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Inside CIM this month

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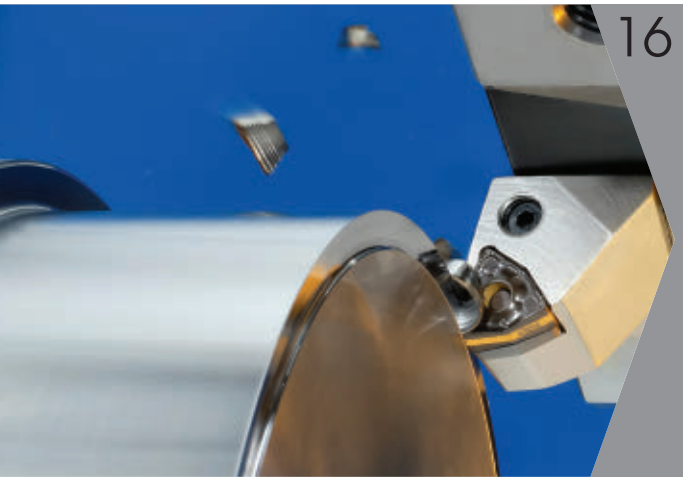

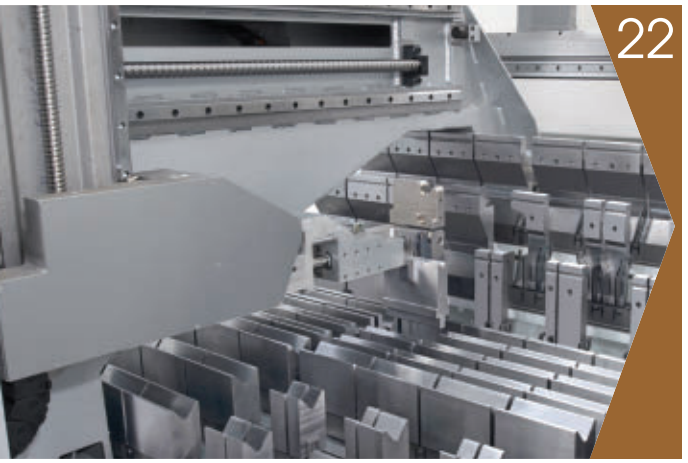

On the cover:
Charles Khairallah, founder of Montreal's Robotics Design, is shown with two mobile robots that incorporate the company's modular robotic technology. Photo by Vitali Dzemidziuk.

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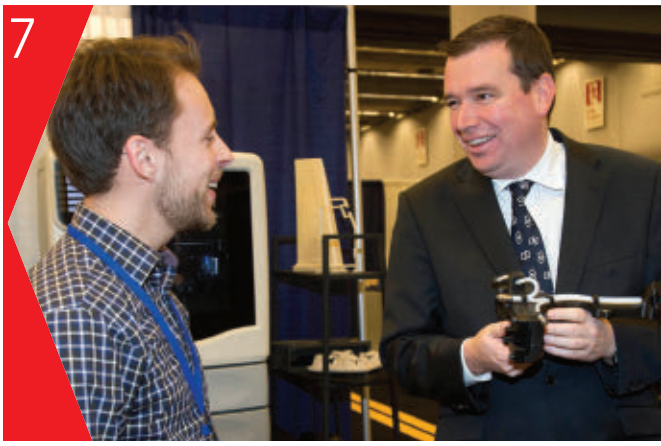

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Imagination Drives Design

Robotics Design builds nontraditional robots one module at a time

By Sue Roberts
Contributing Editor

Modular robotics, at least for Charles Khairallah, owner of Robotics Design in Montreal, was a bit like the chicken-or-the-egg conundrum. The advanced technology that grew out of research at the École de technologie supérieure, University of Quebec, and provided the foundation for his company was ready to go to market, but the market wasn't ready to embrace the technology.

"We had to educate and convince the industry to go in this direction," said Khairallah. "The market of industrial robots was controlled by a few strong companies. The market was very strict, and industry was comfortable with the existing robots. It was not willing to take risks by changing their work methods. They were afraid to make a radical change to go with modularity or hyper-redundant robots."

The possibility of using modular robotic technology in components for toys, aerospace and defense systems, industrial maintenance, and everything in between needed to be communicated to manufacturers. A main difference, said Khairallah, is that a conventional robot with 6 degrees of freedom and without a reconfigurable architecture offers one or two ways to go from point A to point B, but Robotics Design's approach offers an unlimited number of paths. Modularity provides flexibility and options. "With our robots, the problem is deciding how to go from A to B in the best way. It's a good problem."

Cellular Design

The company's technology, accepted in several markets today, is named **ANAT™** for **A**rticulated **N**imble **A**daptable **T**runk. It basically comprises a series of U- and H-shaped modules that work together. Khairallah described the interaction as similar to the cells of the human body. Each module connects to the next at four locations. This gives the robot its snake-like flexibility and allows the arms to withstand outside pressure and carry heavy payloads or tooling like a camera, drill, or welding torch. A motor is embedded in the central axis of each module to create and control movement.

Individual modules have 1 degree of freedom, bending and folding along the axis relative to their linked neighbors and assembled in such a way as to eliminate gravity effects. The resulting robot, similar to a bicycle chain, has the ability to move, twist, and turn to avoid obstacles and perform tasks in tight spaces.

Modules can be connected to meet one need, and then disassembled and reconfigured to accomplish a completely different task. Modularity also adds to ease of repair. If one module has a problem, it can be removed and replaced quickly with another standard component.

Khairallah described the **ANAT** modularity as LEGO®-like. "Modules can be combined in myriad ways, but like the building blocks, imagination is required. To build traditional robots you might need 100 different

The essential module shown on the left combines with other modules, right, to create virtually unlimited flexibility of **ANAT** technology.

Charles Khairallah, shown with an **ANAT**ERGOARM snake arm toolholder, founded Robotics Design after emigrating from Lebanon. He earned his master's degree in engineering in technology systems with a specialty in robotics from ÉTS, École de technologie supérieure, University of Quebec. He works with students at ETS and other higher-education institutions around the globe to advance his modular robotic technology. Photo by Vitali Dzemidziiuk

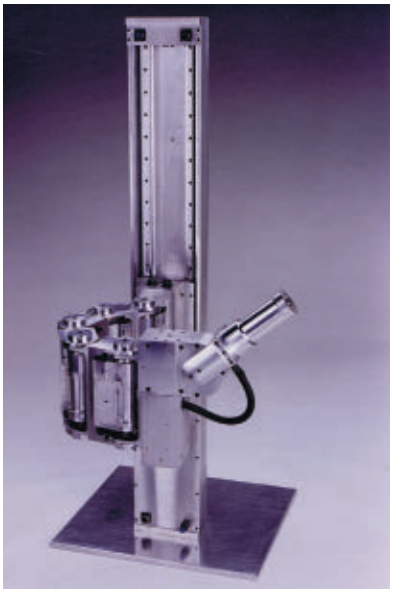
kinds of parts. With ours, you might need many of only one type of part. This technology is a genetic family of products. We can create different products from mass-produced, identical modules which are scalable for larger or smaller robots.

"We designed flexibility in the mechanics of our robots, not just in the programming. The mechanical flexibility allows us to change the nature of the robot as easily as a programmer can change the task of a program; we can use the programming to reconfigure the robot to change the task performed."

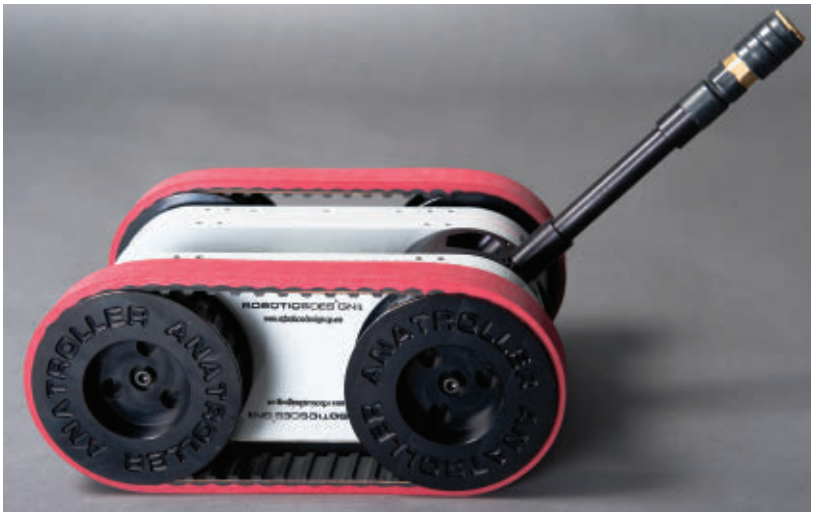
Designing robots based on one component, Khairallah said, provides design freedom and a delivery advantage. "Robots and snake arms are typically designed around a challenge faced by a client, especially in regards to working in tight spaces."

From a Compact Space

Design, assembly, and testing of each module are done in the 1,000-square-foot facility in downtown Montreal. Machining is outsourced to several shops in the area. "We take the maximum of the competency of each shop, only the best of the best, and assign them a part of production," said Khairallah. "Because we work project by project, outsourcing the machining is a good strategy for now. Technology is our product, and this lets us incorporate our technology into the physical robots without the investment in ma-



This modular manipulator robot has 8 degrees of freedom.



The base of the **ANAT**ROLLER ARI-100, dedicated to duct cleaning and inspection, includes an articulated arm that can move in all directions while spinning an attached cleaning brush. A camera is added to allow inspection and visual monitoring.

chine tools."

Shops contributing to Robotics Design's modules specialize in working with aluminum, which comprises approximately 80 percent of each module. In 2011, about 1,000 kilograms of aluminum went into **ANAT** robots.

Khairallah programs the modules for the robots, often a very complex task, but the end result is presented to the user in a visual, easy-to-use format. His focus is on simplicity. "You need a course at a university to program some robots, but with ours, training would take maybe one day."

Adaptive Marketing

To gain the attention of the 1997 market, Khairallah adapted his product. He incorporated part of the technology into robots designed to meet industrial needs. "For example, we started with a hyper-redundant robot with 32 degrees of freedom. That robot had an arm that we could cut in many parts. We took one part of this arm to build the robot, added wheels, and created a new family of **ANAT**ROLLER™ mobile robots using a part of our technology.

"Our technology now … you can find it everywhere. Companies are using the essence of our technology in toys, bike stands … many products, and we have negotiated licensing," said Khairallah. "In most cases, our customer becomes a strategic partner and leads us to more customers."

Modular Business Model

The company itself is modular, expanding and contracting as needed. "We have an internal team and we access external consultants for individual projects. The expertise of the people I work with depends on the project. We can always adapt."

The breadth of application possibilities, which Khairallah described as a good challenge, was dealt with by creating separate divisions within the company. Each division is responsible for a market niche.

"The divisions don't interact with each other in terms of commercialization or distribution," Khairallah said. "A division can grow independently. We can let her fly without affecting the other divisions." The interaction exception is technology. Research and development done for one division is shared and benefits the markets served by the others.

The HVAC division has been successful in introducing the modular robotic architecture to a variety of products, including cleaning robots that crawl along the interior of ducts to perform air quality improvement tasks.

Patents and Awards

Customers around the globe have provided projects, resulting in more than 18 patents for the company and a number of awards. Each project adds to the patent count because each customer problem is solved with a unique design. "We have many projects today; more in Europe than Canada. For now European markets seem to be more open to change and new technology. The North American market will react differently, with industry bringing manufacturing back to be done locally, and Robotics Design seeks companies willing to adapt to new technology. Manufacturers are recognizing that automation and robotics provide a competitive edge."

The **ANAT**ERGOARM™ TMA-500, a modular manipulator arm designed for Hydro-Quebec's work on hydroelectric turbines, garnered the

ANATROLLER ARI-10 is a miniature mobile robot with a rotating HD camera that works in vertical and horizontal ducts.

company the 2011 Les Prix Innovation en santé et sécurité du travail, presented by the Association pour le développement de la recherche et de l'innovation du Québec (ADRIQ). The manipulator arm can be stationery or mobile with the ability to carry 500-kg payloads along a deployable aluminum rail. It flexes around obstacles and maneuvers through tight spaces to accomplish tasks that could be physically demanding and potentially dangerous to maintenance workers.

The modular unit of the **ANAT**ERGOARM snakes around obstacles and handles 700-pound breaking units at Hydro-Quebec's Robert-Bourassa generating station, saving maintenance time and reducing risks to personnel.

Khairallah was a member of the team that developed the BIXI© Public Modular Bike System, which began in Montreal and is now found in cities throughout Canada, the U.S., England, and Australia. Similar to **ANAT** technology, a removable module that allows the system to interact with its pay station is part of every bike dock. *TIME* magazine named the BIXI system the 19th best invention of 2008. This project added three patents to the Robotics Design count.

Applications of Tomorrow

Khairallah anticipates three key areas for robotic growth.

The first is the service robot. "If you need a service, such as air cleaning like that provided by the HVAC robot today, you will use a robot. It will need an operator to provide service from company to company.

"Another is the personal robot, the fastest-growing niche in robotics today. In five years we won't need to have a PC. We'll have a robot that can do all that a PC can do, plus we can teach him, talk to him, he can talk to us, he can read the journal for us. As PCs advance and become faster, robots gain an advantage because they can incorporate the new PC technologies and they can do the same with advancements in telecommunications. All technologies converge in robotics in the end."

The third area is defense. Khairallah's vision of the future anticipates "Star Wars"-type battles fought by robots rather than humans.

Modular robots continue to gain acceptance. Manufacturers are more convinced of the advantages the technology offers, and the robots themselves have become more user-friendly and less expensive.

"Modular robotics can make a revolution in industry. They are easy to work with and allow anyone, any size company, to use robots for production. Even if you make pizza, you can use a robot to make it cheaper, faster, and have the same outcome each time."

But, Khairallah cautioned, robotics can be dangerous if manufacturers lose sight of the goal that he defines as advancement through simplicity. "We need to control the future, build machines to serve humanity, not allow humanity to serve the machines. We need to do what is correct."

www.roboticsdesign.qc.ca

Each bike dock in the award-winning BIXI Public Modular Bike System contains a Robotics Design module that allows interaction with the pay station.