A 30-Year Perspective: The Past and Future of Robotics *by Jeff Chapman*

As it appeared in the 2004/05 RIA Print Directory

Congratulations to the Robotic Industries Association (RIA) on reaching its landmark 30th year as the only North American trade association charged with driving the growth of the robotics industry. All that has happened in robotics during the past 30 years really comes into focus when you review old videos of the early robots and their applications. In 2003, I helped create the opening video for the annual RIA Robotics Industry Forum in November, and as I searched for video for the project I enjoyed viewing all the old tapes from the RIA archives. When you see those grainy images, you can't help but marvel at the strides we've taken since Joe Engelberger launched an industry with his fantastic, hydraulically actuated, Unimate robot arm.

The industry grew slowly at first, but then in the late eighties and through the nineties it enjoyed steady growth until the tech bubble burst and 9/11 happened, bringing us a business downturn that finally seems to be fading. The good news now is that once again grippers are gripping, motors are whirring and products are being manufactured. The use of automated manufacturing processes and equipment, including robots, is back and on the upswing.

Now is the time to evaluate the past and to use lessons learned to formulate a plan for the next thirty years. To help put things into perspective, I've asked some industry experts to provide their thoughts on some very important questions. As a provider of professional search and recruiting services to the robotics industry for the past 23 years, I've had the good fortune of having developed wonderful industry contacts that I call colleagues and friends, some of whom agreed to help sort out robotics past, present and future. They are all very busy people but are always willing to give their time to support the RIA and the robotics industry. I thank them for their participation and their insight (and for returning my phone calls).

Brian Carlisle

Brian is president and founder of Precision Automation, but is more widely known as co-founder and past president/CEO of Adept Technology. In 1994 he won the Joseph F. Engelberger (JFE) Robotics Award.

Charlie Duncheon

Charlie, a recipient of a JFE Robotics Award in 1999, started his career as an engineer at Monsanto. Before moving into consultancy, he was executive vice president of Adept Technology. He is an Engleberger award winner and a past president of RIA.

Craig Jennings

President of Motoman and a veteran of the business, Craig began his automation career with GMF (now FANUC Robotics), Craig also is a past president of RIA.

Tom Jerney

Sales manager for automation machine and system builder, Oak River Technology, Tom has more than 20 years experience selling robotics and automation.

Joe Gemma

Joe is general manager of North America for Staubli Corporation, and has worked on the systems integrator/machine builder side and on the product side (robots) of the business for more than 20 years.

Adam Brown

An “up and comer” in the robotics business, Adam has a Mechanical Engineering degree from Purdue, and now works as business development manager at Universal Instruments.

Here are the questions and some of the many nuggets of wisdom gathered in my conversations with these knowledgeable industry professionals.

JC Looking back, given the opportunity to do it all over again, what would do you think the industry should have done differently?

Brian Carlisle: “The people who first developed robots imagined these universal mechanical devices so they focused more on the machine technology and less on targeting a particular market and a particular application. Those companies that have been successful and those industries that have learned to apply robots, have learned to use them in a few high volume applications so I think if we had it to do all over again we would certainly start by thinking

about the application first and then targeting the mechanical and software designs more toward providing specific application functionality."

Joe Gemma: "The mechanics of robotics were well ahead of the software and expectations were set very high. Industry was generally disappointed in the earlier days because robots could not meet the expectations. We could have told a better story and progressed more slowly and more steadily, allowing the development to happen. We also didn't listen to the customers well enough."

Craig Jennings: "The industry should have held its ground on what qualified as a good application for a robot. Specifically we should not have tackled applications that required too much in sensory feedback, both vision and touch, as the computing power was not there in the early to mid-Eighties. Also, cycle time commitments should have held at industry benchmarks."

Charlie Duncheon: "For people who got started in the very beginning there were a lot of missteps which happens in the startup of new technologies. Most missteps relate to the eighties when things started to pick up and there was a fervor for robotics and when that happens people tend to move quickly to answer the interest. In general the industry had an exaggerated perception of the end user's ability to implement automation. The robot companies attracted very bright people and they over estimated the end user's ability to understand how to implement. There was a lack of application focus in the early days when too many people tried to do too many things with the same robot. For example there were companies trying to do arc welding and electronic assembly under the same roof."

JC Based on past lessons learned, what adjustments have you made for the future?

Tom Jerney: "Focus on industries that are impervious to change like Medical devices, food and photonics and find processes that humans can't do regardless of economics."

Craig Jennings: "We have to be clear and honest with our customers as to what can be done and what alternatives will cost. We can't over-commit or under-deliver. Sometimes we will lose orders due to our unwillingness to tackle specifications we do not feel are achievable

but in the end, these customers will call us again for their next project or to fix their current project."

Adam Brown: "We're now asking more questions of our vendors and we are talking to our customers before making a design decision. We've learned that it's not always wise to be on the cutting edge of your vendor's development road map and having contingency plans [for other approaches] is vital to keeping products shipping to customers."

Brian Carlisle: "I think if we had it to do all over again we would certainly start by thinking about the application first and then targeting the mechanical and software designs more toward providing specific application functionality."

Charlie Duncheon: "The more you can focus on developing for the application the simpler the application software layer is and the more robust and cost effective the solution becomes."

Joe Gemma: "We have all learned to listen better to customer demands regarding product development from both the hardware and software perspectives. We have tried to bring more added value to our products which benefit multiple industries."

JC What technology advancements are likely to most impact robotics in the next three to five years?

Adam Brown: "Sensing and controls will see the most advancements in the near future, specifically in the area of vision sensors. Prices have come down enough on high-quality vision systems to make them a viable option for many steps of a robotic manufacturing process. This will benefit robotics the most by producing a more robust solution that is tolerant of normal variations but able to catch real defects. The area of personal robotics will also see substantial growth in the next few years as consumers now can choose to automate such mundane tasks as cutting the grass or cleaning the house. Costs continue to drop on these products and those companies are finding more effective paths to the market."

Joe Gemma: "The food industry is the automotive industry of the future, and I believe we will

see more product development specific to this market. Additionally, the bio-tech area is really starting to become a force in manufacturing and will effect product designs."

Charlie Duncheon: "In the near-term you are going to see more and more of the effect of micro electronics technology and with the compression of the form factor will come the ability to do processing and control at the sensor level. You can push the smart components and embed and distribute them throughout the mechanism. This can be done with FireWire with deterministic Ethernet leading to dramatic cost reduction, performance and reliability enhancement because you are eliminating components that are subject to failure. It will get a lot more like the human body, no longer a mechanism cabled to a big box to control it, the smarts are disseminated throughout the mechanism. High-speed networking allows for multiple axis coordinated motion. We'll soon see, for the first time, form factor changes on the mechanical side."

JC What do you think the state of the art in robotics will be in 30 years?

Adam Brown: "State-of-the-art in 30 years will mean that robots will be more aware of their environment without having a human tell them what's there. Right now we spend a lot of time teaching and providing instructions to robotic devices to the point where the overall payback is not what we expected. I can see a time when sensing and control systems are smart enough to map out an environment that a robot can use to complete a task with only loose instructions from humans. There is a need for a basic "brain" for robots that combines sensors and computer processing to automatically construct an environment with inputs from various sensing technology. Once the robot has a complete and accurate idea of environment, it makes the teaching task much easier. Right now everyone is writing their own robot control programs for their specific task and we end up doing a lot of redundant development across the industry. Humans all have the same brain "hardware" to begin with that includes an awareness of our environment, why can't robots evolve to the same level?"

Brian Carlisle: "Thirty years out our concept of a robot is going to become many, many different concepts. There is going to be an explosion of different robot applications outside of manufacturing and highly structured environments in the next thirty years. In a very general sense, a robot is going to be a computer with some way to sense and act upon the physical world.

For the last 30 years computers have been these disembodied boxes that had no inputs or outputs other than a keyboard. Now computers are being hooked up to sensors and actuators for controlling motors, wheels and planes. The robotics technology that has been developed for motion control, sensing and reasoning and navigation will be used for many different applications like toys and entertainment, bio-engineering like artificial organ development, actuator driven prosthetic devices controllable by the human, and autonomous vehicles for exploration. People are already looking at planes that can fly themselves and land themselves."

Joe Gemma: "If I had a crystal ball.... I would play the lottery!" We say today we have integrated vision that has allowed robots to react to what they "see." It is still a primitive version of the human aspect of vision and process. It is not unreasonable to believe that we will have real, seeing "humanoids" in the next 30 years. Can you say "Jettsons?"

Tom Jerney: "Robotics technology will see the most change in the areas of software, data, feedback, controls and communications."

JC What new technology frontiers are there for automation?

Brian Carlisle: "We believe that one of the very important things is this whole trend toward miniaturization. The environments to manufacture these things cannot allow any contamination from people. We are down to the level where we are putting things together with tolerances that are approaching the wave length of light and people just cant handle those parts; they can't see those parts; and they can't align those parts. So this whole area of miniature, micro and nano-technology is certainly going to be an area where industrial robots are going to grow and in fact it's going to be impossible to develop those areas much further without that kind of technology."

Charlie Duncheon: "New, lighter, stiffer materials that will decrease inertia and increase cycle times are being studied. Smart electronics will be designed into these new materials that will lead to something that, frankly, will be more human-like."

Adam Brown: "Miniaturization is an area in automation that holds great potential. Many are focusing on MEMS and nano-scale automation right now, but there are lots of applications in

the micro scale as well. Being able to manipulate objects and materials at this level is an exciting new area for automation."

Craig Jennings: “Continued advancements in sensory technology in performance and affordability will open up a myriad of new markets like the body invasive medical field.”

Brian Carlisle: “While we’ve miniaturized electronics, we’ve done less well miniaturizing mechanical systems and I think in the areas of actuators. When you consider the amount of power consumed by a person at rest it’s about 100 watts. A person running around a track might consume 250 watts. We are a very, very long way from developing a robot that can run around a track and only consume 250 watts, so the whole area of actuators has a long way to go.”

JC What kind of talent will be the most difficult to find in the future?

Charlie Duncheon: “There is going to be a whole new wave of requirements for multi-disciplinary engineers who know software, electronics and mechanics.”

Brian Carlisle: “One of the two areas I believe we are shortest on talent are systems engineers, that is people who have a very good sense for how you make trade offs between a mechanical system, a controller and software in order to perform a particular application. That requires a multi disciplinary approach. It requires program management capability. It requires some sense of marketing and understanding the value of what the customer wants. We don’t do a very good job of training engineers in these systems discipline so that can evaluate market needs and application needs. We tend to focus on one or two technologies and we get a lot of highly trained specialists. In the U.S. there is a move away from interest in mechanical engineering and design. Mechanical design is very highly regarded in Japan, China and Europe for that matter. In the U.S. we tend to regard that as somehow less rewarding engineering when, in fact, I that many of the breakthrough areas will be in that area.”

Adam Brown: "Well-rounded individuals will be hard to find. We no longer need dedicated Electrical Engineers who don't need to know anything mechanical or a Software Engineer who doesn't understand the user's application. Someone who feels comfortable with several

areas of expertise and can quickly adapt will be hard to find. Overall, I think Engineers with Business expertise continue to be in high demand. Only having an MBA is not enough; the bar has been raised for managers."

Joe Gemma: “I would say that with the advancements in technology, finding strong technical sales people will be increasingly difficult (of course I come from the sales side so I would say that!). Another area is in real creative engineering talent.”

Tom Jerney: “The kind of people that will be difficult to find in the future are those who can conceptualize and create a solution knowing what does and doesn’t work in a specific application.”

JC Are you comfortable with the quality and quantity of the available talent to ensure success for the industry?

Charlie Duncheon: “One of my concerns is that with all of the migration of manufacturing to Asia, high school students will get disillusioned with manufacturing as a career goal which may result in a shortage of manufacturing engineering and automation talent.”

Craig Jennings: “The good news is that there are accredited universities with robotics programs that are training qualified people and with so much software development going off shore the engineers who did that type of work are again turning their talents to automation and robotics.”

In Summary

The lessons of robots past have been closely studied by industry leaders to prepare them for a successful future where realistic commitments made and kept will continue to solidify robotics as a cost effective way to compete in the world market. Paying close attention to customer input, robots will be developed with the specific applications in mind while new materials are applied to the physical design and sensors with embedded intelligence will improve cycle time and throughput and overall product quality and value. More attention will be paid to developing applications that humans just can’t do such as machines for nano-positioning. The growing importance of computer, software, controls and sensor technologies will further en-

hance the capability of robots forcing engineers to become more conversant with the broad set of disciplines required to most effectively create the robot of the future. In thirty years the prospect of human like robots may become a reality, and for those who are fortunate enough to see that day, today's robots will seem every bit as simple as that very first robot, the hydraulic Unimate, seems to us now.

And finally, something that Craig Jennings mentioned as we finished up our conversation: "The flow of manufacturing to off shore markets will decrease as they struggle to meet quality demands and their manufacturing costs escalate. Robotics based manufacturing will win and flourish."