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EDITORIAL

A robot for every situation

Robots have been fascinating children and adults alike for decades. But since the first one made its appearance on the movie screen in 1927 — in the film *Metropolis* — science fiction authors' imagination has been increasingly challenged by the emerging science of robotics. Industrial and service robots are now commonplace, rovers are rolling around Mars, humanoid entertainment robots are getting more and more sophisticated, and robots are now used for tasks as precise and crucial as surgery.

In 2013, there were over 1.1 million industrial robots worldwide. And the figures are even more impressive when it comes to service applications, such as smart vacuum cleaners and medical robots. Over the next three years, the International Federation of Robotics (IRF) predicts that globally there will be about 22 million robots for private use. In such a booming market, EU investment in research and innovation can make a difference. Horizon 2020 notably aims to tackle market fragmentation and the gap between innovation and market impact, the two major issues currently faced by researchers.

To celebrate European Robotics Week, which took place from 25 November to 1 December, the *research*eu results magazine* gives the floor to some of the minds behind new EU-funded robot concepts across Europe. This issue includes an interview with Dr Paolo Fiorini, who presents the results of EUROSURGE, a project pioneering the resolution of obstacles in the field of robotic surgery (page 6). Then Dr Markus Waibel tells us more about the ROBOEARTH project and the new area of 'cloud robotics', which aims to create a World Wide Web strictly for robots to share their knowledge and experiences (page 30).

Other topics include, in the 'social sciences and humanities' section, 'Personalised, dynamic stories for engaging museum visits' on page 13. The latter is followed by the 'energy and transport' section which starts with 'Electronics for safe, efficient electric vehicles' on page 17 , then the 'environment' section which kicks off with 'Weather and environmental forecasts tailored to you' on page 23.

The 'industrial technologies' section begins with 'Nanodevices for a "More than Moore" world' on page 38, while the 'space' section focuses on 'Flexibility for effective satellite communication' on page 43.

The issue ends, as usual, with a list of events and upcoming conferences.

We look forward to receiving your feedback on this issue and on the *research*eu* publications in general. Send questions or suggestions to:

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The editorial team

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Special topic

Each issue of the *research*eu results magazine* sheds light on a specific science topic. To find out more about the latest results and findings, look out for this icon next to article headlines.

Videos

Want to see EU research projects in motion? Some of the projects presented in this issue have a dedicated video available on the internet. To view a video, just open the digital version of the magazine (available at http://cordis.europa.eu/research-eu) and click on this icon.

See you next month!

Coming up in issue 29 of *research*eu results magazine* — a special dossier called 'Shaping the future of air transport'.

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IT AND TELECOMMUNICATIONS

From pizza-maker to physiotherapist: Italian robot's promising skills

Have you ever thought about the complexity of making pizzas: stretching the dough, tossing, seasoning, and baking it with dynamic turning — it is a real art. A robot — named RODYMAN — will soon have the required dexterity to reproduce this 'gastronomic choreography'.

This original and challenging idea was born in the mind of a leading scientist in robotics, Professor Bruno Siciliano, and is funded by the European Research Council (ERC). With unprecedented manipulation skills and an enhanced ability to work in human environments, the future looks bright for RODYMAN[1]. From assisting elderly people to repairing a human limb, the potential applications of RODYMAN are numerous and could greatly improve our daily lives.

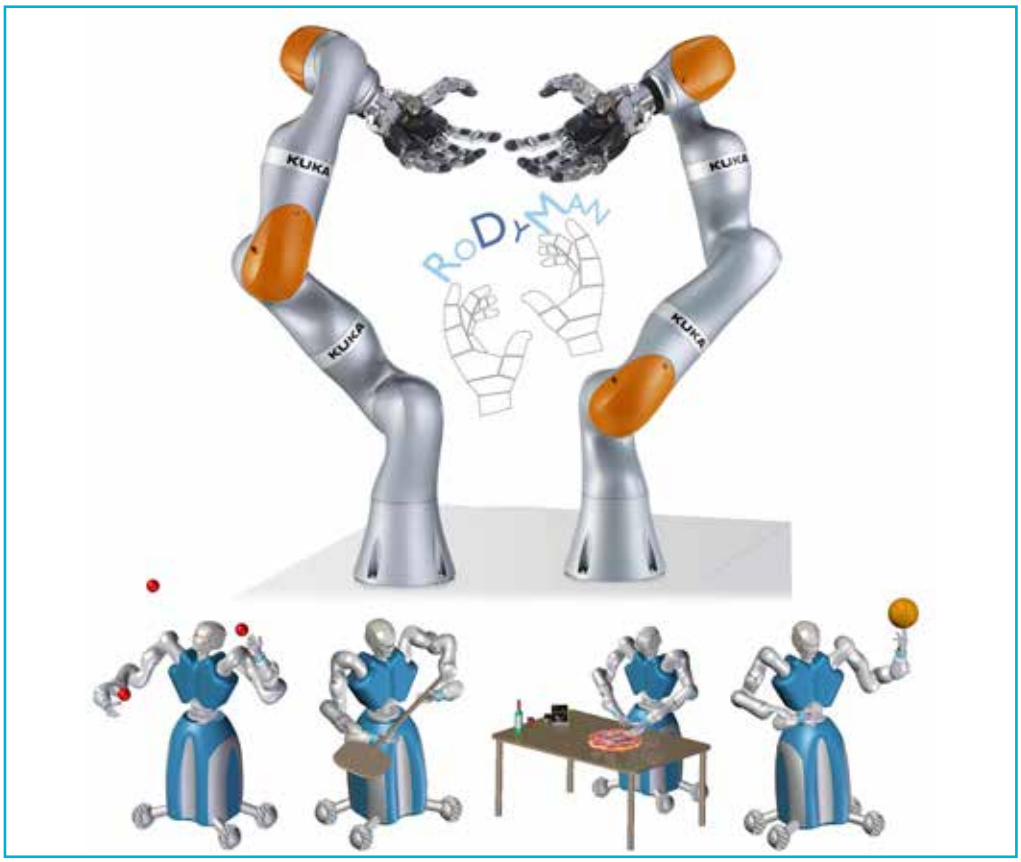
The Naples region does not only host Mount Vesuvius, but it is also the home of a worldwide renowned laboratory in robotics, the PRISMA Lab. It is headed by Prof. Siciliano, an expert in robotics, author of several bestsellers and former president of the most important professional association in the field.

The professor is a son of the Neapolitan soil. He obtained his PhD from the University of Naples Federico II in 1987 and then became a professor there. The idea of a robot making pizza came to him quite naturally. 'Beyond the real technical challenge, it is also a way to honour and keep track of a tradition. I have colleagues in Japan who have developed robots able to reproduce ancestral dances. Cultural heritage plays a role in robotics, and vice versa,' he explains.

Dexterous, mobile and safe

RODYMAN — the acronym for Robotic Dynamic Manipulation — is a service robot that will be able to mimic complex human tasks with a level of dexterity and mobility never seen before. 'The manipulation of non-rigid, deformable objects — food or clothes in our daily lives, soft tissues such as muscles and skin in medical operations — has not been investigated much so far and offers an important challenge to the robotics community,' comments Prof. Siciliano. RODYMAN will be composed of a torso, two lightweight arms and multi-fingered hands. It will not have legs but it will be mounted on an omni-directional platform with wheels. Its head will be equipped with a stereo camera system and a structured lighting set-up. It will have proximity and range sensors, as well as tactile sensors.

Interaction with humans is at the core of the project. 'For this reason, safety is a key feature of the new system,' says Prof. Siciliano. 'This autonomous robot should be able to control the flow of events in the task, react to and learn from its environment. It will be able to deal quickly with unexpected situations, such as the presence of humans or obstacles.'



© Rodyman project

Ready in five years

The project is at the crossroad of different disciplines, involving not only mechanics and engineering but also cognitive science and artificial intelligence. As a result, Prof. Siciliano's team includes different profiles. 'With the ERC grant, I plan to hire four postdocs and three PhD students, who will tackle the challenge of tossing the pizza dough and turn the peel into the oven by using a mobile dual-arm/hand robotic platform,' he explains.

At a later stage, this robot might be in your home, helping you with your daily tasks. 'Service robots are tomorrow's computers,' says the professor. Demand is on the increase. According to data from the International Federation of Robotics, about 2.5 million service robots were sold for personal and domestic use in 2011, 15% more than in 2010. 'The ageing population will drive the application of robotic technologies that improve the quality of life and assist people to live longer and more comfortably in their houses,' continues Prof. Siciliano. Applications in the medical field, notably in physiotherapy, can also be foreseen.

In the next five years, RODYMAN's challenge is to make pizzas. Asked whether they will be as tasty as those of Neapoletan pizzaiolos, Prof. Siciliano replies: 'That is nearly impossible! Yet we will involve one of the best pizzaiolos in town and learn the skilled and artistic movements directly from him through the use of a biokinetic sensorised wearable suit and a 3D motion capture system'. The tasting session is planned for 2017!

The project is coordinated by CREATE in Italy.

1 'Robotic dynamic manipulation'.

Funded under the FP7 specific programme 'Ideas' (European Research Council).
http://erc.europa.eu/ > Projects and results > ERC Stories
Project website: http://www.rodyman.eu/

New underwater robot swims and senses like a fish

In recent years, robotic underwater vehicles have become more common in a variety of industrial and civil sectors. They are used extensively by the scientific community to study the ocean. For example, underwater robots have been used to discover or study a number of deep-sea animals and plants in their natural environment.

Now, a new class of underwater robot has emerged that mimics designs found in nature. These 'biomimetic' vehicles can achieve higher degrees of efficiency in propulsion and manoeuvrability by copying successful designs in nature.

The EU-funded FILOSE[1] project is addressing a key bottleneck for underwater robotics, namely the problem of understanding how fish sense the underwater environment.

A fish swimming in its natural environment is able to sense the flow of water around it and react to changes in flow patterns. FILOSE project partners, led by Tallinn University of Technology's Centre for Biorobotics, believe that once they understand how a fish works, they can potentially apply that knowledge to the development of better underwater robots.

A crucial experimental tool for FILOSE has been a robot prototype that looks and acts like a fish. The 'FILOSE fish' resembles a rainbow trout in shape but also in its behaviour — trout are 'subcarangiform swimmers', i.e. fish that move forward by creating undulations in the rear part of the body while the front remains almost rigid.

© YorkBerlin, Shutterstock

The FILOSE fish's tail is actuated by a single servomotor located in its thorax. It creates an undulating wave that travels along the body and pushes the robot forward. FILOSE researchers can change the fish's tail to investigate how material properties alter the robot's efficiency and swimming pattern. Meanwhile, the head of the robot is watertight and contains sensors and electronics to control the fish.

The experiments were done in the lab using a flow tank. Project researchers determined that robots equipped with such features not only seek out areas where disruptive currents are weakest, but they can also use eddies to actually help push them forward.

The results of the FILOSE project have been ground-breaking. Researchers have successfully developed the first-ever flow-sensing underwater robot with flow-aided and flow-relative navigation. A key step in the design of the robot was the development of an artificial hair cell that mimics natural hair-cell sensing physiology.

The project has also established new hydrodynamics research facilities and trained personnel who are continuing the work begun under FILOSE.

Taken together, the results promise to lead to new underwater technologies that could help the oil and gas industry, underwater humanitarian demining, environmental monitoring, search-and-rescue operations, anti-terrorist activities, harbor surveillance, coastal security and fisheries management, and more. All will feel the impact of more efficient and better-performing underwater robots.

The project was coordinated by the Tallinn University of Technology in Estonia.

1 'Artificial fish locomotion and sensing'.

Funded under the FP7 specific programme 'Cooperation' under the research theme 'Information and communication technologies' (ICT).
http://cordis.europa.eu/news/rcn/35903_en.html
Project website: http://www.filose.eu

Flying robots get off the ground

Attaching a platform to a high-rise building to evacuate people in an emergency, or creating a landing stage for an aircraft on uneven terrain — these are just two areas in which flying robots could have a huge impact — potentially saving lives.

The ARCAS[1] team is 18 months into a four-year project to develop such machines. The team is working on the first-ever cooperative free-flying robot system able to assemble and construct structures in inaccessible sites, including in space. The project is funded under the Information and Communication Technologies strand of the EU's Seventh Framework Programme (FP7), having received EUR 6.15 million from the European Commission.

Advances in five key areas are needed to get the robots up and flying: the helicopters or quadrotor systems themselves; motion control for transportation and assembly; robot perception; cooperation between multiple robots; and tools to allow human intervention.

The team has already developed prototypes. The first is a quadcopter with a robotic arm and a 'hand' designed to grasp cylindrical objects. Keeping the arm's weight as low as possible was a priority; the result is minimal impact on the quadcopter's stability.

The second prototype is an electrical helicopter fitted with a gripper mounted on an arm able to bend in any direction.

Each robot will be equipped with a manipulator able to grasp objects. The team is working on motion-control techniques for this manipulator, which must include coordinating the control of multiple flying robots grasping the same object during a construction task.

© ARCAS

Perception is key to any task-oriented robot. For the ARCAS robots, this includes scene recognition, fast three-dimensional model generation, simultaneous localisation and mapping by multiple aerial robots, accurate 3D

>

positioning and tracking so that assembly operations can be guided, and cooperative perception for assembly — the robots must be able to work together.

Cooperative planning will ensure safety during the simultaneous operation of multiple flying robots during assembly, disassembly or inspection tasks, while human operators must be able to intervene in this autonomous perception, planning and control when necessary. They will do this using virtual reality haptics — technology operated through touch.

Once the concepts, methodologies and algorithms are in place, they will be tested in three different ways. Autonomous quadrotors and an integrated system for positioning will be assessed for basic manipulation and assembly functions. These tests will take place indoors. More advanced manipulation devices with integrated force sensors mounted on autonomous helicopters will be tested outdoors. And multiple robot arms will be used to simulate free-flying objects manipulating objects in space.

The project is expected to lay the foundations for designing and developing cooperating flying robots with various physical characteristics that could be used in a range of applications. ARCAS' industrial partners will be the first to adopt the project's technologies, providing a path to commercialisation, whether in inspection, maintenance, repair, satellite servicing or structure construction.

The project is coordinated by FADA in Spain.

1 'Aerial robotics cooperative assembly system'.

Funded under the FP7 specific programme 'Cooperation' under the research theme 'Information and communication technologies' (ICT).
http://cordis.europa.eu/news/rcn/35804_en.html
Project website:
http://www.arcas-project.eu/

Scaling up breakthrough optical-fibre micro sensors for market

Scientist Davide Iannuzzi and his team have developed a method to place novel miniaturised mechanical devices on the tips of optical fibres. The technology has many applications, such as providing a new generation of small, super-sensitive sensors for research, medical and industrial applications.

The team received support from the European Research Council (ERC) in the form of two grants. The first EU-funded project was called FTMEMS[1] and he secured the second one, called FTBATCH[2], to demonstrate that the technology could be scaled up to market competitively.

Iannuzzi likens the round end of the optical fibre to a swimming pool and the 'fibre-top cantilever' to a diving board. Inspiration for the idea came to Iannuzzi, who is based at the Vrije Universiteit Amsterdam, while he was conducting experiments in fundamental physics. The usual approach of shining a laser beam on to a cantilever proved unwieldy and was not always accurate.

'Commercial instruments were causing spurious effects,' recalls Iannuzzi. 'After some searching around it struck me — why not fabricate the cantilever on to the end of an optical fibre?'

This innovative idea offers a number of clear advantages. By combining the mechanical reliability of microelectro mechanical systems (MEMS) with the precision of optical-fibre interferometers, it is highly sensitive. In addition, its all-optical sensing and portable size means it can function in extreme conditions and be controlled remotely.

Without the backing of the ERC, Iannuzzi would have had a much harder time proving the commercial worthiness of his innovative ideas. ERC support helped the researcher to scale up the production processes and analyse the market potential of different applications.

One of the most promising uses of this technological breakthrough is as ultra-versatile, super-sensitive sensors. For example, fibre-top cantilevers can be used, without the need for bulky and expensive equipment, for atomic-force microscopy (AFM) to record, 'like the stylus of a record player', the surface of an object with a nano-scale resolution.

Numerous other promising avenues exist for the fibre-top cantilever, such as minimally invasive surgery. With all this potential at stake, Iannuzzi discovered that being in the lab was not enough and decided to take his idea to market.

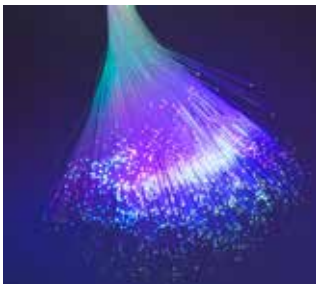
Drawing on the Italian tradition of design excellence and small-scale innovation and the Dutch acumen for transforming ideas into profitable products, in 2011, Iannuzzi established a start-up called Optics11.

'The company is going very well,' he reports, with evident pleasure. 'We have three employees and are about to hire a fourth, on top of the two founders. We're expanding our range of applications.'

In fact, the firm is pursuing a customer-driven approach to its patented technology. Through interactions with scientists and researchers in various fields, says Iannuzzi, Optics11 is able to identify exciting new ideas for applications.

In addition to benefiting society and provide the basis for new business and jobs, this also has a benevolent feedback effect. 'This helps the academic perspective as well, by generating ideas for new research avenues. For example, after talking to neuroscientists, we are now exploring ways to apply the technology in the neurosciences,' he says.

What advice would this scientist-entrepreneur give other researchers wishing to take the leap into business? 'It requires a change of mindset. You have to know that this is not your field, so you have to be open to learning and getting the right help and advice,' he says. And this is exactly what Iannuzzi has done, seeking assistance from his university's technology transfer office and teaming up with a professional entrepreneur to run the firm.



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Iannuzzi has also become an unofficial adviser and mentor to fellow scientists at his university, helping them to consider the best way to bring their ideas to market.

While acknowledging the importance of innovation and commercialisation, Iannuzzi cautions against the dangers of overemphasising this aspect. 'It is important that we give scientists the opportunity to try academic entrepreneurship,' he says. 'However, it is wrong if everything is focused on that. Blue sky research is also necessary.' 'I don't want to live in a world without philosophers,' he concludes.

The projects were coordinated by VU University Medical Center in the Netherlands.

1 'Fibre-top micro-machined devices: ideas on the tip of a fibre'.
2 'Small, but many: scalability to volume production in fibre-top technology'.

Funded under the FP7 specific programme 'Ideas' (European Research Council).
http://cordis.europa.eu/news/rcn/36202_en.html