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Elena de Momi

IEEE RAS Interviews

Q1: Welcome. If we can begin by just getting some background on you. If you could tell us your full name, where you were born, your date of birth, and then perhaps talk a little bit about, if you would like, about your family, if they're influential on your career, and your early training, where you went to school and where you started your career.

Elena de Momi: Wow. Backing story. Okay, I'm Elena de Momi. I was born in Verona. I hope that you know where Verona is. It's the city of Romeo and Juliet, and it's located between Milan and Venice. I grew up there, and it's not a big city. It's a city where you have close connections with people at school, so you share also time with the other students, so you are, let's say, hosted at the other families to play and so on. So I was there in high school, so I did classical studies. So I studied ancient Greek, ancient Latin, and also some math and physics. And then I moved to Milano, because Milano was the city offering the degree that I wanted to get, which was biomedical engineering. And my family was supportive, because I was the only child, and they were workers, and my mother was a teacher, and my dad was an employee in public service. So they had to do a lot of sacrifice to allow me to go to Milano, because Milano was expensive, and I had to have an apartment there. So it was a really big sacrifice.

And so I got a degree there, biomedical engineering. So after classical study, it was not that easy to approach...so, I did some equations, did some basic physics, but then it was a PRMs, and so it was a bit of a shock. And I had to change the way I was used to study. But it was a really big satisfaction to achieve the degree. And then I decided to pursue a PhD, because my dream when I was a kid was to do research. So why not? So let's try. And it was not easy, because, yes, it was not easy to understand, so how to, let's say, cut your place in research, especially during the PhD. But then I had wonderful mentors during the PhD and didn't stay the whole time in Milano. I also traveled. So I traveled in the US and in Switzerland. And that was a big INAUDIBLE step, because I managed to learn how to work differently with respect to what I was used to. So in Switzerland, I learned to respect time, to respect deadlines, to let's say, to... And in the US, I understood enthusiasm and teamwork. Yes, so it was nice changing the settings, but also it was nice to come back. Yes, because I chose Milano as my... the city I like to live in and Politecnico is really a nice university. I like working there.

Q1: Yes, thank you. So you can interpret this next question however you'd like. But when or how did you first get interested in robotics? Was this as a child? Or was it through books or reading? Or how did you come to know the field?

Elena de Momi: So I first read a lot since I was a child. So I think that it was kind of inspirational. Some movies, there were some movies about robots going around. So I think that technology has always fascinated me. But when I was 18, I didn't know what I put myself into digging in archaeological studies or to... in a lab developing robots. So it was a bit of a choice I did by chance, because I said maybe I could be good also in building something. And then during the PhD, I was working more on computer graphics for surgery. But I was fascinated by

robots. So I think that it was a leitmotif in the background of my mind. But then I was able to actually buy our first robot and to play with our robots in the lab when I finished the PhD

Q1: You mentioned some books and films. Do you happen to remember the first robot?

Elena de Momi: Yes, I think that's also the decision to undertake bioengineering was inspired by the desire to dig into the... how does the human body work? So this parallelism between the body and the machines, I think it was kind of inspirational towards robotics. And there was a course, I remember, was one of my favorite one. And I remember that I was aiming at attending that course from the very beginning. It was called something between natural and artificial intelligence system. And it was... So the first part was explaining understanding how the brain works, the sensory motor functions and so on. And the second part was on artificial systems, artificial neural network. And this was really a milestone, I think, in my career because that gave me the... So artificial intelligence was something that everybody was talking about also 20 years ago. But that approach was really, really mind changer.

Q1: So do you see a connection then between kind of human body and robotics?

Elena de Momi: Yes. That connection was mainly on how the human reason, now artificial system reasons, then can be extended to the body. So robots are just the embodiment of artificial intelligence. That's how it's seen. And so, when I teach robotics, I teach basic course on... it's a laboratory course on robotics. I always start with the human arm. So to explain kinematics, to explain joints, the degrees of freedom, actuators, sensor, and also to let the student to understand what is serial kinematic chain.

Q1: Yes. Yeah. Has that background or... Yeah. Or have those connections shaped your research agenda? And if so, how?

Elena de Momi: Yes. Because then during the PhD, I started approaching the words of surgeons because of the technology that they might need to perform better surgical care. And so my, let's say, the main applications that I'm being studying since the PhD, since almost twenty years ago, has been robots in surgery. So human robot collaboration also in order to assist either the surgeon doing, for example, tasks together, or robots which can be teleoperated like the Da Vinci system and so on. And yes, so the degree I got was, let's say, indicating the pathway afterwards.

Q1: How has your research agenda changed over time?

Elena de Momi: I think so, as engineer, we start from applications. So from the requests that comes from surgeons. So at the beginning, we were working with orthopedic surgeons and then with the neurosurgeons. So it was really fascinating. The field of the brain came again into my path. And then we were exploring the possibility of performing delicate interventions within the brain with curvilinear robots. So cerebral catheters or with bigger systems like KUKA arms used to place probes within the brain. And then I almost lacked the flow of what's going around. So my main, let's say, what I like the most is doing control. But a lot of other topics came also because of the interest of the PhD students, because I started also doing computer vision because we have the images from the endoscope. And using those images, we can do a lot. But some brilliant ideas on how to use those information, how to process, how to enhance the context awareness during the intervention came from students. So if you, let's say, allow students to have responsibilities, have the freedom to explore their own research, they come back with a beautiful idea. And I think that the idea of exploring artificial intelligence in computer vision, machine learning computer vision, came from my best students.

Q1: If I could just pick up on this question about bodies, human bodies and artificial bodies. How do you think about the relationship of, say, robotics and artificial intelligence and computer science? Obviously, they're related. But what, for you, defines a robotics project as opposed to a project in image processing or recognition?

Elena de Momi: I would say that robotics is a combination of everything. So we are not building robots apart from some keeping robots with sensors, apart from some catheters that we actually build, combining actuation and sensing. But basically, this is just the body and then it has to be combined with vision or with the cognitive capabilities. So in our case, for example, the robot can also be autonomous in some aspects, for example, in targeting or in preventing some unwanted movements. So it's not acting completely autonomous. It's just a way of increasing safety, preventing some unwanted actions. But in our case, the human is always in the loop. So we have always an overseeing authority that decides that everything is going according to plans.

Q1: You've already talked about your own academic journey. Can you talk at all about challenges that you've experienced in your career? They could be technical, or professional or social. What kinds of challenges?

Elena de Momi: Every day it's a challenge. So I was thinking about the lesson learned because when asked to have this keynote here, the guidelines, they ask also to think about the lesson learned from failures. And I think that, yes, so we did several projects, as I said. It also depended on the surgeon's request or the funding that we were able to find also to satisfy our curiosity and research. And I have been working closely with some UK partners. We were exploring the use of cerebral catheters in the brain. It was really, really fascinating to work with neurosurgeons. So we also reached the milestone, having in vivo studies with animals. So it's preclinical studies when you're intending to use some animals. And it was really a big experience, a big impact because you're thinking that your technologies has reached some maturity, that it's worth

sacrifice an animal in order to prove that it can be translated effectively on humans. And it's something which is necessary. Otherwise you're stopping research.

But that project didn't come to, let's say, clinical translation yet. And it was difficult to find the interest of companies. Because there was a lot of money that would have been needed to translate effectively to increase the number of tests because you need to prove effectiveness of your approach. And that was, I consider that a failure because maybe we didn't invest in the right direction. So maybe we should have pushed a bit more. And so we gained a lot of knowledge. But I think that something that I learned in these years is that getting knowledge is not enough. You need to push a bit more. You need to, if you want to have an impact, you have to do a step ahead.

Q1: Has that perspective on a challenge changed the way you think about training your own students?

Elena de Momi: Yes, dramatically. In the sense that now I also, it depends on the student's attitude, I would say. But if I see that in some students there is the passion, the enthusiasm towards this business, I would say, so to check with companies, to talk with potential investors, to think about a business case. So because we didn't start from a business case in that case. We just were starting from a clinical interest. And what I see in students that are interested in business cases... I'm trying to... So what I'm doing now is that I'm putting some resources, some investments in their training in that sense. And fortunately, my university has also started some years ago in pushing towards this direction. It's offering a lot of courses, training, possibilities to young students, to PhD students, and also postdoc, of course also to professors. We have so many other activities that we have to carry out. So I think it's super good for them. I see their enthusiasm and I love it.

Q1: Were there any tools, either technical or conceptual, that, like Connect or large language models, or other kinds of things that have in the past changed your research in significant ways or are doing so now?

Elena de Momi: They're doing so now. So actually, there were some standards that were introduced. So for example, the robotic operating system that was introduced some years ago that has changed the way that we, for example, do integrated projects with different researchers working together. So they had to meet that standard, I would say. And of course, deep learning has changed the way that we do computer vision. And now this generative AI, this system ChatGPT is also changing the way that, for example, we are annotating images, because surgeons and our endoscopists are asking us, because they see the potentialities and they have to see a lot of images, endoscopic images, they have to detect structures there. And they love to see that ChatGPT is able to provide captions automatically.

Q1: As you reflect on your career and your contributions to robotics and to the field, what do you see as your most important contribution?

Elena de Momi: That's a difficult question because that's the question I ask myself when I try to justify myself why I was invited here. And so I think that the thing that I'm still doing actually is to collaborate with, so to have a close collaboration with clinicians and to bring our research into the clinical practice. So we are now discussing with them or working with them to have a clinical translation, to prove that we are effective in improving the clinical outcome. So this is the most difficult thing that I think that we could do as biomedical engineers. So it's not just to work on the real-time registration, real-time deformable registration, real-time augmented reality. Those are results that we can achieve, we can impact in a journal, we can publish that we are faster, more accurate than others. But the real impact is to convince that it's giving a try, it's worth giving a try in clinical trials.

Q1: How do you see the field as having changed over the past few decades? And how do you see it changing now and in the immediate future? This could be in terms of core technologies or approaches or training. Again, interpret that question however you'd like.

Elena de Momi: In terms of training, you mean in terms of education?

Q1: That could be a part of it. So we're interested in changes in the field and what you think the next 10 or 20 years will look like.

Elena de Momi: So, starting from education, which I think that it's an important question, what I see, especially in Italy, is that there are more and more courses combining robotics, artificial intelligence at the master level, which means that companies are asking that profiles in students and engineers. So not only automation engineers, information technology engineers, but engineers who have attended courses in robotics and artificial intelligence together. So this is really important and it's also shaping the future because I think that robots will enter more and more companies in terms of substitution, of tiring tasks, for example, to avoid injuries in workers. This would be a huge impact in industrial production, for sure.

And in my field, so the medical field, I think that you can see the future if you, for example, look at the automotive industry. So we are relying a lot more and more on autonomous cars because they are safer. So the more and more this autonomy, which is not completely autonomous, it's just autonomy in preventing accidents, will be translated effectively in a surgical domain. So these are, I see, in parallel to the miniaturization of the approaches. So for example, now a lot of tumors can be cured with energy, not just with the surgical cuts. So there will be some, let's say, robotics should also follow the advancements of the therapeutic approach, which is provided by the innovations in medical devices.

Q1: You've talked already about the use of your research in clinical settings and medical practices. Are there other ways in which you see your research kind of moving out into the world and shaping the work of others?

Elena de Momi: Yes. So because, as I said, I'd also like to work on control on the human-robot interaction part. So recently, I've been collaborating with also with other partners in the Italian Institute of Technology, for example, to have this shared approach, a shared task between the human and the robot. And yes, so in Politecnico, we have also some other professors working on industrial settings and so on. So I think that these approaches of shared task of understanding the human, so measuring the human stress, understanding the human cognitive load, for example, could also, which we are also measuring in surgeons, for example. We have some eye tracking data to understand whether the surgeon is tired or not during intervention. And this can be translated to the industrial application, whether you want to understand whether the worker is as fatigued or not.

Q1: So it sounds like, in your work, you collaborate and contribute a lot to industry or medical practice.

Elena de Momi: For medical practice, something goes to industry.

Q1: Yes. Do you have any recommendations for students who are interested in pursuing career in robotics?

Elena de Momi: Well, first of all, I think it's not an easy path. But I see that a lot of them come to me. So maybe they don't know anything about robotics, but they come to me and they say, "I like robots." And I think that this is the first requirement that a student should have, because it won't be always fun. There will be a lot of problems, batteries, rapture. And then you have to wait months until the robot is alive again. So that can be frustrating and so on. So according to me, it's the best because it's a combination of software and hardware. It's a combination of ideas and technological advancements and so on. So you have sensor, actuators, you have everything there. And so it's always fascinating to see that the robot is actually doing what you are asking the robot to do. So this is really a big accomplishment for students. So we have just had the summer school of one week of students first year, PhD, and they had to from scratch. So they didn't have a program in the robot yet. They had to program the robot, take the dice and turn the dice according to the design number, and see the enthusiasm in their faces to approach for the first time a real robot, and move it, and commanding robot to have a strategy to solve. It was really, really fascinating from a teacher perspective, I would say. So my suggestion is don't be discouraged when things don't work because it will be the case.

Q1: Are there any topics that we haven't covered yet that you think are important or that you would like to share?

Elena de Momi: I don't know. So yes, I think that, for example, the fact that only 15% of the society is made by women in robotics. And what could be the strategies for increasing those numbers? I really don't know. I think that the presence of role models could help. I don't know whether the strategies that are now in place could work about encouraging women to apply to positions and so on. I don't know whether it's going to work and how it can be sustainable. But the only promising trend is increasing. So there might be a slow process, but I think that, for example, in my case, I have a lot of female students, and it's a good hint that things would be better.

Q1: Thank you.

Elena de Momi: Thank you so much.

Q1: I think that that is our time. I appreciate you very much taking your time.

Elena de Momi: No worries.

Q1: Congratulations on your keynote and best of luck.

Elena de Momi: Thank you. I really need it. I really need it.