Mind / Iron

by Bryan Bergeron, Editor

INFRASTRUCTURE

A fundamental aspect of robotics is that the application domain can range from ocean beds and table tops to the nooks and crannies of extraterrestrial dunes. It's no coincidence that the techniques and technologies described in the article featured in this issue of *SERVO* can be applied to virtually any application areas. However, if you have a particular interest in space exploration, then you'll find Fulvio Mastrogiovanni's article, "Space Robotics," of particular note. Fulvio, a PhD candidate from the Mobile Robotics and Artificial Intelligence at the University of Genova, Italy, offers a focused consideration of control theory applied to the practical challenges presented by the NASA Mars Explorer Rover mission. The article also hints at an often ignored and poorly understood aspect of robotics — that of infrastructure.

Space exploration and transport, together with development of more traditional military gear, are responsible for many of the innovations in sensors, software, and platform designs that trickle down to civilian robot developers. However, even if you have access to the components and algorithms used by NASA engineers, you'd probably find it impossible to develop a robot that even approximates the abilities of the impressive Martian rovers. The missing ingredient is infrastructure — the robots, conventional tools, and processes used to develop the vehicles and robots destined for space.

Consider the array of advanced robotics used in the construction and testing of the shuttle's external tank. The shuttle's external tank, which has a length of 55 feet and diameter of 28 feet, is fabricated at the Michoud Assembly Facility, near New Orleans. When I toured the facility, I was amazed at the robots and other automated equipment required to achieve the tolerances necessary for space flight. In particular, I witnessed a fully assembled fuel tank mounted horizontally on a motorized spindle in a way that enabled robots to apply insulating foam to the aluminum-lithium tank. I tried to imagine the control systems and motors necessary to rotate the 58,000 lb tank and maintain a precise coating depth. Although I haven't seen it first hand, I assume that the robotic equipment used to create the multi-stage Boeing Delta II that transported the Martian rovers is just as impressive.

Sam Christy's article on programming for FIRST controllers and Tim Paterson's article on square roots illustrate a key 'invisible' component of the infrastructure required to develop robots. If you're like many roboticists, you probably have a drill press, soldering iron, a few boxes of spare parts, perhaps a library of reference texts, and a PC. To the uninitiated, the PC may be simply another artifact in your workshop. However, if you're involved with developing control loops, machine vision, wireless communications, or other computational tasks, then your PC may be your primary development tool. In this regard, traditional tools and components often fail to capture the enormity of effort, planning, and time that goes into developing a robot.

If you're new to robotics, then you're just beginning to appreciate the depth and breadth of your development infrastructure (or lack of it). Whether you're primarily involved in developing pneumatic weapons for battle bots or vision recognition algorithms for a commercial robotic platform, you'll soon discover that a development infrastructure is a prerequisite for efficient, unencumbered robot development.

At the start of my robotics career, I invested almost a year of effort developing a flexible infrastructure. The major components include:

- Drill Press and Bit Assortment
- Vise
- Work Bench
- Dremel and Accessories
- Dual-Trace Digital Oscilloscope
- Multimeter
- Regulated Power Supplies (3)
- Lamp
- Glue Gun
- Heat Gun

Mind/Iron Continued

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In re-reading my December 2007 Robotics Resources column, I spotted a small error regarding the light wavelength of the laser diodes used in DVD players. Most commercial DVD players use 650 nanometer (deep red) laser diodes, rather than the 780 nanometer (infrared) laser diodes common in CD players.

Gordon McComb
Robotics Resources

- Air Compressor
- Hand Tools
- Glues and Adhesives
- Nut and Bolt Library
- Clamps
- Cables, Wire, and Shrink Tubing
- Connectors and Pins
- Soldering/Desoldering Station
- R/C Unit
- Nibbler Tool
- PC
- Software (Schematic generation, simulation, compilers)
- Sensors (US, IR, motion, etc.)
- Microcontrollers (STAMP, PICs, ATMEL)
- Storage Bins
- Breadboard System
- Multi-drawer Tool Chest

I'm still working on the infrastructure, but at a much lower level. So, how do you go about building an infrastructure? If you're fortunate enough to be financially well positioned, then the anticipatory approach is a viable option. Assuming that you can accurately anticipate your upcoming needs, then you can assemble an infrastructure within a few weeks. Even with equipment in hand, you'll need several weeks to learn how to operate and apply your new hardware and software.

At the other extreme is the as-needed approach, which entails purchasing tools and test equipment on an as-needed basis. While easy on the pocket, this approach often results in a loss of momentum. Stopping a project midway to await delivery of a drill or torque wrench and then learning how to use the device can derail an otherwise focused project. There is also the defocusing associated with taking time to identify the best oscilloscope, drill press, or other item.

The two approaches aren't mutually exclusive. For example, I use a hybrid approach in which a few major purchases — drill press, multimeter, hand tools, and oscilloscope — are added to as needed. I've learned the hard way that when you build an infrastructure, buy the best that you can afford. Don't be lured by an inexpensive hand tool or soldering iron that will satisfy your current project. Instead, try to anticipate what you'll need over the next five years. It costs more to buy a cheap tool and then a more expensive tool a few months later, than to buy the right tool to begin with. I'm a big fan of eBay where — if you're patient enough — you can find good deals on equipment that might otherwise be out of your reach.

Another option is to outsource your infrastructure by joining a well-stocked robotics club. For modest dues, you can have access to a supportive infrastructure that may prove invaluable to your success in robotics. A related approach is to extend your infrastructure with external services, such as laser cutting. I use Pololu Robotics and Electronics (**www.Pololu.com**) for laser cutting on large projects. Outsourcing can be expensive, but it allows you to focus on what you do best.

As a word of warning, as you construct your infrastructure, remember that it's tempting to use robotics as an excuse to amass a huge collection of fantastic tools and equipment. This is fine if your intent is to collect tools. However, if your goal is to produce functional robots, then do your best to avoid the seduction of gear. **SV**