

The Pransky interview: Brian Carlisle, pioneer, robotics entrepreneur, President and Co-Founder of Precise Automation

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Abstract

Purpose – The following paper is a “Q&A interview” conducted by Joanne Pransky of *Industrial Robot Journal* as a method to impart the combined technological, business and personal experience of a prominent, robotic industry engineer-turned entrepreneur regarding his pioneering efforts in the industrial robot industry and the commercialization and challenges of bringing robotic inventions to market. This paper aims to discuss these issues.

Design/methodology/approach – The interviewee is Brian Carlisle, President and Co-founder of Precise Automation, a robot manufacturer that specializes in collaborative robots. Carlisle discusses the highlights of his 40-year career that led to groundbreaking innovations in small parts assembly and handling robots, along with some of the challenges. He also shares his thoughts on the future of the industry.

Findings – Brian Carlisle received his BS and MS degrees in Mechanical Engineering from Stanford University. After Stanford, Carlisle and colleague Dr Bruce Shimano worked for Vicarm, a three-person company started by robotics pioneer Victor Scheinman. Vicarm was sold to Unimation and Carlisle became Unimation’s Director of R&D where he and his team developed the PUMA™ series of electric robots and grew sales from \$0 to \$40m in five years. In 1983, Carlisle and Shimano co-founded Adept Technology and as its CEO for 20 years, Carlisle grew Adept to over \$100m in robot sales. In 2004, Carlisle co-founded with Shimano, Precise Automation, and is the President and CEO.

Originality/value – Brian Carlisle is a pioneer of the small parts assembly and handling robot. He was one of the key members of the team that developed the PUMA™ robot for Unimation. The PUMA™ robot was the watershed product that launched the assembly robot business in the USA and Europe. At Adept, he led the design of the first Direct Drive SCARA Robot and under his helm, Precise Automation introduced the first commercially available collaborative robots. Carlisle was President of the Robotic Industries Association for three years, is the recipient of the Joseph Engelberger Award for Leadership in Robotics, and an elected IEEE Fellow. He has served on the Board of the National Coalition for Advanced Manufacturing, the Boards of the National Center for Manufacturing Science, the Automation Forum of NEMA and is a founding member of the National Electronics Manufacturing Initiative. He holds multiple patents for robot designs.

Keywords Robotics, Cooperative robots, Flexible manufacturing, Assembly, Robot design, Handling

Paper type Case study

Pransky: Of all the robots you developed, what was your personal favorite, and why? (Figure 1)

Carlisle: One very significant one was the PUMA™ robot, which was a spinoff out of Stanford University and MIT. Vic Scheinman did some of the original conceiving and then I joined Victor at this little startup company called Vicarm in 1975, along with Dr. Bruce Shimano (Figure 2). At Vicarm, our three-person startup developed this six axis computer-controlled electric robot that we had delivered as a prototype for General Motors (GM). In around 1977, GM, which had taken delivery of these early Vicarm robots, came out with an

RFP (Request For Proposal) that they called the PUMA, a GM acronym for Programmable Universal Machine for Assembly.

That was the first time that a major industrial customer got the idea that you could use robots for small part or light assembly and that entire concept was based on that early Vicarm prototype. At Vicarm, there was no way we were going to be able to supply General Motors so we sold Vicarm to Unimation and became an R&D group for Unimation and developed PUMA™ robots, along with input from General Motors (Figure 3). So that was really kind of a groundbreaking new technology, specifically targeted for assembly (Figure 4).

My favorite project was the AdeptOne, which Dr. Shimano and I looked at when we started Adept Technology https://en.wikipedia.org/wiki/Omron_Adept. I had spent some time investigating a new technology with high reliability for assembly robots and identified direct drive motor technology as intriguing. The AdeptOne became the world’s first direct

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Figure 1 Brian Carlisle, President and Co-Founder, Precise Automation**Figure 2** Scheinman's MIT Arm, built for MIT's Artificial Intelligence Lab ca. 1972

Source: Credit: Wikipedia

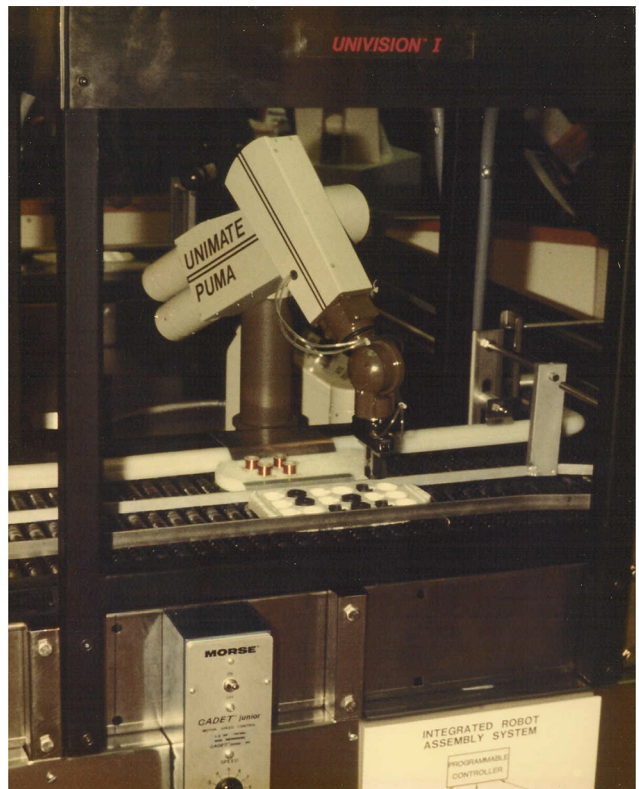
drive industrial robot, which eliminated gears in the two major axes. As a consequence, it was very high precision, extremely robust and reliable, and they were very successful robots (Figure 5). The AdeptOne was certainly what put Adept technology on the map and they sold 10,000-20,000 of them over the years.

Pransky: How did you and Precise Automation <http://preciseautomation.com> come up with the first collaborative SCARA robot?

Carlisle: For years and years, what we were trying to do, especially in the assembly and small part area, was make a robot as fast as possible. We started a kind of speed benchmark with

Figure 3 The Unimate PUMA™, shown here at the Smithsonian Institution, was developed by: (left to right) the late Joseph Engelberger, Brian Carlisle, Bruce Shimano and the late Victor Scheinman

Source: Credit: Smithsonian Institute

Figure 4 PUMA™ sales grew from 0 to \$40m in five years

the AdeptOne in trying to make robots very fast and highly efficient.

Subsequently, other people kept putting more and more power into the SCARA robot and also made the robot physically smaller, down to screaming speed. The issue with that approach is there's a point of diminishing returns. What

Figure 5 An assembly cell of AdeptOne SCARA robots for Xerox Corporation, 1986



happens when you double the speed is you need four times the power because there's this point where you're just wasting power while trying to make robots go exceedingly fast. Robots got to the point where they were much less efficient than people and they were wasting energy. At the same time, more and more protection such as proper screening, was being put onto these factory applications to protect people from getting accidentally hit by these high speed robots.

We started thinking: How can we make robots that run at a reasonable speed but are inherently safe? The whole collaborative thing was a fundamental philosophy change: Can we make robots that are as safe as possible instead of as fast as possible? And, could you do so without the high expense of having to separate robots with all kinds of shielding and screening from the people?

If you can set up collaborative robots and intersperse them with people on the assembly lines and have people do a more difficult job that might involve a lot of manipulation such as wiring, while having robots do the really simple tasks like loading and unloading a test fixture, then you could justify robots much more easily. Thus we started collaborative robots in a fairly narrow domain that was laboratory automation and life sciences.

And we picked life sciences and laboratory automation as an initial focus point, because the life sciences customers are going to be doing their R&D in the United States, and not do their R&D in China. Clinical laboratory applications, handling blood samples and urine samples, etc., are all regional, within a few hundred miles of the customer, and they're not going to send all that overseas to China. That whole industry was setting a trend for personalized medicine with more analysis and testing and to figure out treatment and analysis for particular diseases. In some cases, hundreds of people just sit there all day with what I call pipettors, these little suction devices that you squeeze with your thumb and you aspirate some fluid out of a test tube and then squirt it into another test tube. Some of these labs get 50,000 test tubes coming in one night and they have to analyze them all by the next day and not make any data errors.

The life sciences industry became Precise Automation's initial focus and we developed these collaborative robots that could work on laboratory benches, where they didn't have to be

walled off from the technicians who could walk up and load a new rack of plastic trays or test tubes and not worry about the robot hurting the technicians or the other expensive lab equipment (Figure 6). Precise now has a leading market share in that space by quite a bit.

Pransky: Did you have formal safety approvals or how did that work for the first times?

Carlisle: We actually started this development around 2008/2009 before the Robotic Industries Association (RIA) collaborative robot safety standards came out. However, we did track work that was going on around 2010 at the University of Mainz in Germany. They were doing tests on graduate students for something that they developed that I call a "pain machine".

They built a big frame with instrumentation and actuators on it that they would literally stuff graduate students in and they'd hit graduate students with applied calibrated pressures to various parts of the graduate students' bodies – the hands, torso, limbs – until the graduate student said, "Ouch, that's really, really painful." University of Mainz published some data in conjunction with the German equivalent of the safety agency there. www.dguv.de/medien/ifa/en/pub/ada/pdf_en/aifa0372e.pdf

Precise looked at that as we then designed our robot to be well under those safety limits. We built up these collision and force tables and had our data collection and tests verified by the TÜV, the European safety certification agency.

In terms of the RIA, there was not any agreed upon methodology for how to test for those numbers but in the spring of 2019, the RIA came out with a testing standard for collaborative robots, which was basically based on our publications of what we had been using internally at Precise Automation. One of the things we pointed out in our findings, but is not well understood, is that some of the companies that are out there right now who are calling themselves collaborative robots, are still using harmonic drives for the major axes of the robot. Harmonic drives are extremely stiff speed reducers. All speed reducers have the effect of generating reflected inertia at

Figure 6 Ekaterina Mikhalev at Ginkgo Bioworks' in Boston, Massachusetts teaches the Precise Automation PF3400 SCARA, the world's first collaborative four-axis robot



the output shaft which is equal to the inertia at the input shaft multiplied by the square of the gear ratio. In the case of high-ratio reducers, such as harmonic drives with a ratio of say 100:1, the input inertia is increased by a factor of 10,000 at the output shaft. For a table top four-axis robot with say a 200 W motor, the resulting inertia is equal to a 6 kg mass at the gripper. Given that there are typically 2 or more such gear trains in a series, a table top harmonic drive robot with a rated payload of 2-3 kg can have 12 to 15 kg of effective mass at the gripper due to reflected inertia. If you try to stop a robot with harmonic drives with your hands in a collision where your hand is trapped against a rigid object, these high-ratio robots will cause serious injury if they are moving faster than 100 or 200 mm/sec. To avoid this problem, at Precise, we use two classes of drives – low ratio timing belt drives and direct drive motors.

Pransky: in trying to stay ahead and project future market needs, what do you think will be the next evolution of small part assembly and handling robots?

Carlisle: I think it's not going to be so much about how fast you can go; it's going to be are you safe and can you use sensors effectively such as machine vision to feed parts? I think the other thing we will continue to see is a growing market for robots for parts that are five kilograms or less, as some parts and electronics are way down to a few grams level. Most electronics are assembled overseas and I think there's going to be a significant market, particularly in Asia, for a very small robot to handle one kilogram or less. Many of the electronic parts that are left here in the States are sort of medium-sized parts and tend to have a payload about four or five kilograms. So you'll see robots for just small parts.

I think that greater flexibility in grippers will certainly be important. Though there's been a lot of work in multi fingers or more flexible grippers, they're still pretty awkward, expensive and difficult to control. But at some point it's quite possible that more flexible grippers will be developed.

There's also a lot of interest in mobility right now, especially for general machine loading. There's a market to have a local robot come around with a vertical tower on a mobile base and intermittently service machine tools such as a core tester or some kind of processing machine like a molding machine, where there are various cycles that require loading and unloading.

Pransky: What is the single proudest moment of your illustrious career?

Carlisle: My proudest moment was probably when we started Adept Technology. We grew it from a startup to a public company and that was certainly a very big achievement.

Pransky: What is the biggest mistake or greatest lesson you've learned?

Carlisle: I think the biggest mistake occurred when Adept was growing very quickly back around 1998 to 1999. We had a lot of pressure to expand from several customers; one in particular, JDS Uniphase. We had been signing three-year leases on the

facility that we were in in Silicon Valley. This space went for \$2 a square foot, but our next lease was going to go up to \$6 a square foot. Instead, we moved over to Livermore, CA and signed a new ten-year lease on a much larger facility. This happened just before the whole market cratered when Adept's revenue went from \$120m down to \$40m. We had to honor this ten-year lease when the entire business from a market standpoint, suddenly collapsed, due to many of our automation customers moving to low cost labor in China. Signing a ten-year lease that obligated us to an inflexible cost structure in a financing business, was probably the biggest mistake that I ever made. We eventually renegotiated the lease but it was very painful. It cost millions of dollars, and while it didn't put Adept out of business, it took a tremendous amount of the cash that we had and it took years to get out of it.

Pransky: What do you think masters and PhD engineering students should be doing to best prepare themselves for the commercial world?

Carlisle: If you want to join a business and make an engineering contribution, I think the single most important thing is for people to understand and take courses in systems engineering. Engineers that want to grow to be team leaders in robotics need to be good across multiple disciplines. You can't just be a mechanical engineer and know nothing about software, electronics or machine vision. There are now these mechatronic-type of interdisciplinary curriculums that are available at a number of universities. I also think that the ability to work as a member of a team and understand team dynamics to form and achieve goals, make tradeoffs, listen to other people's opinions, and reach a consensus, are really important.

If you want to start your own business, there's a whole other layer of education that's extremely useful. The first thing is you really need to at least take some courses in finance. You need to understand cash flow, balance sheets, and know what P&L (profit and loss) is because if you want to start any kind of small company, cash is king and if you run out of cash, you shut the place down. I've seen lots of entrepreneurs that were all focused on the technology and ignored the business side of the finance/cash side and just ran out of cash.

The second thing that's critical is marketing. Technology does not sell itself. A lot of engineers think, "I've got a great new technical idea, and I'm going to invent this thing and the world will beat a path to my door". But that just never happens. You need to understand marketing, market analysis, and ways to reach the evolving market. You need to understand product positioning. How will people view your product relative to others?

Lastly what is useful, although I certainly dismissed it when I went to school, is psychology, at least an introductory course. Ideally, the psychology of teamwork and personnel management, because much of what you wind up doing as a manager is motivating, understanding and listening to people. One of the things I learned over my career as a manager is you've got to understand the hidden and unstated motivations. There's way more psychology involved in managing a business than you would ever imagine.

Pransky: As you get older and less able, would you prefer to be assisted by a robot or human caregiver, or a mixture of both?

Carlisle: Probably a mixture of both when it comes to some things. For example, you can imagine when going to the bathroom, a very personal thing, that it might be more comfortable to have a robot than a human caregiver engaged in that sort of thing. When it comes to companionship and someone to talk to, I think the human caregiver is certainly a lot more compelling than some sort of a robot trying to emulate a human character.

There certainly would be a market for these type of service robots if we could do it, although we still have a way to go. We still need development in a lot of the core technology and that includes collaborative robots that wouldn't hurt people while they're helping them, but even more so, we need mobility. We need dexterity. We need grippers that can grasp a wide variety of things. We need to continue to develop machine vision and to develop some AI. We need environments, i.e. homes, condominiums or townhouses or assisted living facilities that are designed with the capabilities and limitations of the so-called service robots in mind. Additionally, we need to make home robots more user-friendly, less threatening and also not invasive. One of the things that people find intimidating and scary about technology with devices like Alexa and others, is

hooking up the internet to their personal space, and the risk of entities whether it's tech companies or hackers or weird people, somehow getting access into your home and that is the single most invasive thing you can imagine. If we're going to do home robots, there has to be thought and care for privacy and security and comfort.

About the author

Joanne Pransky has been an Associate Editor for *Industrial Robot Journal* since 1995. Joanne was also one of the co-founders and the Director of Marketing of the world's first medical robotics journal, *The International Journal of Medical Robotics and Computer Assisted Surgery*. Joanne served as the Senior Sales and Marketing Executive for Sankyo Robotics, a world-leading manufacturer of industrial robot systems, for more than a decade. Joanne, also known around the globe as the World's First Robotic Psychiatrist®, has consulted for some of the industry's top robotic and entertainment organizations including: Robotic Industries Association, Motoman, Staubli, KUKA Robotics, STRobotics, DreamWorks, Warner Bros., as well as for Summit Entertainment's film "Ender's Game" in which she brought never-seen-before medical robots to the big screen. Joanne Pransky can be contacted at: joannepransky@gmail.com