‘This is the future’: a glimpse into the evolution of robotics with Bruno Siciliano

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‘Keep the gradient’ is the inspiring motto of Bruno Siciliano – Professor of Control & Robotics at the University of Naples Federico II (http://www.unina.it/unina-international), and Past-President of the IEEE Robotics & Automation Society (http://www.ieee-ras.org/). It’s a phrase he coined in 2002 that means to endlessly pursue the expression of new ideas - and in doing so - create new solutions. Siciliano completed his PhD in Electronic and Computer Engineering at the University of Naples Federico II in 1986, and has collaborated with an international network of scientists in the field of robotics and beyond ever since. His belief is that robotics research will advance through ongoing collaboration with other disciplines and research communities. He also thinks a multi-disciplinary approach will be more successful in addressing the combined issues of cognition (perception, awareness and mental models), and physical attributes (safety, dependability and dexterity) in the world of robotics.

Siciliano describes the award winning Springer Handbook of Robotics (https://www.springer.com/gb/book/9783540303015#aboutAuthors), which he co-edited with Oussama Khatib (http://khatib.stanford.edu/), as ‘the most exciting professional experience of my life’. The handbook, whose 2nd edition published in 2016, has involved the co-ordination of more than 200 renowned scientists from across the globe. His aim for the handbook was to ‘provide a service to the international community’ by presenting a balanced view of topics as diverse as field/service robotics, and human-centred/life-like robotics.

Siciliano has always fought against the idea of robots as ‘job killers’. He firmly believes in their potential to work

alongside, collaborate and physically interact with humans, to support and maintain our welfare. He and his research team have created the world's first pizza-making robot (http://www.beforetheabstract.com/2018/07/10/bruno-siciliano-from-pizza-making-to-human-care/), with the aim of advancing the techniques of dynamic manipulation to enhance robot-assisted surgery, amongst other things. Here, he charts the evolution of robotics over the past 40 years and considers what is yet to come.

The advent of Intelligent Control

The 1980s were a time of industrial application of robots. By today's standards those robots seem pretty dull, but back then this leap in industrial engineering was a novelty. They were programmed to carry out repetitive actions and were set at a safe distance from the human workforce, behind a screen. Human interaction with these robots started and ended by switching them on and off.

The arrival of more sophisticated computers in the late 1980s moved the robotics landscape on from one of pure mechanics to 'intelligent control'. They introduced the possibility of robot sensors such as cameras, distance sensors and force sensors.

Since then, more sophisticated designs and improved material have allowed for built-in sensors to become much more commonplace (think, Kinect sensor in Xbox). This integration of sensory-feedback control has enabled robots to solve tasks that were either too difficult, or too dangerous, for humans. Examples of such activities include 'identifying and removing land mines and improvised explosive devices (IEDs) in former conflict zones around the world' (Staff, 2018); nuclear disaster clean-up; and other nuclear plant work. This is what constituted 'field robotics' in the 1990s. Then, at the turn of the 21st century, 'field robotics' evolved into 'service robotics', which saw the birth of medical and social robots that could deliver professional, health and personal

services.

Human-robot interaction: ethical and cultural implications

Previously separated from humans behind a screen, today robots (or cobots) are sharing our workspace and collaborating with us. Increasingly sophisticated built-in sensors enable them to see and feel the presence of humans, and avoid accidental contact.

“These intelligent ‘plug and play’ robots can now be used safely to do what humans want them to - with the highest possible accuracy.” - Bruno Siciliano

Such a marked evolution has opened up the field to numerous new applications. Drones that were once limited to the function of a flying camera, have quickly morphed into sophisticated ‘quadcopters’ that incorporate the mechanics of limbs.

Of course, this rapidly increasing level of robotic sophistication will always raise the question of what the future holds - and more specifically - whether we can feel safe living and working alongside our evermore intelligent counterparts. The final chapter of the Springer Handbook of Robotics deals with the topic of roboethics, considering the ethical responsibility of the people who design and program robots. How is Artificial Intelligence ethically incorporated into the military for example? And how do we ensure ethical, legal, societal and economic (ELSE) principles are upheld to the highest standard?

The future of employment is also an increasingly pressing concern, but Siciliano maintains that some of the jobs we’ll lose to robots are either too dangerous or too difficult for humans to do effectively.

“Robots can fulfil these roles more safely and more efficiently, and create jobs as a consequence. Companies that are expanding their robotic workforce generally need more employees to work alongside them, so in many cases employment can be boosted rather than cut (https://www.eu-robo

tics.net/sparc/upload/Newsroom/Press/2018/briefing/jobs-briefing-web.pdf)."

Siciliano believes that in a few years' time, robots will be as ubiquitous in our society as PCs and smartphones are today. And he thinks the perception of robotics technology is improving, as we experience more ways it can improve our lives. The social and medical benefits of robots, in particular, are starting to get more attention. But there are two ethical sides to this coin. A nurse using a 'wearable robot' to enable him or her to easily carry a patient would be a powerful advancement in healthcare. But there is always the potential for that same technology to be used unethically to make super-human soldiers, for example.

A question of cultural identity: can we truly integrate with robots?

A recent article in Wired: *Why Westerners fear robots and the Japanese do not* (https://www.wired.com/story/ideas-joi-ito-robot-overlords/?CNDID=51252695&mbid=nl_080418_daily_list1_p4) explores the implications of the different perceptions of robots in the East and the West. In a country like Japan, for a machine to be accepted as an assistant, culture dictates that it should look like a human or an animal. But in the West, robots are considered more as machines than as extensions of ourselves, so there's more resistance to humanoid forms in this society. Roomba vacuums and even robotic prostheses are starting to become more integrated into our western culture. Meanwhile in Japan, scenarios like the one in the film *Robot and Frank,* are already playing out in real life: 'Robear (https://venturebeat.com/2017/11/14/meet-the-robots-caring-for-japans-aging-population/) is a nursing robot touted as a gentle bear that is also strong enough to lift an elderly person.' (Zaidi, 2018).

Harnessing robotics to improve life: a race to the top.

Whilst the terms 'Artificial Intelligence' and 'Robotics' are liberally

used, and frequently interchanged today, Siciliano is very clear they are two distinct fields: “Robots involve the physical world – not only brains, but bodies as well.” Robotics is an applied science. A child learns to grasp a toy with its brain (intelligence), but also mechanically using the musculoskeletal structure of its hand. This concept is called ‘embodiment’.

“The terms AI and robotics are thrown together too easily. The physical nature of the robotics system distinguishes it from the pure abstraction of AI. AI is Information Technology which is very different from ‘Interactive Technology’.”

And while progress in AI has been made in Europe, it is still lagging behind the US and Asia, both in terms of industry and research. Siciliano thinks that Europe has the potential to lead the next tech revolution that will see us living alongside personal robots. But economically, he believes that the US and Asia will remain the frontrunners in this space. Two robotics companies - one in France (Aldebaran Robotics, specialising in personal robots), and the other in Germany (KUKA, specialising in industrial robots), were recently acquired by larger operations in Japan (Softbank) and China (Midea) respectively.

“Venture Capitalists in robotics tend to be concentrated in the US or Asia and they’re buying up technology built in Europe at a rapid rate, which is a shame.”

‘This is the Future’

So, what does the education picture for robotics look like today? Siciliano explains that, once an incredibly niche area, there are now established master’s and PhD programmes in robotics. In the US and Asia, the education landscape has changed even more dramatically, with robotics being taught to younger students at high school. Siciliano himself visits elementary and high schools to talk about robotics and spark interest in a field of escalating significance with some of the youngest members of society. Microsoft has also started distributing robotics kits to students.

“Robotics is a nice way to teach maths, engineering and

computers in a ‘joined up’ way. And young students now have the resources to build a home robot and control it with a controller that costs just a few pounds.”

Talking about the Automation Engineering programme at the University of Naples Federico II, Siciliano explains:

“We’re seeing a dramatic year-on-year increase in enrolment. 200 students enrolled in the 2017/18 academic year, which was nearly double the previous year. This is the future.”

Springer Nature's Intelligent Technologies and Robotics eBook Collection

In 2019, Springer Nature will be launching its first eBook collection in Intelligent Technologies and Robotics. The collection will contain 375 titles covering subjects including automation, control, ambient intelligence, big data, and cyber-physical systems, to name but a few. Siciliano is very excited about the launch of this collection:

“Springer Nature is considered the most active publisher in robotics today. I’m very pleased to see the word ‘intelligent’ included in the title of this new collection because this is a vital element in creating the robot of the future.”

On the subject of intelligence, Siciliano explains that robot sensors (including infra-red, UV light and thermal sensors) are already ahead of human capabilities, but that humans are still more intelligent because they know how to use and apply that sensory information.

“When we talk about ‘intelligent technologies’, we’re talking about the autonomous fusing of sensory information with the brain. This requires Intelligent Design in addition to Artificial Intelligence, and consecrates robotics as a science beyond engineering and technology.”

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