restrictions limited the ability to hold workshops, engagement events and twinning activities – all of which are essential to advancing international collaboration. This in turn has made it more difficult to engage with the project's Japanese partners.

"By quickly adapting our methods and shifting our efforts to the digital domain, we've been able to advance our work and have already achieved a number of important results," notes Haskovic.

Among these early results is the technical implementation of web platform and its integration with the OECD AI Policy Observatory. This unique platform helps researchers understand how AI is being used in the manufacturing setting within both the EU and Japan.

"This platform allows us to identify the potential benefits of and opportunities for EU-Japanese collaboration in the field of AI for manufacturing," says Haskovic. "They will also pave the way for developing concrete plans to support stakeholders in leveraging these benefits."

Enhanced cooperation ahead

Haskovic says that the project is progressing well and that researchers are keen to build on this momentum. "We expect to see enhanced cooperation between various stakeholder groups in Japan and the EU, particularly between research funding agencies, local governments with strong manufacturing bases, and SMEs," he adds.

To achieve this, the project is currently focused on refining and improving the platform's functionality, adding new features, and increasing the number of active users. "By building a user-friendly, central hub for all things relating to AI and manufacturing, we are confident our platform will grow into a vibrant online community that facilitates knowledge exchange, cooperation and partnership between EU and Japanese stakeholders," concludes Haskovic.

PROJECT
EU-Japan.AI – Advancing Collaboration and Exchange of Knowledge Between the EU and Japan for AI-Driven Innovation in Manufacturing

COORDINATED BY
MINDS & SPARKS in Austria

FUNDED UNDER
Horizon 2020-LEIT-ICT

CORDIS FACTSHEET
cordis.europa.eu/project/id/957339

PROJECT WEBSITE
project.eu-japan.ai

Robots that are built to build

Innovative robots designed for the construction sector are set to improve safety, increase quality, and reduce time and costs. The EU-funded HEPHAESTUS project is helping to make them a reality.

Currently, the presence of autonomous systems in the building and construction sector is nearly non-existent. While other industries have quickly digitised, most construction tasks remain largely manual, performed using equipment that requires a high level of human supervision.

This, in part, is why the sector has a high accident rate. According to data collected by Eurostat in 2018, one in eight workplace injuries and one fifth of all fatal accidents occur in the construction industry.

Another common problem related to the industry's heavy reliance on manual processes is a lack of structural quality in some projects and the extra time needed to remedy these inaccuracies.

With these problems in mind, the project HEPHAESTUS (Highly automatEd PHysical Achievements and PerformancES using cable roboTs Unique Systems) is on a mission to introduce advanced robotics to the construction sector. "We believe that robots can automate some of the tasks that are now

© Tecnalia, on behalf of the Hephaestus consortium

performed manually, such as the installation of facades," says Julen Astudillo, a researcher at Tecnalia, the project's coordinating partner.

An autonomous, cable-driven robot

At the heart of the project is Hephaestus, an autonomous robotic system that can accomplish multiple tasks on the vertical and inclined planes typical of a construction site. "We believe that our system will not only improve safety, it will also increase the quality of the construction and reduce time and costs."

Hephaestus is a cable-driven robot that can be draped over the sides of a building. With the cables running from roof to ground, the robot can automatically move to different spots of the building's facade with a high level of accuracy. It also has the capacity to hoist up to 1 000 kg, meaning it can transport heavy equipment to various points of the building site.

We believe that robots can automate some of the tasks that are now performed manually.

Furthermore, because the robot's end effector is modular, the same system can be used for multiple tasks. "On one side of a building, the robot could be performing all the tasks related to installing the prefab wall – drilling the concrete slab, inserting bolts, installing the facade modules – while on the other side it might be cleaning, painting, or repairing an already installed facade," explains Astudillo. "All this with minimal human intervention."

Compared to other systems, Hephaestus has the noted advantage of being lean and easy to move. It is also compatible with other handling and support systems, such as gondolas, scaffolding, etc. The system is highly versatile and can be easily adapted for use on a wide range of building types.

The benefits of construction robots

The project demonstrated the benefits of using robotic systems in construction and, specifically, for installing facades. "With our system, companies can achieve a 20 % reduction in installation time and a substantial increase in installation quality," concludes Astudillo. "But most importantly, the system significantly increases the safety of construction workers working at height."

Although the project is now finished, its nine partners would like to further increase the flexibility of the system and add new tools to its end effector. For this, they are currently looking at additional funding opportunities and to partner with other companies working in the facade and construction fields.

PROJECT
HEPHAESTUS – Highly automatEd PHysical Achievements and PerformancES using cable roboTs Unique Systems

COORDINATED BY
Tecnalia Research & Innovation in Spain

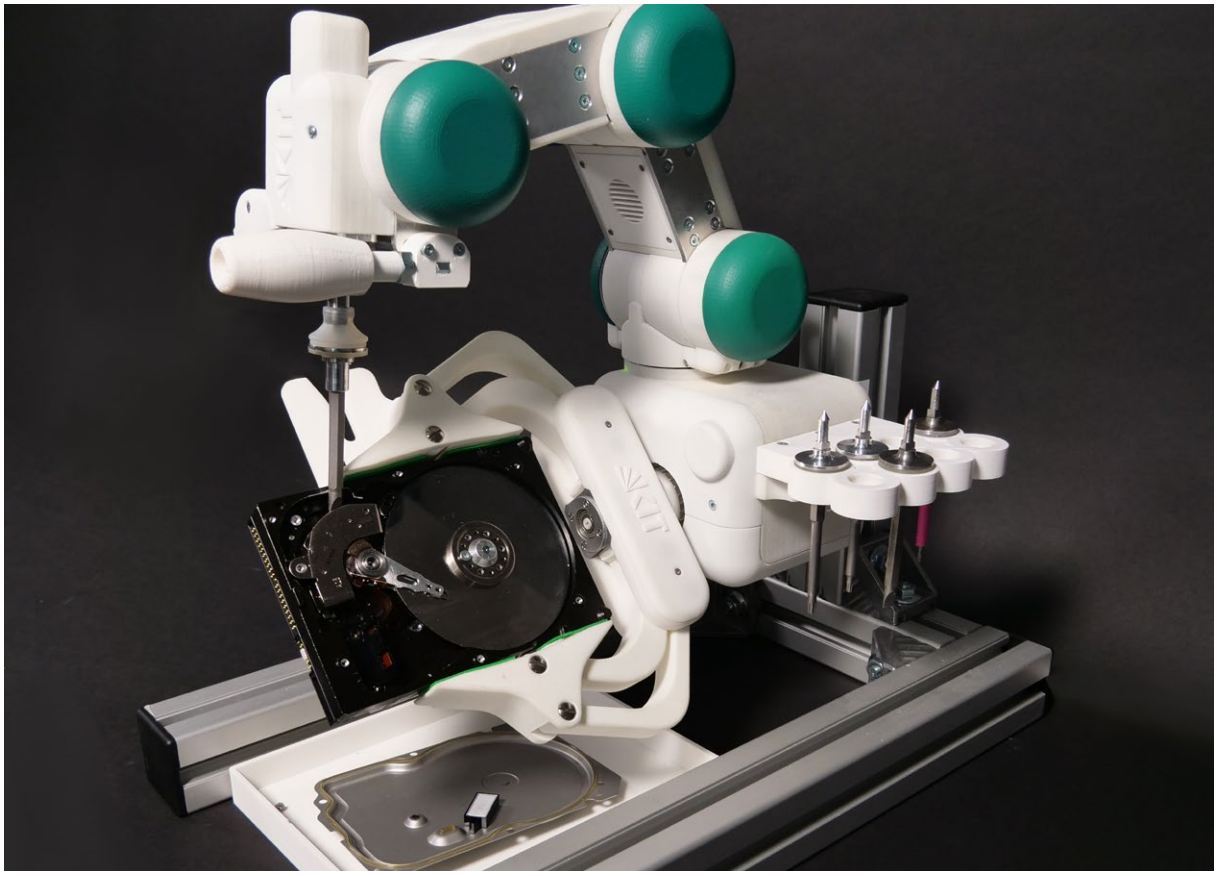
FUNDED UNDER
Horizon 2020-LEIT-ICT

CORDIS FACTSHEET
cordis.europa.eu/project/id/732513

PROJECT WEBSITE
hephaestus-project.eu

Intelligent robots can learn to recycle hazardous hardware

Automation could make a big impact on Europe's growing e-waste problem. But in order to dismantle electronics and domestic appliances for recycling, robots need to be able to cope with unfamiliar objects.



© Gripper_Karlsruhe Institute of Technology IAR-H2T

Electronic waste is the fastest-growing waste stream in the EU, yet less than 40 % is recycled. Dismantling smartphones, computers and other household gadgets is intricate and potentially dangerous work for humans to carry out. Many of these devices were built with the assistance of advanced robotics. Could these machines also help with their disposal?

Robots are typically programmed to execute tasks within a limited repetitive range. The EU-funded IMAGINE (Robots Understanding Their Actions by Imagining Their Effects) project has developed an intelligent system to enable a robot to 'understand' how to disassemble a device version it has not encountered before.

Even a small device can have hundreds of screws, which can be laborious to manually take apart. "As a result, whenever these expensive recycling procedures arise, in practice recycling just doesn't happen," explains project coordinator Justus Piater, head of the Digital Science Center at the University of Innsbruck, Austria.

Instead, it can lead to disposal that is a risk to health and the environment, he adds. The 4-year project raises a robot's capabilities by improving adaptability, perception and autonomy in making decisions by combining machine learning with physics-based simulation of what the robot is likely to encounter with a device.

"Our biggest breakthrough is the highly integrative aspect of the system to partially or fully disassemble objects it has never seen before, in a way that could not have been planned or programmed from scratch because the information was just not there," says Piater.

Intelligent system

A major novelty is that the system can trigger physical simulation to estimate the usefulness of certain actions, Piater explains. "If you can estimate this in advance, then you can gather experience and statistics that describe the utility of those actions so that, next time around, it can help you make a better decision. The system learns from this."

Physics-based simulation generates and visualises objects and their interaction with the environment. Camera images of a device are analysed to detect opportunities for action, known as 'affordances' which can include unscrewing, levering, pushing away and turning, shaking and so on.

Perceptual capabilities, like detecting or recognising objects or estimating the position and orientation of parts, were enhanced by the IMAGINE team. They also developed new screwhead detection systems, specific affordance detectors and detectors for wiring inside electronic devices. "We have state-of-the-art perceptual, especially visual perception, capabilities and we developed specific new functionality," Piater notes.

Innovative planning

In terms of planning, Piater says: "A special planning system was developed which decides what action to take next, not only by choosing one of the affordances to act upon, but also by looking at the future and coming up with as much of a plan as possible." This can be based on simulated and real interaction.

Existing planners are formulated mathematically to construct a complete plan or no plan at all. "If they cannot get to the goal then they have no way to figure out whether any action would be useful. But the planner developed by the IMAGINE team knows how to make progress even if it cannot produce a full plan, just like humans would do," he remarks.

Whenever these expensive recycling procedures arise, in practice recycling just doesn't happen.

A sophisticated multifunctional robotic gripper with a built-in tool changer was specially designed for disassembling small electronic devices. The demonstrator system was trained to dismantle computer hard drives and can also handle some types of graphical processing unit.

"We let the robot perform the entire operation many times and analysed the state before and after and let the robot learn from that experience," Piater adds.

PROJECT
IMAGINE – Robots Understanding Their Actions by Imagining Their Effects

COORDINATED BY
University of Innsbruck in Austria

FUNDED UNDER
Horizon 2020-LEIT-ICT

CORDIS FACTSHEET
cordis.europa.eu/project/id/731761

PROJECT WEBSITE
imagine-h2020.eu/index.php

AI to future-proof the global supply chain

The EU-funded LOGISTAR project reveals how automation, artificial intelligence, and data could be the key to optimising logistics operations within global supply chains.

Efficient supply chains are the backbone of the world economy. But as the COVID-19 pandemic made clear, global supply chains can easily be disrupted. That's why, as we slowly segue into a post-pandemic world, it is essential that we work to better protect them against future disruptions.

"Global economic growth has put a significant strain on our very limited logistics infrastructure," says Enrique Onieva, a professor in Computing and Intelligent Systems at the University of Deusto in Spain. "The efficient use of this infrastructure and of available transportation resources is a critically important goal."

This is where the project LOGISTAR (Enhanced data management techniques for real time logistics planning and scheduling) comes in. "By taking advantage of the increasingly real-time data gathered from the interconnected environment, the LOGISTAR project aims to clear the way towards the effective planning of transport operations within the supply chain," adds Onieva, who serves as the project coordinator.

An end-to-end architecture

The main outcome of the project is an end-to-end architecture that can automatically capture and harmonise data, send the corresponding messages to the modules in charge of executing different algorithms, and gather results to be displayed to stakeholders.

"This solution takes real-time available data and feeds it to AI-based algorithms," explains Onieva. "These algorithms are then used to run a number of services, each of which is geared towards optimising supply chain operations."

For example, one service uses precise estimated time of arrival prediction and incident detection to optimise warehouse operations. "By helping warehouses use their available resources more efficiently, this service reduces wait times and the supply chain bottlenecks such delays cause," adds Onieva.

By helping warehouses use their available resources more efficiently, this service reduces wait times and the supply chain bottlenecks such delays cause.

Another service improves how freight is routed and load capacity optimised. "By taking advantage of different modes of transportation, such as trucks, trains and ships, we're able to both optimise the use of all available infrastructure while also reducing the overall costs of logistics transport," he notes.

On this note, the project also developed a tool for horizontal collaborative planning. "By helping different supply chain stakeholders share available resources, we can reduce the number of kilometres travelled by empty trucks, which in turn reduces greenhouse gas emissions," says Onieva.

Practical answers to real problems

Onieva says COVID-19 didn't just disrupt supply chains, it also impacted research projects like LOGISTAR. "The pandemic struck just as we were about to start our test activities, forcing us to conduct everything remotely," he explains.

Despite this unforeseen challenge, the project succeeded at providing practical answers to real supply chain problems. "Our success is a direct result of the commitment of all the people involved in this project," concludes Onieva. "We may have been a large team coming from different backgrounds and sectors, but we all shared the same objective of future-proofing our global supply chains."

Although the project is now finished, Onieva and some of the project's other partners are working to improve the technology readiness level of LOGISTAR services. The end goal is to advance the technology towards commercialisation.

PROJECT
LOGISTAR – Enhanced data management techniques for real time logistics planning and scheduling

COORDINATED BY
University of Deusto in Spain

FUNDED UNDER
Horizon 2020-TRANSPORT

CORDIS FACTSHEET
cordis.europa.eu/project/id/769142

PROJECT WEBSITE
logistar-project.eu

Bringing predictive maintenance to the factory floor

A new tool uses smart algorithms, artificial intelligence, and data analysis to predict the remaining useful life of a part or piece of equipment.

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The modern-day factory is a complex, often high-tech environment. Assembly lines comprise a range of equipment and components, each of which performs a specific task in a given order. An issue with just one component can throw a wrench into the works, bringing the entire manufacturing process to a screeching halt.

Such stoppages are extremely expensive, so factories place a significant emphasis – and budget – on maintenance. The problem is that most maintenance activities are either routine, meaning they happen regardless of whether a piece of equipment needs fixing, or reactive, meaning they happen after something breaks down. Although both approaches help reduce the risk of a lengthy shutdown, neither does a very good job at preventing the shutdown in the first place.

What factories need is predictive maintenance – which is exactly what the EU-funded PROGRAMS (PROGnostics based Reliability Analysis for Maintenance Scheduling) project aims to provide.

"We intend to extract information from every factory level – controllers and sensor data, maintenance reports, operator experience, physical characteristics, etc. – and, using an artificial intelligence-based algorithm, determine the optimal scheduling of maintenance activities," says project coordinator Sotiris Makris, who heads the Robotics, Automation and Virtual Reality unit of the University of Patras Laboratory for Manufacturing Systems and Automation in Greece. "By minimising the impact that maintenance activities have on the production plan, we can help increase productivity and decrease costs."

A game changer in predictive maintenance

The project's defining outcome is the development of an innovative tool for predicting a part's remaining useful life (RUL). "Using smart algorithms that exploit AI-based models and data collected from the field, this tool is nothing short of a game changer in predictive maintenance," notes Makris.

According to Makris, knowing a part's RUL allows a company to make short- and long-term capital expense calculations. "Such information supports decision-making on ordering spare parts or scheduling maintenance activities," he adds. "It can also be used to ensure that personnel are properly trained on performing a specific maintenance task."

This tool is nothing short of a game changer in predictive maintenance.

In developing the tool, researchers faced a unique challenge. "Surprisingly, no breakdowns occurred during the project period, meaning we didn't have any data on breakdown cases to feed into our AI algorithm," explains Makris.

Instead, the project used AI-based models to simulate the underperforming status of the equipment. "Machinery breakdown is preceded by some deterioration in performance and a resulting decrease in product quality," adds Makris. "This adjustment was actually very welcomed by our industrial partners as it allows them to avoid not only a breakdown, but also the preceding decrease in performance."

An important milestone

The project is now working to advance the maturity of its tool and move it towards commercialisation. "Our ultimate goal is to prepare robust, AI-based predictive maintenance solutions that can be integrated into industrial applications," notes Makris.

Achieving this goal has been made easier thanks in part to the project being a member of the ForeSee Cluster, a network of six EU-funded projects working on predictive maintenance technologies.

"Our participation in the cluster has been an important milestone for the project," concludes Makris. "Not only does it ensure that our results are incorporated into standardisation efforts, it also introduces us to an array of stakeholders who can use our work as a foundation for their own research."

PROJECT
PROGRAMS – PROGnostics based Reliability Analysis for Maintenance Scheduling

COORDINATED BY
University of Patras in Greece

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/767287

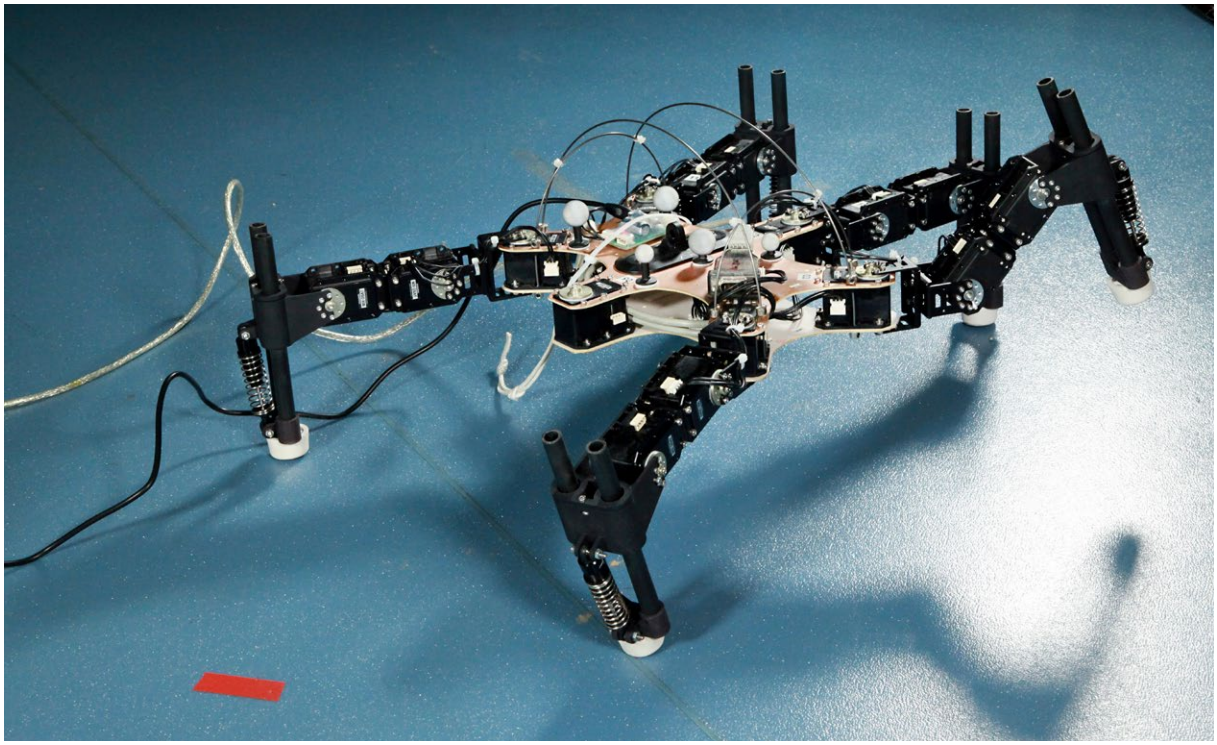
PROJECT WEBSITE
programs-project.eu

Inspiration from the animal kingdom helps robots get back on their feet

Today's robots are typically far from robust. New algorithms developed by this European Research Council-funded project help them quickly and autonomously recover from unexpected damage.

Even after 50 years of research, most robots are more fragile than the smallest, simplest animals – in short, they can easily stop functioning if they encounter difficult conditions or take an unexpected tumble. For robots to become more embedded in human societies, and be useful in emergency situations, they need to overcome their inherent frailty.

That's where the ResiBots (Robots with animal-like resilience) project comes in. "The objective of our project was to develop new algorithms to make it possible for robots to autonomously recover quickly without having to anticipate every possible damage condition," says Jean-Baptiste Mouret, the principal investigator of the project.



"This is especially important when this involves mechanical damage that is very challenging to diagnose with on-board sensors – our vision is to develop robots that have the ability to 'improvise' when they need to complete a difficult mission."

A new perspective

This vision is in direct contrast to the current approach to fault tolerance, which is inherited from safety-critical systems (such as for spacecraft or nuclear power plants). This is inappropriate for low-cost autonomous robots because it relies on diagnosis procedures, requiring expensive proprioceptive sensors and contingency plans. These cannot cover all the possible situations that an autonomous robot operating on its own can encounter.

Our vision is to develop robots that have the ability to improvise when they need to complete a difficult mission.

"Overall, the general idea is to leverage a simulation of the 'intact' robot to accelerate the adaptation for a robot with unknown damage," Mouret explains. The algorithms developed by Mouret and his team circumvent the older-style thinking, being specifically designed for data-efficient adaptation in robotics.

"We routinely have robots that learn to walk right in front of our eyes, in just a few minutes, compared to hours or even days before," Mouret adds. "These were the kinds of robots I really dreamed about when I was a child!"

From diagnosis to reinforcement

Importantly for the project, this first result uses 'episodic learning', which means that each trial starts in exactly the same position. A more recent algorithm allows the robot to learn independently without any reset, whilst taking its environment into account. "There is no reason for the robot to try a gait that is likely to make it move forward if we know there is an obstacle in the way," notes Mouret.

Thanks to recent advances in deep learning, machines are now able to understand their surroundings better than their forebears. "However, if we want robots that can truly learn new skills and tasks, they need reinforcement algorithms and not only perception algorithms," remarks Mouret. "For this to happen, we need to make them more data-efficient before they can be deployed outside research labs." He is optimistic that this could happen within the next 15 years.

Looking to the future

Mouret and his team plan to keep their research going even after the project's official end in April 2020. "We are currently working to introduce data-efficient learning to humanoid robotics – humanoid robots are the 'next frontier' of robotics because they combine all of the challenges of robotics at the same time," says Mouret.

Whilst no humanoid robot is currently using data-efficient learning to adapt to changes in its environment, Mouret and his team want to be at the forefront of changing this.

PROJECT
ResiBots – Robots with animal-like resilience

HOSTED BY
Inria in France

FUNDED UNDER
Horizon 2020-ERC

CORDIS FACTSHEET
europa.eu/project/id/637972

PROJECT WEBSITE
resibots.eu

Robot-assisted ship inspections sail towards certification

Faster, cheaper and safer, robotic and autonomous systems such as drones and crawlers are an attractive solution for ship inspections. The EU-funded ROBINS project set out to certify these systems and help establish them as a standard tool for ship surveyors.

Ship inspection surveys are essential to ensuring the safety of a vessel throughout its life. Conducted by classification societies, these periodic surveys include extensive examinations to verify that a ship's structure, machinery and key systems remain in a condition that satisfies all rules and regulations.

Traditionally, these surveys are conducted by highly qualified personnel. However, as ships become both larger and more complex, many surveyors are using technology to reduce the risks and costs associated with inspecting hazardous, harsh and dirty environments.

"Wide volumes with significant heights, like a bulk carrier's cargo hold, require costly means of access such as scaffolding or hydraulic platforms, and pose a significant risk to the surveyor," says Alessandro Maccari, marine research and development director at RINA Services. "On the other end of the spectrum you have narrow and confined spaces, which pose hazards related to access, mobility, ventilation and cleanliness."

What we found was that robotics and autonomous systems gather information faster, cheaper and safer.

Robotics and autonomous systems (RAS), such as drones and crawlers, are becoming an attractive alternative to traditional ship surveys. Not only are they more affordable and safer, RAS-based inspections can acquire and process visual data faster without compromising its accuracy, greatly reducing the time vessels are docked in harbour for inspection.

However, before robots become a standard tool in the surveyor's belt, they must first be certified. The certification process requires testing, metrics, protocols and guidelines – which is exactly what the ROBINS (Robotics Technology for Inspection of Ships) project set out to do.

Traditional vs RAS-assisted inspections

The goal of ROBINS was to establish a framework for assessing the equivalence between traditional and RAS-assisted inspections, defining measurable qualitative and quantitative standards. "Our aim was to fill in the existing technology and regulatory gaps for the adoption of RAS in the life-cycle surveys of ships," adds Alessandro Giulio Grasso, a project coordinator at RINA.

To do this, the project improved and tested a variety of RAS. These included a collision-tolerant drone for inspecting irregular confined spaces like ballast tanks, along with a semi-autonomous drone for surveying bulkheads and structures inside large cargo holds. ROBINS also developed a crawler: a small, agile robotic vehicle for close-up surveys that can climb steps, manoeuvre around corners, and reach and probe structures.

Furthermore, the project developed a range of innovative software tools for autonomous RAS inspections. "These programmes leveraged such emerging technologies as LiDAR, photogrammetry, machine learning, artificial intelligence, and 3D model augmentation for navigation, localisation and data acquisition," notes Maccari, who helped coordinate the project.

Faster, cheaper and safer

Next, test campaigns were completed in field trials and in testing facilities. These were used to measure the RAS' capabilities, compare them to traditional surveys and, based on this, develop performance standards.

"What we found was that these systems gather information faster, cheaper and safer," notes Grasso. "Not only are these technologies able to detect and accurately map defects throughout a ship, they also are highly cost-effective in hard-to-reach areas."

Other benefits include the ability to use RAS in most ship types and offshore units and to provide instant feedback from vessel to shore. Drones also have the advantage of being easily deployed and operated by a single person without any need for extensive – and costly – safety equipment.

"By proving equivalence between RAS and traditional inspection activities, we've opened the door to the massive adoption of RAS in Class and Statutory ship inspections," concludes Maccari. "Not only will this create safety and cost benefits for ship operators and surveyors, it will also stimulate the EU robotics industry, unleashing the economic potential of new markets."

PROJECT
ROBINS – Robotics Technology for Inspection of Ships

COORDINATED BY
RINA Services in Italy

FUNDED UNDER
Horizon 2020-LEIT-ICT

CORDIS FACTSHEET
cordis.europa.eu/project/id/779776

PROJECT WEBSITE
robins-project.eu

Robot-human collaboration to empower European manufacturing

The development of collaborative robots can make European industry safer and more productive. The ROSSINI project is developing a high-tech platform to bring robots into the workplace.

Europe is experiencing a return of production facilities that had previously been offshored to emerging markets. The manufacturing sector is experiencing a paradigm shift in how things are produced, moving away from a traditional high-volume/low-mix set-up and towards a low-volume/high mix of products.

As a result of this shift, factory workers are facing increasing pressure to keep up – pressure that increases the risk of error and injury.

One possible solution is found in greater human-robot collaboration (HRC). "Working alongside humans and performing some of the more challenging and risky manufacturing tasks, robots have the potential to revolutionise manufacturing, making factories both safer and more productive," says Matteo Zanaroli, group innovation funding manager at Datalogic.

Before humans and robots can start collaborating, they first need to learn how to get along. This is where the EU-funded project ROSSINI (RObot enhanced SenSing, INtelligence and actuation

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to Improve job quality in manufacturing) comes in. The project is working to design and develop factory-safe robots that can increase job quality, achieve production flexibility, and improve productivity.

"This project systematically addresses the obstacles preventing the large-scale uptake of HRC systems, including safety concerns and employee concerns about job security," notes Zanaroli, who is the project's coordinator.

A seven-layered solution

At the heart of the project is an advanced, automated and collaborative platform. The platform consists of seven layers, including a sensing layer that can scan a scenario and identify any potential dangers, and a perception layer that notes which working areas are safe.

"There's also a cognitive area that serves as the robot's brain, optimising its movements and tasks while also allowing it to recognise and take into account human factors," remarks Zanaroli. "This is followed by the control layer, which executes the optimal course of action as identified by the cognitive layer."

Robots have the potential to revolutionise manufacturing, making factories both safer and more productive.

Because these robots are intended to work alongside humans, the platform has a human layer, which allows it to understand the preferences of their human co-workers. "This layer ensures the robot knows that it is meant to perform complex, repetitive and risky tasks, leaving the higher-level work for the humans," adds Zanaroli. "As such, this layer aims to address the very real concerns of employees about having their jobs automated or replaced by robots."

Last but not least are the actuation layer, which allows the robot to quickly start, move and stop and accurately use its arm and joints, and the integration layer, which ensures safety even when an accident is unforeseen.

"All of these layers are integrated into the ROSSINI platform and are scalable to robots of different sizes and complexities," explains Zanaroli.

Real-world testing

The ROSSINI platform is currently being validated at three real-world industrial sites. According to Zanaroli, partial demonstrators are already running with promising results. "Preliminary results represent a significant step forward for the HRC paradigm," he concludes. "For instance, we've already shown that the collaborative range around the robot can be enlarged using the safety layer controller."

Following the completion of the tests, the project will turn its attention towards standardisation. The project is due to conclude in March 2022.

PROJECT
ROSSINI – RObot enhanced SenSing, INtelligence and actuation to Improve job quality in manufacturing

COORDINATED BY
Datalogic in Italy

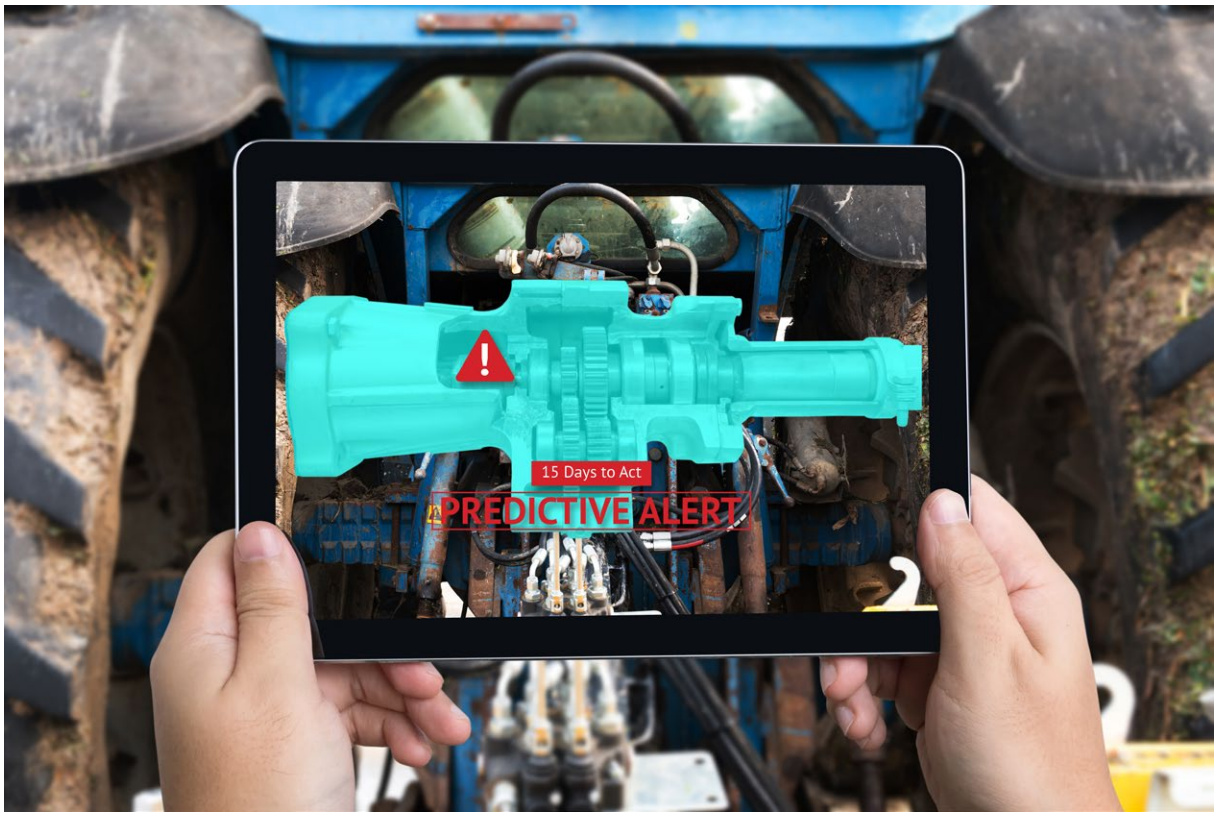
FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/818087

PROJECT WEBSITE
rossini-project.com

An AI-powered platform for predictive maintenance solutions

Artificial intelligence offers many rewards for the manufacturing sector. This project brings these closer with the development of a scalable and resilient industrial internet of things platform that aims to reduce costs and improve productivity.



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The EU-funded project SERENA (VerSatilE plug-and-play platform enabling remote pREdictive mainteNAnce) is at the forefront of the AI revolution in industry. Specifically designed for manufacturing, its platform is based upon four key technologies: remote condition monitoring and control, AI condition-based maintenance, augmented reality-based tools for remote assistance and human operator support, and finally, a cloud-based platform for versatile remote diagnostics.

"In summary, we have developed a distributed, lightweight and scalable industrial internet of things (IIoT) platform which, through the collective use of its integrated services, will provide predictive maintenance solutions to 'shop floor' personnel," says Massimo Ippolito, SERENA project coordinator.

Industrial challenges

The platform uses a lightweight micro-services architecture, utilising Docker containers to wrap the offered services into deployable units. The AI components for predictive analytics, both distributed and centralised, are used for estimating potential failures in manufacturing equipment, allowing for the planning and scheduling of maintenance activities in a specific time frame. This ensures that the production within the factory is not interrupted by unexpected downtime.

On top of this, the SERENA system facilitates remote support by maintenance personnel using VR and AR-based technologies, helping them assess the status of machinery and overall equipment within the factory. This functionality is accessed through the use of smart glasses, smartphones and tablets.

It wasn't always plain sailing for the project team. "It became evident from the first phases of the project that predictive analytics is a matter not only of data availability but of data of the proper quality as well," explains Ippolito. "If the data does not contain the features that correspond to the potential failure of equipment, then it is of no use."

In addition, there is no single rule for every case, with human analysis often required. "Nevertheless, SERENA moved a step beyond those limitations by introducing a self-assessment mechanism and a methodology that could potentially be generic enough to capture a variety of problems," Ippolito adds.

Finally, another set of challenges encountered and conquered was the need to deploy the SERENA system in versatile environments with different connectivity capabilities and legacy systems. The SERENA system is designed to support many versatile cases and can be deployed via the cloud or physically on the premises.

Looking to the future

Regarding the future, Ippolito strongly believes that overall, now is the time that commercially viable AI-based solutions will gradually begin to filter through onto the market.

"In the future, it is expected that AI applications will keep extending into new areas providing interpretable results of increased accuracy and reduced response time," he remarks.

Ippolito adds that developers should always consider the ethical use of this technology: "AI should have a positive impact on society and the environment, and in some cases, this might not be as easy or as obvious as it sounds."

We have developed a distributed, lightweight and scalable industrial IoT platform which will provide predictive maintenance solutions to shop floor personnel.

Since the project's conclusion in March 2021, consortium partners have continued to build on SERENA's innovations to introduce them onto the market and into industrial practice.

In the meantime, the SERENA book, a joint dissemination activity by the entire consortium, has been published. Alongside this, the ForeSee cluster (which SERENA belongs to) has finalised a roadmap on predictive maintenance with key findings of the research now being carried out. Further developments are currently being undertaken by both industrial and academic partners.

"Whilst the SERENA project has finished, project members are still working together but also individually to make sure that SERENA's legacy will last for a long time to come," concludes Ippolito. "This will generate positive effects on each consortium partner related to predictive maintenance projects as the new competences will allow them to more fully leverage their internal and external exploitation experience."

PROJECT
SERENA – VerSatilE plug-and-play platform enabling remote pREdictive mainteNAnce

COORDINATED BY
Comau in Italy

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/767561

PROJECT WEBSITE
serena-project.eu

New miniaturised technology to give autonomous robots vision

Real-time 3D sensors are key to allowing autonomous systems to interact with the surrounding environment and perform such complex tasks as gesture control, vital sign monitoring, and facial recognition.

Collaborative robots, self-driving cars, flying taxis, augmented reality (AR) – this is the exciting future that we're told is just around the corner. But what we're not being told is that without accurate 3D sensors, this high-tech, automated future will be nothing more than science fiction.

"The greatest challenge for the future of automation lies in the sensor technology that can produce real-time and accurate 3D information from the surrounding environment," says Jouni Halme, co-founder of Ladimo Smarter Vision. "This information is the starting point for many of the applications that will define our future, be it machinery, robots, assisted or autonomous driving, AR/VR, or facial recognition."

With the support of EU funding, Ladimo is developing Smarter Vision Micro (The most accurate 3D sensor in the world), a real-time miniaturised 3D optical system that will allow these applications to safely interact with their surrounding environment.

A more compact sensor

The Smarter Vision Micro solution is essentially a miniaturised version of Ladimo's existing real-time 3D sensor. "A more compact sensor will enable such advanced capabilities as gesture control, vital sign monitoring, heartbeat measurements, facial recognition, and a range of safety features – all of which are essential to advancing automation in the consumer electronics, automotive and robotic sectors," explains Halme.

The greatest challenge for the future of automation lies in the sensor technology that can produce real-time and accurate 3D information from the surrounding environment.

Although still a work in progress, the project has already achieved several important results. For example, the core components of the Smarter Vision Micro solution, including the laser, camera, optics, and diffractive optical element (DOE), have all been selected and are undergoing initial testing.

According to Halme, as these tests are being conducted with potential partners, they allow researchers to learn a lot about the unique requirements of different industries.

"One of the most important things we've learned so far is that our algorithm can be run in real time within a mobile phone platform," he adds. "This discovery has opened the door to commercialising not only the Smarter Vision Micro solution as a whole, but also some of its individual components."

Pilots and patents planned

While the project continues to progress, Ladimo is currently focused on finalising the 3D sensor platform. One of the biggest challenges in doing so is securing the necessary hardware components. "The COVID-19 pandemic has put a monkey wrench in global supply chains, so delivery time for some essential components can be over 4 months," remarks Halme.

Once these components are secured and integrated into the final solution, the company is excited to begin piloting the 3D sensor with its strategic partners. In the meantime, Ladimo has secured a patent for the solution in Finland and is now looking to do the same in such global markets as Europe, China, Japan and the United States.

The project is set to conclude in September 2022.

PROJECT
Smarter Vision Micro – The most accurate 3D sensor in the world

COORDINATED BY
Ladimo in Finland

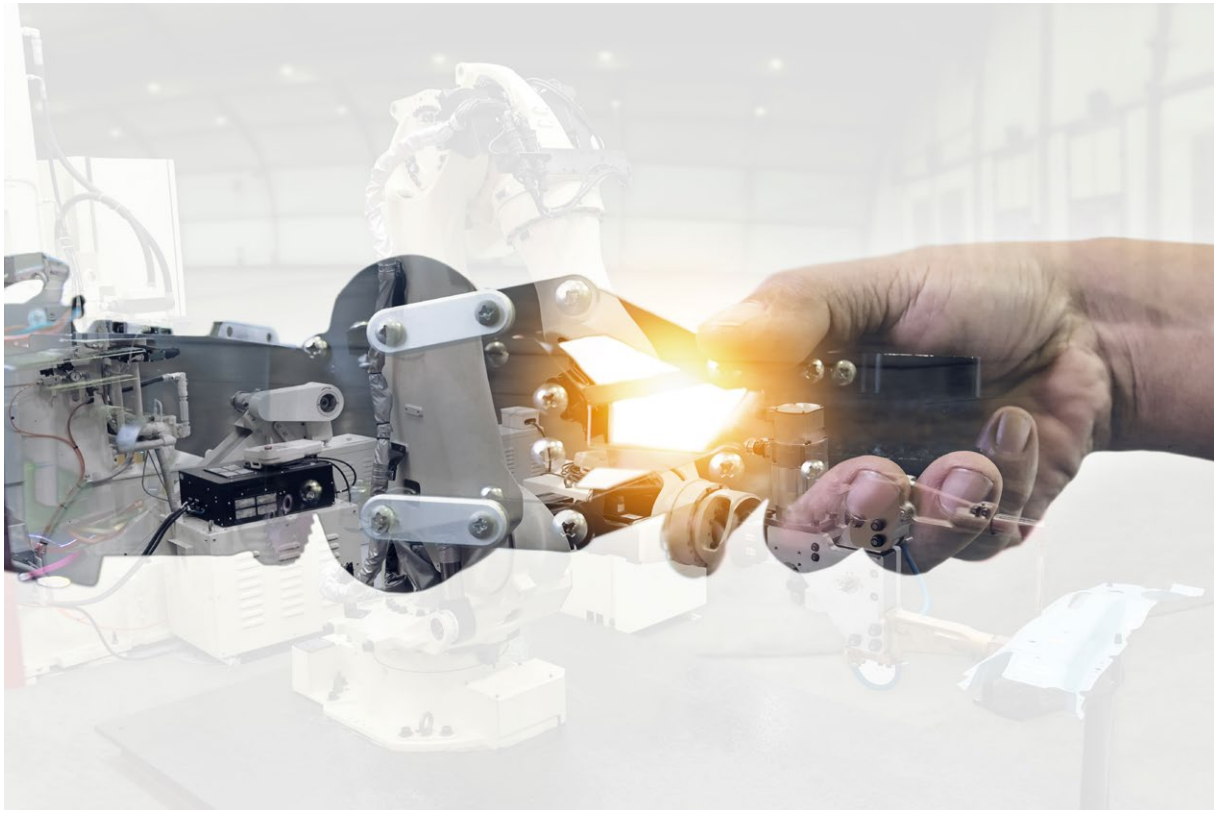
FUNDED UNDER
Horizon 2020-Societal Challenges,
Horizon 2020-SME and Horizon 2020-LEIT

CORDIS FACTSHEET
cordis.europa.eu/project/id/880709

PROJECT WEBSITE
ladimo.fi

Why your next work colleague might be a robot

By leveraging AI and advanced automation, a team of EU research and industrial partners has developed a dual arm configured robot that can move freely around a factory floor, perform complex tasks, and even interact with its human co-workers.



Factories have long been defined by the assembly line model. But with manufacturing becoming increasingly customer-centric, there is a growing need for a more flexible factory.

For the EU-funded project THOMAS (Mobile dual arm robotic workers with embedded cognition for hybrid and dynamically reconfigurable manufacturing systems), the answer is smarter machines. "Cognition-embedded robots allow factories to quickly adapt to varying customer demands while minimising the costs of maintaining large inventories," says Niki Kousi, a research engineer at the University of Patras Laboratory for Manufacturing Systems and Automation (LMS) in Greece, who coordinated the project.

"By taking on many of the strenuous, repetitive and dangerous tasks, intelligent robots can also improve the health, safety and well-being of human workers," adds Sotiris Makris, head of the Robots, Automation and Virtual Reality in Manufacturing group at LMS.

A reconfigurable factory

With the goal of creating reconfigurable factories based on autonomous, mobile robot workers, the project started by creating an innovative mobile dual arm robot. "Thanks to their dual arm configuration and ability to move freely around a shop floor, these robots are capable of performing advanced tasks, thus creating a new production paradigm," notes Makris.

Next, researchers digitalised the factory floor. "As a digital twin of the physical factory, these models contain everything from human operators to robots, parts and processes," explains Kousi. "The model is also dynamic and uses 2D and 3D sensor data to provide a real-time capture of the shop floor status."

These models serve as a roadmap for the robots, allowing them to autonomously – and safely – navigate the shop floor and perform multiple operations, including screwing, handling and drilling. It also allows them to assist and interact with their human counterparts.

By taking on many of the strenuous, repetitive and dangerous tasks, intelligent robots can also improve the health, safety and well-being of human workers.

"Capable of advanced reasoning, the robots can cooperate with each other and other production resources – including human operators," says Makris. "Each robot is equipped with certified sensing devices that allow it to safely move and interact with humans within a fenceless environment."

Behind these advanced capabilities is an innovative technology called robot perception libraries. These libraries allow the robots to navigate without colliding, properly align themselves with and virtually dock at different workstations, and detect the positioning of the various tools used during the assembly process.

All the project's technologies have been integrated into the THOMAS Open Production Station (OPS).

Robots will assist – not replace

While some could view THOMAS as another example of jobs being lost to automatisation, Makris is adamant that this is not the case.

"THOMAS is designed to act as an assistant to its human operators, taking over the most dangerous and strenuous tasks," he adds. "Not only will this increase the safety of our factories, it will allow humans to focus their attention on the most advanced, high-level tasks – including robotic programming."

To illustrate this, Makris notes that the THOMAS OPS was fully demonstrated in real-life settings, including an automotive and aeronautics factory. "The results show that the THOMAS OPS not only improves the human operators' utilisation, but also opens up new job opportunities in a factory," he concludes.

PROJECT
THOMAS – Mobile dual arm robotic workers with embedded cognition for hybrid and dynamically reconfigurable manufacturing systems

COORDINATED BY
University of Patras in Greece

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/723616

PROJECT WEBSITE
thomas-project.eu

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RESULTS PACK ON CHALLENGES TO DEMOCRACY – SECOND EDITION

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