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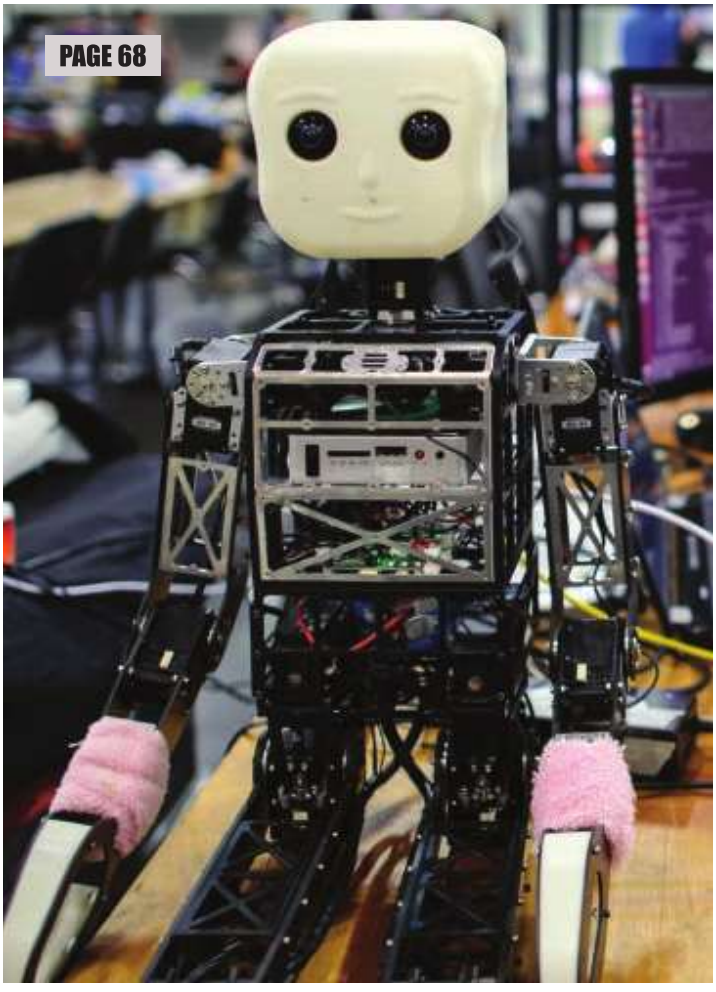

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Mind / Iron

by Bryan Bergeron, Editor

Back to Basics — The Universal, All Digital Device isn't Necessarily Nirvana

I recently acquired a handheld loop magnifier from eBay for $8. Not a bad deal, considering it has glass optics and provides about 30X magnification. Of course, I could have picked up a more versatile USB microscope for about $40 and have the full power of PhotoShop and other image processing software at my disposal. Thing is, I already own two rather high-end USB microscopes.

It's just too much of a hassle to boot up an application and plug in a USB microscope when I want to quickly examine a solder joint or make out the part number on a chip. My new 30X loop magnifier, in contrast, is always on my workbench, ready for instant use. True, I can't save a copy of the optical image and send it to a friend or use it with this article, but most of the time I don't need to.

This is just one example of what I've come to realize is the failure of the do-everything smartphone or tablet. In theory, it makes sense to have everything available through a single device — why have multiple LCD screens, multiple processors, and multiple keypads when you can do everything with a single set? In practice, however, the digital equivalent of a Swiss Army knife isn't necessarily nirvana.

Like a physical Swiss Army knife, a digital device capable of doing everything isn't usually optimum for doing any one thing in particular, and certainly isn't good for doing things in parallel. For example, I have a package that transforms my iPad into a digital oscilloscope. While this is great for traveling, when I'm home, I use the dedicated o'scope, DMM, and other instruments on my workbench.

I suppose the real issue is workflow. While I love the idea of having a single device that can serve any purpose I imagine, I have yet to find such a device that truly supports my workflow. It could be that I learned electronics and robotics using stand-alone devices. Perhaps I need to alter my workflow to suit the most modern digital tools available — but I'd rather not. I'd prefer to keep my programming intact.

My bias to simplicity is reflected in my robotics work. Instead of designing all-purpose robots with a single point of failure, I develop application-specific models. Today, the advantages of having multiple robots — each capable of performing one or more tasks simultaneously — trumps a general-purpose machine. This is likely to change in the future, when the cognitive and physical capabilities of robots approach that of their multi-purpose human designers. It's only a matter of time. SV

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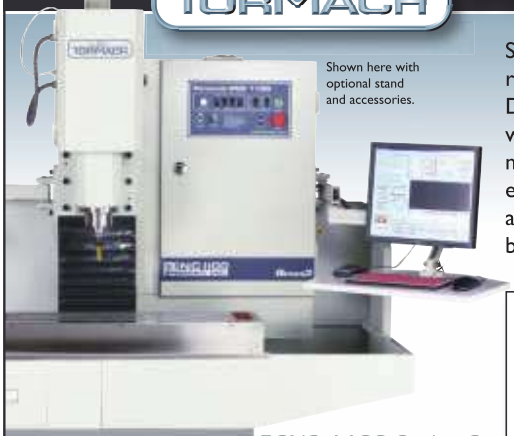

Shown here with optional stand and accessories.

Shown below is an articulated humanoid robot leg, built by researchers at the Drexel Autonomous System Lab (DASL) with a Tormach PCNC 1100 milling machine. DASL researcher Roy Gross estimates that somewhere between 300 and 400 components for "HUBO+" has been machined on their PCNC 1100.

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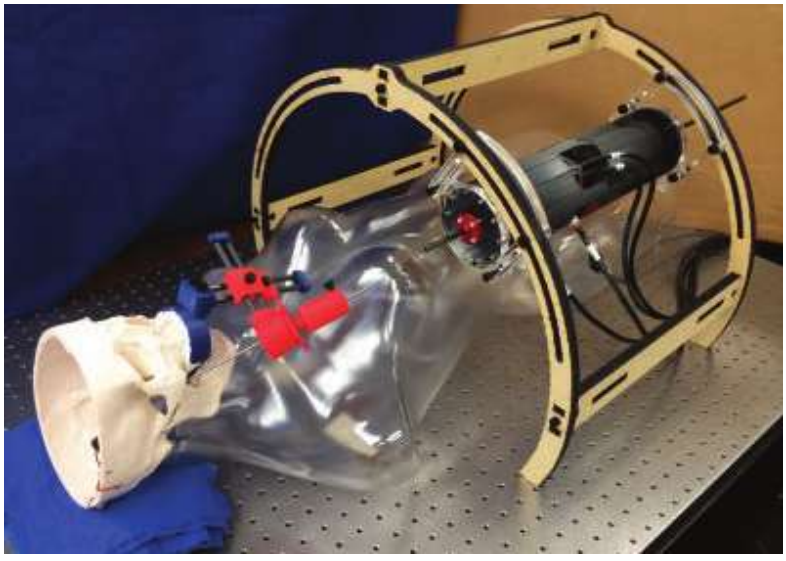
Robytes

by Jeff and Jenn Eckert

It Really *is* Brain Surgery



Mockup of patient being treated in an MRI.

People who suffer from severe epilepsy that cannot be controlled by medications can sometimes be treated successfully through surgery. Unfortunately, that means drilling a hole through the skull and deep into the brain to reach the hippocampus — a highly invasive procedure. However, five years ago, engineers at Vanderbilt University (**www.vanderbilt.edu**) mused that it might be possible to reach the lower section of the brain from beneath the skull. The trick would be to create both a steerable shape-memory needle and a robot to precisely guide it. Furthermore, the robot would have to be suitable for operation inside an MRI scanner.

Late last year, they came up with a 1.14 mm needle made of nickel-titanium (which is compatible with MRIs) that uses concentric tubes (some curved) to follow a path through the patient's cheek to the affected brain areas. The needle — which can be controlled with precision down to 1.18 mm — is operated by a robotic platform driven by compressed air. According to Prof. Joseph Neimat, "The systems we have now that let us introduce probes into the brain — they deal with straight lines and are only manually guided. To have a system with a curved needle and unlimited access would make surgeries minimally invasive. We could do a dramatic surgery with nothing more than a needle stick to the cheek."

The system is still being tested on cadavers only, but the developers believe that it could be in operating rooms "within the next decade."

No Tartar Sauce Needed

This engineered micro-scallop can navigate bodily fluids via magnetic fields.

Another robotic critter that might someday be moving around inside you is a microswimmer patterned after scallops. Developed by researchers at the Max Planck Institute for Intelligent Systems in Stuttgart (**www.mpg.de/154324/intelligentSystems**), this little mollusk is only a fraction of a millimeter in size, so there isn't any room for a motor or complex actuation system. Instead, it is driven by magnetic fields that make it open slowly and close quickly, allowing it to squirt its way along inside your eyeball, blood, joint fluid, or other liquids that slosh around inside your body.

Right now, you're no doubt thinking, "Hold on there, turkey! Edward Purcell's 1977 'scallop theorem' clearly states that 'a swimmer must deform in a way that is not invariant under time-reversal.'" Or, in nonobfuscutory terms, "If you flap your fins in one direction first and in the opposite direction second, you'll end up where you started." No, the scallop theorem applies only to Newtonian liquids.

Because non-Newtonian fluids display variable viscosities depending on how much pressure is exerted on them, when the robotic scallop opens, it faces less resistance than when it closes. Thus, it doesn't even need a flagellum for self-propulsion. You and I are essentially big Hefty bags full of non-Newtonian fluids. So there!

The device is still considered to be "a general scheme" for micro-robots rather than something with a particular use at this point, but in time maybe they'll think of something.

Get Your Groove On

If you want to boost the sound of your smartphone, tablet, MP3 player, or anything else with a 3.5 mm audio port via an external speaker system, you can simultaneously reveal your passion for all things robotic with the GOgroove (**www.gogroove.com**) Pal Bot — a portable sound system designed to resemble Google's Android logo. Sporting twin 2W stereo speakers plus a passive subwoofer on the bottom, the Pal Bot offers a frequency response of 90 Hz to 20 kHz, and has received highly positive reviews for its sound quality.

The lithium polymer battery will last six hours on a charge at maximum output, and its glowing LED eyes provide an ongoing indication of battery status. Recharging is via a micro-USB cable (included) which takes two to three hours. Sure, it's not a pair of Bose 301s, but what do you expect for $29.95? SV

Pal Bot: A speaker system for bot fans.

Jibo, the "world's first family robot."

Bot Gets Personal

The idea of a companion robot isn't exactly new, but Jibo — the first product from a company of the same name (**www.myjibo.com**) — seems to be taking the concept a step beyond anything that came before it. Billed as "the world's first family robot," Jibo is the creation of Dr. Cynthis Breazeal, who is not only the company CEO but also director of the Personal Robots Group at the MIT Media Lab. Rather than mowing your lawn or mopping the floor for you, Jibo basically sits on a table and interacts with people.

It can't pick things up or move around; rather, it learns to recognize and communicate with family members, provides an interface with various Android and iOS apps, tells stories, reminds you of things, and otherwise communicates in a human-like fashion. For sensory input, it uses two high-res cameras and a 360° microphone, so it can take photos and relay messages to and from other members of the household.

To fully grasp the concept, you need to log onto YouTube and watch the three-minute video. Whether your own Jibo would become a beloved companion or just another annoying family member remains to be seen, but quite a few people must like the idea. As of this writing, Jibo had raised almost $2,300,000 in Indiegogo funding and even stopped accepting preorders so as to catch up with the backlog of 4,800 units.

by David Geer
geercom@windstream.net

ClearPath's Kingfisher, Husky, and Jackal Utility Robots

Meet three ClearPath land and water robots that make light work of research, recon, exploration, and numerous other scientific and industrial jobs at a savings over traditional methods.

A single operator shows how easy it is to transport the Kingfisher unmanned surface vessel once its pontoons are folded in. It weighs in at just 62 lbs. (Okay, so maybe you'll need help if you're carrying it really far.)

Kingfisher on YouTube
www.youtube.com/watch?v=27E7eKFXotM

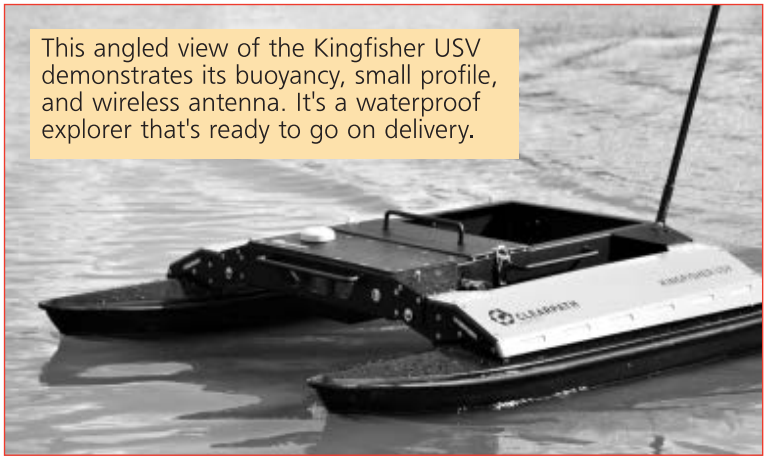
Husky Video Gallery
www.clearpathrobotics.com/husky/gallery

Post comments on this article at **www.servomagazine.com/index.php/magazine/article/january2015_GeerHead**.

For tough terrain or in turbulent waters, ClearPath Robotics has robots that get the job done. Waterproof/weatherproof/all steel construction protects the electronics, sensors, and payloads that collect research data, perform reconnaissance, and perform any other tasks its users can custom-fit it for.

In this column, we'll explore the Kingfisher unmanned surface vessel and the Husky and Jackal unmanned ground vehicles — all working class data collection robots from ClearPath.

The Kingfisher



This angled view of the Kingfisher USV demonstrates its buoyancy, small profile, and wireless antenna. It's a waterproof explorer that's ready to go on delivery.

Named after the fish and insect eating birds, the Kingfisher unmanned surface vessel (USV) sits atop the waters, sensing and interpreting the depths below.

The Kingfisher USV has a catamaran-like configuration with two pontoons on which it steadies itself as it travels through the water — including extremely shallow depths — using electric water jets. The Kingfisher offers high maneuverability and the ability to make sharp turns because its two differential jets run independently of each other and at different speeds.

Portability is a chief concern for research robots that work in the field. One or two operators can carry the Kingfisher in a truck and then to the water thanks to its folding pontoons. The vessel weighs in at only 62 lbs. The surface vehicle can interface with up to a 22 lb payload for various tasks while being controlled via teleoperation, programming, or following GPS waypoint navigation.

No assembly is required. The Kingfisher does not require any special assembly, but rather works immediately so researchers and industry can apply the technology to solving water-based data problems right away.

The Kingfisher provides enough battery power for a single day's excursion. The NiMH battery powered vessel has seven and a half hours of standby power or three hours of power when in use. It takes eight hours to fully charge the USV.

The Kingfisher provides readings to help operators ensure it stays in good working order. The vessel offers feedback about itself when in the water, including battery voltage, motor currents, control system status, and temperatures. It communicates via Ethernet and RS-232 technology. The Kingfisher uses 2.4 GHz wireless communications, as well.

The Kingfisher comes with a certain level of sensing capability, as well as interfaces for additional sensing. Base sensing for the device includes GPS location and IMU (Inertial Measurement Unit) sensors.

The USV uses ROS (the Robot Operating System), C++, and MOOS-IvP for its software drivers and APIs. These run on the vessel's internal computer. The Kingfisher system is compatible with software from the open source community, which means that interested members can create and improve software, and share it with the rest of the community.

This view of the Kingfisher in motion shows it maneuvering through the water at a good clip, thanks to its differential jets. See the video link for a real demonstration in aquatic movement.

The Kingfisher is useful in examining underwater surfaces, water-based life, the water and its health, and consistency as well, given the right payloads. It can test water-based contaminants and

Here, an operator with a remote command and control toggle switch device stands next to the Husky UGV.

The Husky drills the soil to retrieve samples of the earth beneath Alberta's tailings deposit ponds, which are pools of mud deposits that authorities have left to dry out in hopes of reclaiming the land.

The Husky UGV is taking elongated mud samples as part of a project to reclaim land from pools of mud deposits known as tailings deposit ponds.

recon underwater infrastructures, among many other uses. Using wireless, the Kingfisher can send raw data and data processing results to shore or to a larger vessel, for example.

The Husky

This is definitely no regular sled dog. The Husky Unmanned Ground Vehicle (UGV) weighs in at 110 lbs and rides on four 13 inch low slippage lug tread wheels, leaving a five inch ground clearance so it can scale large(r) objects. The unit offers a high torque drive system that can haul an increasing amount of payload over varying environments. The Husky is suitable as a utility and research platform on virtually any terrain.

The unit can bear the weight of up to a 165 lb payload and travels at a maximum of 2.3 mph. The vehicle employs a 4x4 zero maintenance power train. It can climb a grade up to 45 degrees.

The Husky runs on power from a sealed lead-acid battery. It can run up to eight hours on standby, and up to three hours with modest usage. It has a four hour charge time before operators can deploy it again.

The Husky's communication interfaces include RS-232 operating at 115200 baud. The unit's control modes

include direct voltage, wheel speed, and kinematic velocity. Operators receive feedback from the Husky about its battery voltage, motor currents, wheel odometry, and control system output.

Its drivers and APIs include ROS, LabVIEW, C++, and Python. Husky — like other ClearPath robots — is compatible with the popular ROS which, as mentioned, is open source and invites contributions from developers.

The Husky open source serial protocol and open API enables developers and users to reach all raw variables in the system to adjust anything as they like it. Nothing is locked inside a proprietary black box or held out of reach of the customer; everything is transparent to the user. An extensive free code library does much of the development work for the user, saving time in ramping up code for projects.

The Husky uses a programmable controller that supports low level user defined vehicle control. Husky uses high resolution encoders offering improved state estimation and dead reckoning. The tuned controller maintains incredibly smooth motion profiles at slow speeds, while enabling disturbance rejection. Husky has a number of control options for flexibility for specific research objectives and applications.

The Husky platform enables rapid prototyping and customization, and ClearPath can build it to spec. The platform is suitable for a variety of computing and sensing payloads.

The Jackal

The Jackal UGV weighs 37 lbs, offers a ground clearance of 2.6 inches, and can carry a payload up to 44 lbs. It runs on ithium-ion battery power, runs two hours with heavy use, and takes four hours to charge. The Jackal also has a 4x4 drive train like other ClearPath UGVs.

The Jackal comes with an onboard computer and Wi-Fi adapter.

One of the latest robots from ClearPath Robotics, the Jackal motors across the mud and muck with its antenna and sensing devices ready to go to work.

The PC is a Celeron J1800 dual core 2.4 GHz with 2 GB RAM and a 32 GB HDD. This is the standard PC. An Intel core i5 4570T dual core 2.9 GHz with 4 GB RAM and a 128 GB HDD is also available.

The Jackal's control modes include kinematic commands for velocity and angular velocity, open loop motor drive commands, and wheel velocity commands. Communications on and off the unit include Ethernet, USB3.0, RS-232, and IEEE 1394.

The Jackal's feedback includes battery and motor current, wheel velocity and travel, an integrated GPS receiver, and an integrated gyroscope and accelerometer.

The Jackal comes packaged with ROS Indigo, and is operable via a wireless game controller.

That's a Wrap

Investigate these and other land, water, air, and lab based research robots from ClearPath Robotics of Canada, including the Grizzly, the Hummingbird, the Pelican, the Turtlebot 2, Jaco, Entact W Series, Vicon, and the PR2 support robot. It's truly a menagerie. **SV**

ASK MR. ROBOTO

by Dennis Clark

Our resident expert on all things robotic is merely an email away.

roboto@servomagazine.com

Tap into the sum of *all human knowledge* and get your questions answered here! From software algorithms to material selection, Mr. Roboto strives to meet you where you are — and what more would you expect from a complex service droid?

It is January and here in sunny Colorado, we are in the freeze-n-ski season. Hmm, I wonder if I can create a balancing skiing robot? Have any of you done that yet? I hope that Santa (or the Great Pumpkin, or whoever was good to you this past holiday season) got you a lot of cool robot toys. Since we're talking about toys, I thought that I'd report on a kind of "merger" between three of my current favorite gadget candidates: the Digilent chipKIT board series, 4D Systems, and UECIDE. If you remember some of my previous articles, you'll recall that the chipKIT hobbyist and prototyping board series helped to create an Arduino compatible IDE (integrated development environment) called MPIDE that uses the Microchip PIC32 series of embedded processors. It's based on the Arduino 0023 compiler series (pre-1.0). 4D Systems is the maker of the very cool instrument front panel dedicated GUI controllers that work with Arduinos and chipKIT boards. Finally, remember UECIDE — the *much* better IDE for Arduino, chipKIT, and several other embedded environments. How do all these relate to each other? Read on and I'll tell you!

PICadillo-35T 3.5" Resistive Touchscreen chipKIT Compatible Controller

Yup, that's right. The 4D Systems PICadillo is based on the chipKIT board designs, has a chipKIT bootloader, and a 3.5" resistive touchscreen that puts the finishing touch on the whole thing. The PIC32MX795F512L processor has 512K of FLASH and 128K of RAM on a 32-bit 80 MHz core. Add to that a 320x480 HVGA display and you have a nifty experimenter's platform.

Majenko Technologies — the creators of UECIDE —teamed up with 4D Systems (or vice versa) and created a simple graphics library for the PICadillo that is tuned to its display and hardware. As you can see in **Figure 1**, this hardware isn't just a microcontroller and a display. Included is the standard chipKIT UNO32 I/O connector set (like Arduino, but with many more I/O lines and ports). Also included is a speaker that has good volume for game note style sound output and (Ta Da!) an integrated micro-SD card slot. You can get the details of the hardware design on the 4D Systems website at **www.4dsystems.com.au/product/Picadillo_35T**/.

4D Systems says that 2 GB is the maximum size you should use. I don't have anything that small, so I used a 4 GB card and it works fine. Because the card needs to be Microsoft FAT formatted and this is an embedded controller, you take a performance hit as your volume size gets larger. It takes a lot of horse power to use the FAT file system. I suspect that my 4 GB card is punishing me by being slower than the system could be (more on that later).

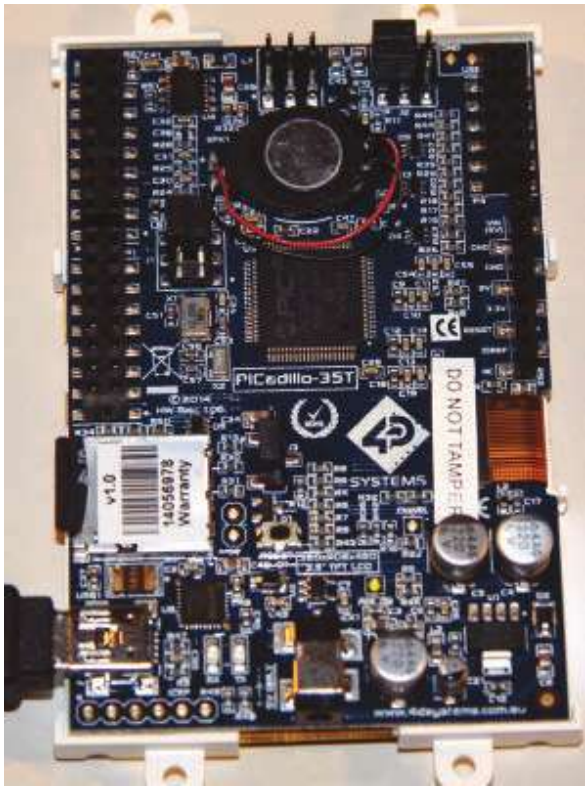


Figure 1.

Post comments on this article at **www.servomagazine.com/index.php/magazine/article/january2015_MrRoboto**.

Before you can play, however, you will need to install UECIDE. This IDE is OS agnostic and will install on any OS. Look back at the November 2014 Mr. Roboto for how to get and set up UECIDE.

Majenko has created a useful graphics library for the chipKIT environment that is very functional. I have only scratched the surface so far by experimenting with the example files that come with their libraries.

Here is a list of those libraries:

TFT: A universal display device library for chipKIT boards and a variety of displays. This has most of the graphics primitives that you would expect like line, circle, rectangle, bitmap, text, etc. It also handles several text fonts and has the display communications standards built in, as well.

BMPFile: This is the bitmap file rendering library that reads its files from the micro-SD card.

Raw565File: Loads and displays raw RGB565 files.

Widgets: This is a basic widget library. Currently, it really only has buttons and bars, but is clearly intended to be extended eventually.

gciWidget: This is support for the 4D Systems' GCI widget objects from their Workshop 4 IDE layout.

You can download these libraries from Github at **https://github.com/TFTLibraries**. Majenko has provided several font libraries at **https://github.com/TFTFonts**.

I won't detail these because they have such descriptive names as Hazard and DejaVuSans, and more. I have not tried them all, but I found that one of the example programs wanted the Liberation font, so I have to put that font into the UECIDE sketch folder to get the code to compile. I should talk a little bit more about the libraries and their install path.

UECIDE follows the Arduino and MPIDE philosophy in that you need to put your non-system default libraries in the folder used to hold the sketches. In UECIDE, that folder is actually called uecide/libraries. In OSX, that folder is in the user's Documents folder. On a Windows OS, that UECIDE folder can be in a variety of places, depending on the operating system. I'm sorry that I can't be more explicit; I do all my work on a Mac, not a Windows OS.

So, how does it run? As with most things I test, the answer is "that depends." I think the speed of the display is impressive considering it is a single line SPI connection to the micro-SD card (like most of us use). The PICadillo really shines when doing programmed I/O graphics not read from the micro-SD card. The schematic shows that the board uses the PIC32's parallel ports to talk to the TFT display 16-bit data bus. Some of the example code shows the board getting 40 frames/second this way.

Figure 2.

The example code that renders bitmapped images from the micro-SD card is slow. This is not a surprise; there is a lot of data involved with a bitmap graphic that is 320x480. All that data has to come over a simple SPI interface one bit at a time. You can get better rates by using less than the full screen size, and I am willing to bet that if I can find a 1 GB or 2 GB micro-SD card, I too would get better transfer rates!

How does it look? I'll show you! **Figure 2** is the "cube" example which can be found under the contributed example files in the TFT library.

What you can't see is that the cube is rotating in all three axes at the same time. These rotations are very smooth and fast. **Figure 3** shows some of the code required for this program.

I don't want to recreate the whole thing; this shows you how simple the API is. Although, like most programmers, the author didn't comment the code, so we have to wonder at some of the method calls. You won't need to wonder long, however. There are very detailed API

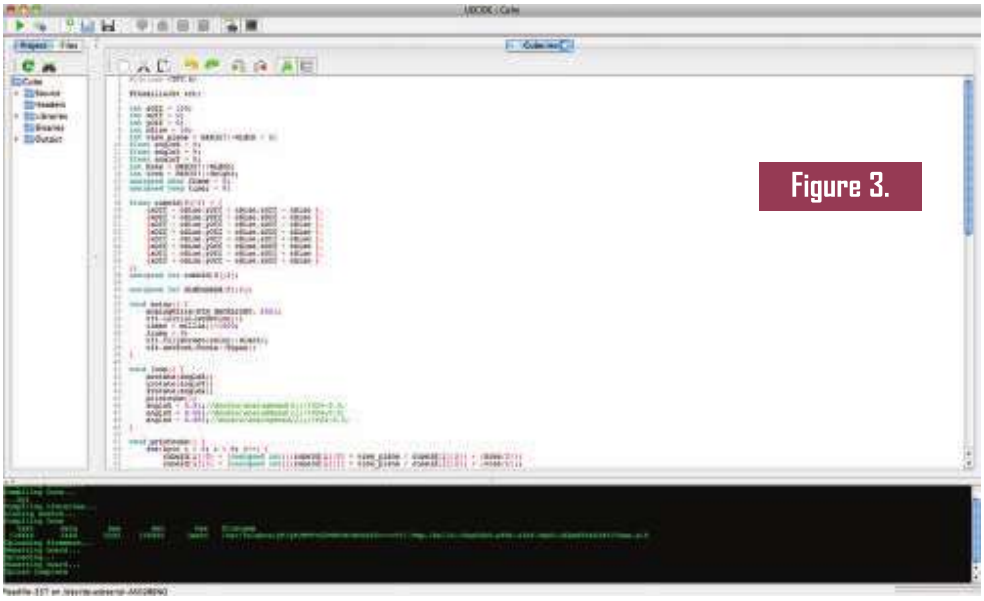


Figure 3.

documents in the library folders. The documentation is very explicit and appears to be very complete, although it could use some example code snippets.

It would be a shame for 4D Systems to come out with a new TFT-based controller board and not include their (IMO) awesome controls system GUI widgets and tools! Although the 4D Systems Workstation 4 does not support the PICadillo, their widget library exists and appears to be usable. In fact, there is an example program under the gciWidget library that puts a variety of 4D widget controls on the screen. All of the expected functionality is there, but as of this writing, I don't know how they are configured. Check out **Figure 4** to see what I mean. The controls are almost as fast as they are with the dedicated 4D microLCD.

Let's be fair. The microLCD board is 100% dedicated to those graphical widgets using a custom graphics controller. The PICadillo is running the chipKIT environment, communications with a media card, and the communications with the TFT display — all at the same time. This is quite respectable! I am looking forward to more updates that add functionality to this demo library.

Both the slider on the top left of the display and the rotary dial on the top right control the progress bars, dials, and gauges shown. The two switches (red and green) select which progress bar and which analog gauge is active. Maybe I am just easy to entertain, but I got a kick out of pushing buttons and moving dials to see what happened.

Figure 4.

Conclusions and Impressions

The PICadillo is a fantastic addition to the UECIDE/chipKIT board club. It has tons of I/O, a fast embedded processor, the easy-to-use Arduino sandbox, and on top of all that, a 320x480 TFT display with a resistive touch screen. You can store graphics and files on the included micro-SD card, and make sounds for games and making announcements.

At $99, it is a more expensive member of the chipKIT line, but whenever you add a display, the cost of every embedded controller goes up.

Regardless, think of all you could do with this and some creative use of graphical interaction with a user or a robot controller, or ... 4D Systems and Mojenko have created a gem, in my opinion.

If you are in the market for an embedded display controller, you should give this board a look. No one I have found has anything out there with this display size for less, and the chipKIT environment makes this super easy to use, too.

I hope that you have enjoyed this month's Mr. Roboto and maybe learned about something you want to go check out. If you want to know more about anything robotic — or even interesting — send your questions to Mr. Roboto, care of *SERVO Magazine* at roboto@servomagazine.com. I'll be happy to work on them. Until next time, keep on having fun! **SV**

EVENTS

ROBOTS.NET

JANUARY

2-4 **Techfest**
Bombay, India
Student competition at the Indian Institute of Technology. Events include Technocalypse, Robotron, the International Robotics Challenge, Dimensions, Xtreme Machines, Moneyball, Algorhythm, and Thinkernet.
www.techfest.org

22-25 **ION Autonomous Snowplow Competition**
St. Paul, MN
Autonomous snowplow robots must remove snow along a designated path.
www.autosnowplow.com

28-29 **Singapore Robotic Games**
Tay Eng Soon Convention Centre, ITE Hdqrters, Singapore
Events include Sumo, Picomouse, Robot Soccer, Wall Climbing, Pole Balancing, Legged Robot Marathon, Underwater Robots, Intelligent Robot Contest, Robot Colony, and Humanoid Competition.
http://guppy.mpe.nus.edu.sg/srg/

28-31 **Kurukshetra**
Guindy, Chennai, India
Annual student competition with multiple events. See the website for an updated list of this year's activities.
http://kurukshetra.org.in

30 **Powered by Sun**
Ostrava, Czech Republic
Race between autonomous solar-powered robots.
http://napajenislun cem.vsb.cz

Know of any robot competitions I've missed? Is your local school or robot group planning a contest? Send an email to steve@ncc.com and tell me about it. Be sure to include the date and location of your contest. If you have a website with contest info, send along the URL as well, so we can tell everyone else about it. For last-minute updates and changes, you can always find the most recent version of the Robot Competition FAQ at Robots.net: **http://robots.net/rcfaq.html**.

— R. Steven Rainwater

NEW PRODUCTS

Parallel Gripper Kit

The Parallel Gripper Kit A from ServoCity is a simple, durable, and versatile kit that is perfect for all kinds of robotic applications. The grippers move towards one another in a parallel motion — hence, the name — and have a maximum width of 2.80". By incorporating the Actobotics 0.770" hub pattern into the back plate and 1.0607" hole spacing on the grippers, users can easily attach nearly any Actobotics component to the assembled kit. The kit is designed for use with any standard size Hitec or Futaba servo (sold separately), and is easy to assemble. It only requires a Phillips head screwdriver. Price is $14.99 ea.

Horizontal & Perpendicular Gripper Kits

Also new from ServoCity in the Actobotics gripper kit line-up is the Horizontal Standard Gripper Kit A and Perpendicular Kit B. The sleek and simple design makes assembly and attachment very easy. The grippers have a maximum width of 4.20" and contoured design to help hold on to larger objects. The Horizontal kit incorporates a 0.770" hub pattern into the back plate that can be easily attached to nearly any Actobotics component. The Perpendicular kit also offers many mounting options and is designed for use with any standard size Hitec or Futaba servo (sold separately), as well. This kit is equally easy to assemble with just a Phillips screwdriver. Pricing is $9.99 ea.

For further information, please contact:

ServoCity Website: **www.servocity.com**

Single-Board Computer With 1 GHz ARM CPU, Reliable eMMC SLC Flash, and High Capacity FPGA

Technologic Systems, Inc., has announced the availability of their newest industrial grade single-board computer: the TS-7250-V2. The TS-7250-V2 is a general-purpose PC/104 embedded system that can fulfill a wide variety of embedded system requirements with high performance, high reliability, low cost components like an 800 MHz or 1 GHz ARM CPU, 512 MB DDR3 RAM, up to 17k LUT FPGA*, 2 GB eMMC SLC Flash, and a flexible PC/104 connector with FPGA driven pins.

Powered by Linux Kernel 3.14, it boots to a terminal shell in 0.87 seconds and can further load the Debian 7 "Wheezy" distribution. The TS-7250-V2 provides an upgrade path for customers using the TS-7250 or TS-7260 single-board computers. Full descriptions, pictures, and resources for the TS-7250-V2 can be found on the Technologic Systems' website.

Highlights of the TS-7250-V2 are its high performance components designed to provide powerful multimedia capabilities and industry

standard interfaces, while maintaining low power consumption and high data reliability. Applications range widely as the TS-7250-V2 is general-purpose and fits nearly any project. The high capacity FPGA enables engineers to customize and further extend the TS-7250-V2 to meet their application specific needs. Furthermore, the industrial temperature option enables the TS-7250-V2 to function in rugged environments such as those found in the automotive and military industries.

Some of the hardware features include:

- 1 GHz ARM Marvell PXA168
- 800 MHz ARM Marvell PXA166
- 512 MB DDR2 RAM
- 2 GB eMMC SLC Flash Storage
- 8 or 17k* LUT Programmable FPGA
- 2x 10/100 Ethernet Ports
- -40°C to 85°C Industrial Temp Range
- 1x micro-SD Card Slot
- 1x SD Card Slot
- 2x USB Host Ports
- 1x USB Device Port (Console Only)
- 75x Digital Input/Outputs
- 3x RS-232 Serial Ports
- 3x TTL Serial Ports
- 1x RS-485 Serial Ports
- 5x ADC Ports
- 1x CAN Bus
- 5 VDC Power Supply Input
- 8 to 28 VDC Power Supply Input
- High Precision Real Time Clock

The TS-7250-V2 also features an onboard programmable Lattice FPGA. The FPGA provides extra peripherals such as 75 GPIO lines, additional serial ports, additional CAN port, dual four-bit mode high speed SD card sockets (full size and micro-SD cards), and more.

All the PC/104 pins are connected straight to the FPGA, giving the TS-7250-V2 the flexibility to add external hardware and physical/transceiver layers. The default FPGA load provides a standard PC/104 bus on the 104-pin connectors, maintaining compatibility with other ARM SBCs and a wide range of PC/104 peripheral boards.

The FPGA on the TS-7250-V2 enables simple inexpensive customization that requires no physical hardware modifications. Should you need a special configuration or a custom load, contact Technologic Systems for FPGA development services.

The TS-7250-V2 boots from the onboard eMMC SLC Flash or micro-SD card to Linux Kernel 3.14 in 0.87 seconds to a BusyBox terminal shell. For full flexibility, the TS-7250-V2 can further load the Debian 7 "Wheezy" distribution which offers a familiar software stack and packages, and a GNU compiler collection for onboard software development. Technologic Systems also includes user space utilities for controlling various aspects of the board, like DIO, SPI, and UARTs.

Some of the software features include:

- Linux Kernel 3.14 (2.6.34 also available)
- Debian 7 "Wheezy" Distribution
- 0.87 sec Bootup Time to Busybox Terminal Shell (.52 seconds with available 2.6.34 kernel)
- FPGA Reloadable in Software
- Flexible Programming Language Support
- Source code examples available

The TS-7250-V2 single-board computer is available in quantity 100 pricing starting at $165 with several additional options available.

The TS-7250-V2-512-8S-I: TS-7250-V2 industrial grade (-40°C to 85°C) SBC with the Marvell PXA166 800 MHz ARM9 and 512 MB DDR2 RAM (micro-SD required to boot) is priced at $199 (quantity 1).

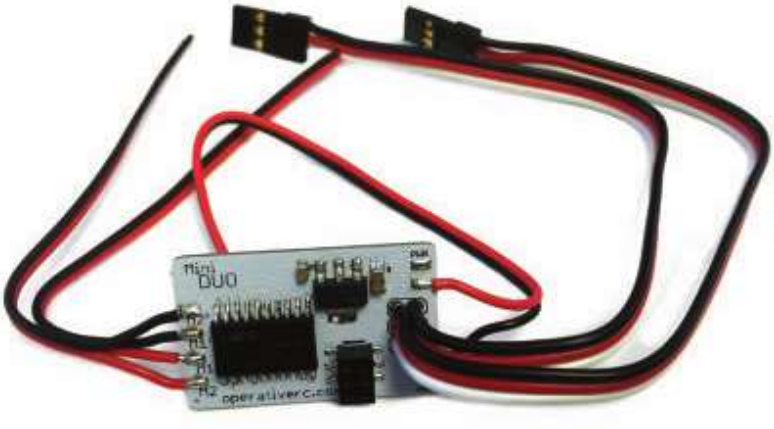
The TS-7250-V2-512-4096F-10S-I-DEV: TS-7250-V2 industrial grade (-40°C to 85°C) SBC with the Marvell PXA168 1066 MHz ARM9, 512 MB DDR2 RAM, 2 GB Flash (4GB eMMC configured as 2 GB SLC Flash), 2x 10/100 Ethernet, and 1x RS-422 (recommended for development) is priced at $251 (quantity 1).

For further information, please contact:

Technologic Systems	**www.embeddedarm.com**

Dual Motor Controller

Operative RCs MiniDUO is a new dual motor controller perfect for Antweight size robots. It was designed with simplicity in mind, and excludes many of the extra features other motor controllers might include for special applications. It can drive two brushed motors independently — providing a maximum of 2.8A per motor — and is controlled by two channels from an R/C receiver.



It has a wide input voltage range of 7V-20V, and the onboard 5V/1A voltage regulator can provide enough power for an R/C receiver in addition to a couple small servos, LEDs, a microcontroller, etc. What's really special about the MiniDUO, however, is its built-in channel mixing which eliminates the need for the additional V-tail mixers seen in many small robots using two independent motor controllers for tank steering. This eliminates the extra wiring, weight, and overall clutter that can sometimes accumulate in small robot platforms.

This motor controller by itself does the job of two single-motor controllers wired to run off the same battery, with their signal wires running through a V-tail mixer. Speaking of simplifying wiring, this motor controller also features an extra set of power and ground solder tabs, allowing it to also function as a power distribution board in situations where the main power needs to be routed to more than one location.

The MiniDUO weighs about 10 grams with the included wiring, but the board itself sans wiring weighs in at a mere three grams. The outer dimensions for the printed circuit board are 0.83" by 1.31" — small enough to fit within virtually any Antweight robot platform.

Additionally, the MiniDUO operates at a switching frequency of 32 kHz which is well beyond the human hearing range. This means that motors will operate silently without the high-pitched "beeping" sound that many other motor controllers emit, which results in more precise control. The MiniDUO is available for $39.99.

For further information, please contact:

Operative RC Website: **www.operativerc.com**

RGB LED Module

The WS2812B RGB LED module from Parallax for a little under $2 has a special LED onboard that contains three separate LEDs – red, green, and blue – as well as a smart control IC that can individually drive each LED. Each color on the small module has 256 intensity levels which allow it to produce 24-bit color, or more than 16 million colors.

Each module is instructed by using a special serial protocol. This protocol allows many modules to be daisy-chained together so that one microcontroller can control the whole lot with a single data signal. Any number of these modules can be chained together by connecting one module's data-out (DO) pin to another's data-in (DI) pin.

These LEDs are extremely bright, so avoid looking directly at them up close when lit.

Key features include:

- String many together to make an array of individually addressable lights.
- With 24-bit color, each module can display more than 16 million unique colors of the rainbow.
- The module's small size is breadboard-friendly with 0.1" header spacing.
- Control all LEDs in a chain with a single I/O pin.

Some application ideas are:

- Holiday decorations
- Multi-color status LED for projects
- Color-changing robotic eyes

Note: This module requires a 5V power supply to work. Devices that interface at 3.3V can still communicate with the module, but the module will need to be supplied with five volts on the 5V pin.

Additionally, the serial communication protocol the module utilizes relies heavily on strict timing constraints. Thus, the BASIC Stamp module cannot reliably communicate with the WS2812B RGB LED module.

GPS Smart Module

Also from Parallax is the VPN1513 GPS smart module which provides a complete GPS solution for electronics projects. This high quality, highly sensitive GPS receiver includes an external antenna, status LED, and a rechargeable battery back-up. An onboard voltage regulator makes it ready to use with 3.3V and 5V microcontrollers.

The GPS smart module is priced around $32 and features a simple command set for accessing NMEA 0183

GPS data. Example programs in PBASIC, Arduino, Propeller Spin, and Propeller C will help add the GPS module to microcontroller projects. The module's onboard Propeller co-processor with 64 KB EEPROM can be reprogrammed for custom stand-alone projects.

Experimenting is encouraged, as the factory firmware is available for free download.

Key features include:

- High performance SiRF chipset provides 20 parallel satellite tracking channels
- Status LED blinks to show when the satellite fix is achieved
- Onboard multicore Propeller co-processor easily interfaces with microcontrollers
- Breadboard-friendly four-pin SIP header quickly connects to projects
- External GPS antenna with SMA connector included

Some application ideas are:

- Geocaching adventures
- Robotics navigation
- Fleet management
- Surveying

For further information, please contact:

Parallax, Inc. Website: **www.parallax.com**

Self-locking Micro Threaded Inserts

STANLEY Engineered Fastening presents Spiralock self-locking Micro threaded inserts which improve electronics performance with resistance to loosening when exposed to vibration, shock, or heat.

The micro threaded inserts also enhance fastener reusability and reduce overall assembly costs by eliminating the need for nylon patch or chemical adhesive applications.

STANLEY offers its self-locking Spiralock internal thread form design to more securely and cost-effectively attach components in compact electronic assemblies.

Electronics can experience vibrational loosening, drop shock, thread damage, and high thermal heat cycles not only during use, but also during shipping — particularly if manufactured overseas. Traditional nylon patch screws and chemical adhesives may progressively lose their effectiveness under these conditions, especially if reused during assembly, inspection, or repair as their bonding material wears away. These traditional thread-locking methods can also add to assembly cost and complexity, when the nylon patches or chemical adhesives are applied on screw threads.

The micro threaded inserts can be used in a full range of electronics — from handheld mobile devices to mainframes including smartphones, tablets, laptops, desktops, and monitors — in sizes as small as M1, in any size thread or pitch necessary.

Spiralock accepts standard male fasteners, eliminating the need for other locking devices, streamlining assembly since they are free spinning, and substantially reduce the potential for fatigue failure compared to standard threads.

The Spiralock thread form solves thread loosening and joint integrity issues by changing the physics of how the threads interact. In traditional 60° threads, the gap between the crests of the screw/bolt and the major diameter of the internal thread is where loosening begins.

With significant transverse motion, thermal variance, shock, or impact, microscopic movements and preload loss occur in the fastener's threads. This tiny clearance gap allows the bolt to minimally "slip" relative to the major diameter of the female threaded hole. Once preload loss begins, the joint will fail and lose most of its clamp load during service. Furthermore, with standard threads, most of the load is carried by the first few threads, where stress concentration and fatigue can lead to premature joint failure.

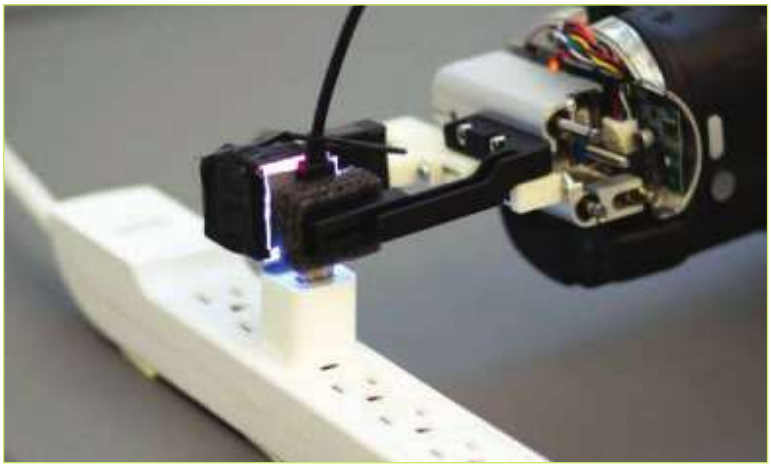
The Spiralock self-locking wedge ramp thread profile eliminates the clearance gap, locking the male fastener in place. The Spiralock wedge ramp creates line contact with the screw/bolt along the entire length of thread engagement, preventing any movement between the screw/bolt and Spiralock wedge locking ramp.

Since Spiralock is free running and begins to lock once torque is applied, tension is created between the male fastener and the Spiralock threads. This enables quick, smooth bolt rundown with minimal drag or resistance when threading components. It also reduces assembly cost and time, as well as extends thread lock reusability and product longevity.

The Spiralock micro threaded inserts can be installed into many

Continued on page 75

AT YOUR FINGERTIPS



Researchers at MIT and Northeastern University have equipped a robot with a novel tactile sensor that lets it grasp a USB cable draped freely over a hook and insert it into a USB port.

The sensor is an adaptation of a technology called GelSight which was developed by the lab of Edward Adelson — the John and Dorothy Wilson Professor of Vision Science at MIT — and first described in 2009. The new sensor isn't as sensitive as the original GelSight was, which could resolve details on the micrometer scale. It's smaller, however — small enough to fit in a robot's gripper — and its processing algorithm is faster so it can give the robot feedback in real time.

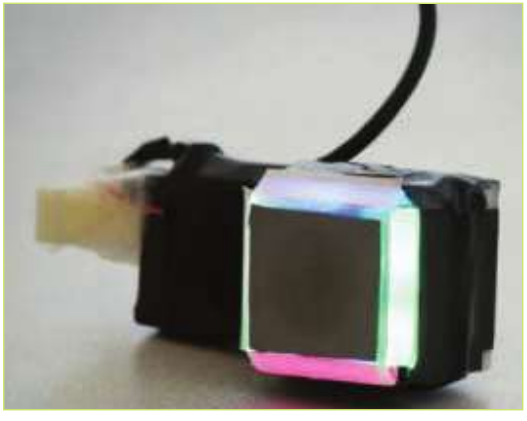
Industrial robots are capable of remarkable precision when the objects they're manipulating are perfectly positioned in advance. According to Robert Platt — an assistant professor of Computer Science at Northeastern and the research team's robotics expert — for a robot taking its bearings as it goes, this type of fine-grained manipulation is unprecedented.

"People have been trying to do this for a long time," Platt says, "and they haven't succeeded because the sensors they're using aren't accurate enough and don't have enough information to localize the pose of the object that they're holding."

The researchers presented their results at the recent International Conference on Intelligent Robots and Systems. The MIT team — which consists of Adelson; first author Rui Li, a PhD student; Wenzhen Yuan, a master's student; and Mandayam Srinivasan, a senior research scientist in the Department of Mechanical Engineering — designed and built the sensor. Platt's team at Northeastern developed the robotic controller and conducted the experiments.

Whereas most tactile sensors use mechanical measurements to gauge mechanical forces, GelSight uses optics and computer-vision algorithms.

"I got interested in touch because I had children," Adelson says. "I expected to be fascinated by watching how they used their visual systems, but I was actually more fascinated by how they used their fingers. But since I'm a vision guy, the most sensible thing — if you wanted to look at the signals coming into the finger — was to figure out a way to transform the mechanical tactile signal into a visual signal. Because if it's an image, I know what to do with it."



A GelSight sensor — both the original and the new robot-mounted version — consists of a slab of transparent synthetic rubber coated on one side with a metallic paint. The rubber conforms to any object it's pressed against, and the metallic paint evens out the light-reflective properties of diverse materials, making it much easier to make precise optical measurements.

In the new device, the gel is mounted in a cubic plastic housing with just the paint-covered face exposed. The four walls of the cube adjacent to the sensor face are translucent, and each conducts a different color of light — red, green, blue, or white — emitted by LEDs at the opposite end of the cube.

When the gel is deformed, light bounces off of the metallic paint and is captured by a camera mounted on the same cube face as the diodes.

From the different intensities of the different colored light, the algorithms developed by Adelson's team can infer the three-dimensional structure of ridges or depressions of the surface against which the sensor is pressed.

Although there are several ways of measuring human tactile acuity, one is to determine how far apart two small bumps need to be before a subject can distinguish them just by touching; the answer is usually about

a millimeter. By that measure, even the lower resolution robot-mounted version of the GelSight sensor is about 100 times more sensitive than a human finger.

In Platt's experiments, a Baxter robot from MIT spinout Rethink Robotics was equipped with a two-pincer gripper — one of whose pincers had a GelSight sensor on its tip. Using conventional computer-vision algorithms, the robot identified the dangling USB plug and attempted to grasp it. It then determined the position of the USB plug relative to its gripper from an embossed USB symbol. Although there was a three millimeter variation in each of the two dimensions in where the robot grasped the plug, it was still able to insert it into a USB port that tolerated only about a millimeter's error.

"As roboticists, we are always looking for new sensors," Lee adds. "This is a promising prototype. It could be developed into practical device."

As reported by Larry Hardesty, MIT News Office. Photos courtesy Melanie Gonick/MIT.

PATIN PENDING

Flower Robotics — a Tokyo-based design studio — is envisioning a future where common household objects like lamps and flower pots spring to life and move around our homes. Earlier in 2014, the company unveiled a concept device called Patin: a service robot platform that can use special attachments to perform a variety of functions.

Unlike task-specific robots such as Roomba, Patin consists of a mobile base with an upper deck to which you can attach different modules. So, rather than having separate robots for specific jobs, you'd just need one Patin and the desired attachments to give the robot new functionalities.

Flower Robotics — known primarily for its robot mannequin, Palette — has been working on a prototype base, and plans to market the robot by 2016. The attachments that will make the robot useful are still at a conceptual stage; in a promotional video, the robot is shown carrying a lamp closer to a person reading a book, among other things.

Image courtesy of Flower Robotics.

The current prototype has an omni-directional wheel base that allows it to move smoothly in graceful arcs (hence, the name Patin which is French for "skate"). The robot is powered by NVIDIA's Jetson TK1 CPU and runs Linux. To navigate and detect people and objects, it uses an ASUS Xtion Pro Live depth camera. It also carries a host of other cameras, an Arduino board, and contact and proximity sensors.

Flower Robotics doesn't plan to develop the functional attachments alone. It hopes that other companies (even those that may lack expertise in robotics) will build specific modules for the robot, which can carry up to five kilograms and has an interface that can be programmed with an SDK. Patin can also connect to cloud services to access data (like music), as well as new behaviors, the company commented.

LAUNDRY CYCLE (ALMOST) COMPLETE

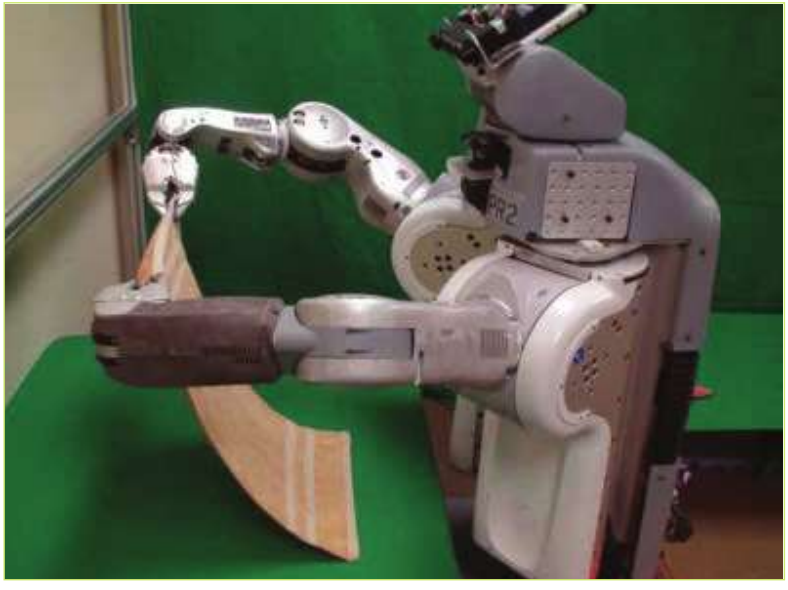
PR2 is famous for (among many other things) folding laundry. Specifically, UC Berkeley's PR2 demonstrated back in 2010 that it could take a pile of towels fresh out of the dryer and neatly fold and stack them. This took something like 20 minutes per towel, but the important thing was that it was completely autonomous. As a human, you could leave the robot by itself with a jumble of towels and washcloths, and then come back a few hours later and everything would be taken care of.

Since 2010, we've seen a few additional examples of PR2s folding things, but what we've been waiting for is a demonstration of a complete laundry cycle. It looks like we're almost there.

A big piece that's been missing from the laundry cycle is the ability of the PR2 to do the first part: picking up dirty clothes, taking them to the washer, and putting them in. In a recent video, Siddharth Srivastava and co-authors Shlomo Zilberstein, Abhishek Gupta, Pieter Abbeel, and Stuart Russell showed they've just about mastered these tasks.

This is obviously a huge step, but how close are we really? Here's what a laundry cycle is, as far as a robot is concerned:

Locate dirty clothes
Pick up dirty clothes
Place dirty clothes in laundry basket
Take laundry basket to washer
Open washer door
Place dirty clothes in washer
Add soap
Close washer door
Program and start washer



Transfer clothes to dryer
Remove clothes from dryer
Fold laundry or put laundry on hangers
Put away laundry in dresser or closet

So, what's the upshot here? PR2 is very close to being able to do an entire laundry cycle autonomously from start to finish, and that's amazing.

Second, some of the places where PR2 falls short are due to its design as a general-purpose robot. As one of the first (if not the first) true general-purpose robotic platforms with the reliability and sophistication necessary to perform a wide variety of tasks, it's not reasonable to expect that its design would make it capable of doing everything flawlessly.

Finally, there are lots of opportunities throughout these laundry tasks (and in most household tasks) where small modifications to an environment that's designed for humans can make a big difference by adding some features that are friendly to robots.

For example, big fat door handles on washers and dryers. A few well-placed QR codes. Appliances that can be controlled wirelessly. None of these things are disruptive to humans, but they could make the difference between a robot being able to do laundry or not.

AEON SCIENTIFIC WINS 2014 SWISS TECHNOLOGY AWARD

The ETH spin-off, Aeon Scientific has won the 2014 Swiss Technology Award in the Start-Up category. The biomedical engineering company impressed the judges with its robot-controlled surgical system, which can be used to treat cardiac arrhythmia quickly and safely.

The cardiologist sits in the control room next to the operating theater and uses a joystick to steer a catheter through the patient's blood vessel into the heart's chambers to treat the cardiac arrhythmia precisely. With this robot-controlled surgical system, Phocus, Aeon Scientific won over a panel of 15 judges.

"We are delighted that our work has been recognized and appreciated," said Dominik Bell, CEO of Aeon Scientific. "The award will help us market our product and find new investors and staff."

PRINT ME A LEG

Image: University of Oslo/Robotics and Intelligent Systems

We humans are continuing to send robots farther and farther away from Earth, even as we ask them to deal with more and more complex situations here at home, and both of these things mean that autonomy is getting increasingly critical. Robots encounter all kinds of unexpected complications if they're operating in unfamiliar environments, and we want them to minimize their reliance on active human involvement.

Autonomy is just the start. The goal is the robot's ability to learn and evolve, and researchers at the University of Oslo in Norway are developing a system that can print out customized robots to tackle any situation it faces.

Professor Kyrre Glette, from the Robotics and Intelligent Systems research group, describes the overall concept of this system:

"In the future, robots must be able to solve tasks in deep mines on distant planets, in radioactive disaster areas, in hazardous landslip areas, and on the sea bed beneath the Antarctic. These environments are so extreme that no human being can cope. Everything needs to be automatically controlled. Imagine that the robot is entering the wreckage of a nuclear power plant. It finds a staircase that no one has thought of. The robot takes a picture. The picture is analyzed. The arms of one of the robots is fitted with a printer. This produces a new robot, or a new part for the existing robot, which enables it to negotiate the stairs."

Several years ago, University of Pennsylvania researchers had a similar idea where they had one robot building other robots out of spray foam. The University of Oslo team is using a very expensive 3D printer to be much more precise with their designs. Inputs to the design of the robots include desired size, speed, efficiencies, and also capabilities — like being able to climb or turn. In response, the system will produce a whole bunch of different robots, each with unique body shapes, legs, and joints. It then sets them against each other in fights to the death (in simulation), and finally, sends the specs of the winning robot off to the 3D printer for production.

Recognizing that simulation often bears little resemblance to the world that's being simulated, the researchers are asking the system to make a handful of robots that it thinks will be equally good at solving a task in a real environment. In one example, there were three robots with four legs, plus one with three legs and one with six legs.

At the moment, the robots are being evaluated on real obstacle courses to see which one is actually better, but eventually, it will all be autonomous — whether in simulation or with the system running live trials of several different designs, and using the results to improve both the next generation of robots and its evolutionary algorithms.

It's a crucial capability for robots that are operating autonomously to take care of themselves. Being able to adapt to new and unexpected environments is one of the things that makes humans so successful, and it's a trick that robots desperately need to learn.

NEW STAFF MEMBER

The SupraPed robotic platform designed at Stanford uses "smart staffs" to improve balance and mobility.

The idea of SupraPeds is to increase locomotion stability by incorporating a pair of actuated smart staffs with vision and force sensing that transforms biped humanoids into multi-legged robots.

Anyone who has ever watched a humanoid robot move around in the real world — an "unstructured environment" in research parlance — knows how hard it is for a machine to plan complex movements and balance on uneven surfaces or traverse levels.

Quadruped robots like Boston Dynamic's BigDog seem to be more adept, but don't have the ability to use their hands to open doors or pull people from rubble.

Humans have trouble balancing sometimes too — say, when climbing a mountain or walking on ice. In many cases, people turn to a trusted and time-tested tool: the walking staff.

"Efforts to make robots emulate humans have ignored an important fact: Whenever humans approach their limits, they augment their capabilities with a diverse variety of assistive tools," said Shuyun Chung, a postdoc working with Oussama Khatib in the Stanford University Artificial Intelligence lab.

"Perhaps the most useful tool is the walking staff which improves support, enables load redistribution, and can also be used as a sensor to probe the stability of planned footsteps."

Working in disaster recovery situations, the SupraPed can use the staffs to explore the terrain around them, expand the range of movements that are possible, and even communicate a sense of touch to a human at a remote site who can then use that data to plan the robot's movements.

The Stanford researchers work is supported by a grant from the National Science Foundation through the National Robotics Initiative, which is an effort to develop the next generation of robots that work beside or cooperatively with people.

ROCKET ROBOTS

In a relentless effort to make orbital deliveries safer and cheaper, SpaceX has been working towards a rocket system that's completely reusable. The vision is to create a version of the Falcon 9 that can be launched into space and then return itself to Earth — landing vertically with pinpoint accuracy.

SpaceX has been making steady incremental progress with the addition of landing legs, guidance wings, and several

tentatively successful landings out in the ocean. The next step is to try to get a Falcon 9 to land itself on something solid, and there's no safer place to do this than on a drone ship out in the ocean.

Take a look at the photo to see what Elon Musk and SpaceX have come up with. It's an autonomous floating landing pad that measures 90 meters by 50 meters. It's completely autonomous, using GPS guidance and four thrusters designed for oil rigs to hold position within three meters — even in bad weather. Eventually, the platform will be able to refuel and launch rockets, too.

Of the two robots involved in this concept, the drone ship has the easier job. It just has to try and stay as still as possible. The Falcon 9 rocket, however, has to fit the 20 meter span of its deployed landing legs inside the landing area, and it has to do that even if said landing area is rolling around on the waves.

To execute the level of control necessary to accomplish this, SpaceX has outfitted the latest Falcon 9 with "X-wing config" wings: deployable "hypersonic grid fins" to help the rocket stabilize itself during reentry.

As of this writing, SpaceX planned to try out this system in just a few weeks, as part of a Falcon 9 cargo delivery to the International Space Station scheduled back in December. Musk puts the odds of a successful landing on this first attempt at about 50 percent. Over the next dozen or so Falcon 9 launches that will take place in 2015, Musk is very confident that it's going to work, according to *SpaceNews*: "It's quite likely — probably 80 to 90 percent likely — that one of those flights will be able to land and refly."

COMBAT ZONE

Post comments on this section and find any associated files and/or downloads at **www.servomagazine.com/index.php/magazine/article/january2015_CombatZone.**

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BUILD REPORT: Nyx v2 Part 3: Weapons

● by Mike Jeffries

With the base of the machine done and working as desired, it was time to start on the weapon modules. Each weapon module was designed to bolt directly to the top plate, and outside of connecting the weapon motors to the internal weapon ESC (electronic speed controller), the entire module was self-contained. This was done to avoid the issue on the previous version of Nyx where it was stuck using the same motor for every weapon attachment, which proved to be less than ideal in practice.

The first step of module assembly was actually installing a safety feature. For both the lifter and axe weapons, the large swing arc and sharp powerful attachments meant that it would need a safety lock for power-up and when in the pits. The lock itself was made out of 1/4" 4130 rod stock that was bent into a T shape. A steel shaft collar was attached to it to set the insertion length, and the handle portion was painted bright green to make it harder to forget.

On the module side of things, a 1/4" diameter, 1/4" long neodymium magnet was glued into a hole adjacent to the weapon lock hole. This magnet would make direct contact with the steel shaft collar, and would reduce the chances of the lock coming out if the robot were jolted or bumped prior to power-on.

Crusher Module

With three complete weapon modules, you have to start somewhere, and for Nyx the starting point was the crusher. This weapon system uses a pair of Gimson Robotics GLA750-S linear actuators with a 100 mm stroke length to power the crushing spike. With a 23A current limit, the estimated force at the tip of the spike is 670 lbs.

The first part of the assembly process was seam welding the two halves of the teeth to create the 1/2" thick tooth. The tooth could have

The business end of each weapon module after some cleanup and test-fitting following waterjet cutting.

Neodymium magnets were glued into the lifter and axe module's frame rails to help retain the weapon lock during load-in and load-out.

The final render of the crusher module on the base platform.

The fully assembled crusher mechanism prior to integration with the crusher mount plates.

been cut from a 1/2" thick piece of steel. However, part of the plan with this robot was to minimize the number of different plates that needed to be cut, so the tooth was cut from the same 1/4" thick AR400 plate the other steel parts were made from.

With the welding done, the bushings and shaft were inserted into the support plates, and the assembly was bolted together. The shaft was inserted prior to bolting to help aid with alignment.

The GLA750-S actuators needed minor modification to fit the system as designed. The mount point at the base of the actuator was drilled out to 3/8" and the connection point was drilled out to 1/4". The 3/8" shaft was then inserted into the two actuators, and the 1/4" shoulder bolt was run through the linkage.

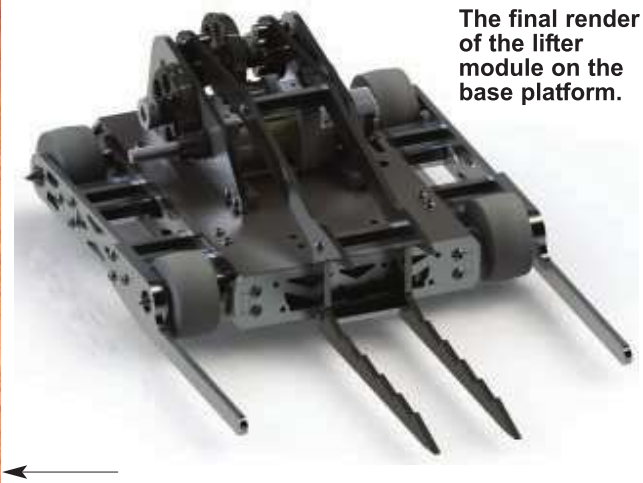
After that, the steel side plates were slid on to tie the whole system together. Shaft collars were used on the 1/2" shaft to lock it in place, finishing the assembly of the crusher mechanism.

After completing the mechanism, the support plates were slid in place and bolted together using aluminum stand-offs. Shaft collars and nutstrip were added to finish off the assembly. The whole module was now completed and ready for competition.

Lifter Module

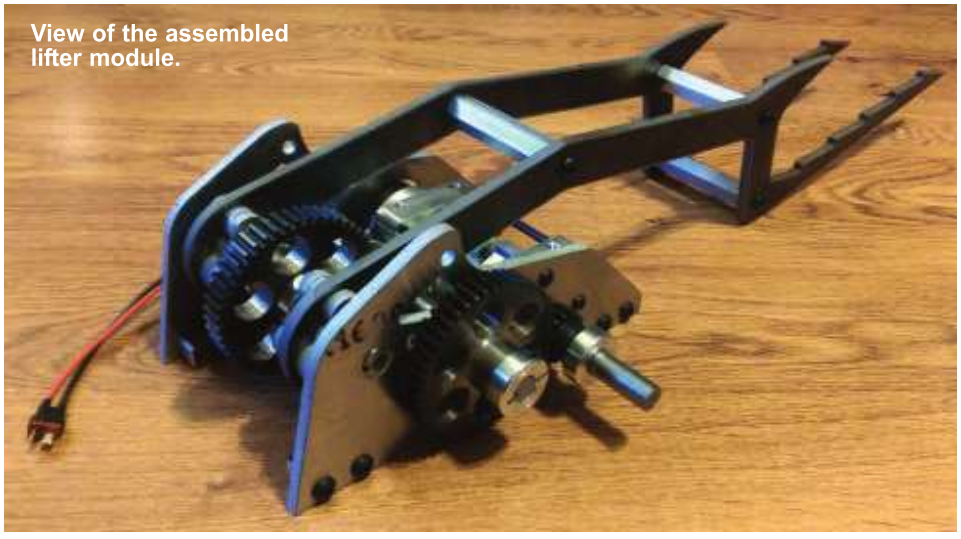
The lifter module uses a DeWut gearmotor from **e0designs.com** to power the forks. The gearbox is set to low gear, and then routes through a two-stage 9:1 reduction for an overall drive ratio of 460.8:1 and a top speed of 50 RPM. With the current limited to 50A, the forks should be capable of lifting 75 lbs at the tips of the 23" long arm. The current limit is being used to prevent the motor from stripping any components should it become stuck or suddenly hit the end of travel, and to provide overcurrent protection to the motor.

The claw portion of the crusher assembled after seam welding the two halves of the tooth together.



The final render of the lifter module on the base platform.

The completed crusher showing some battle scars after its debut at Maker Faire Atlanta.



View of the assembled lifter module.

View of the keyway cut into each half of the lifter arm.

A 30 lb robot at the end of a 23" arm will result in almost 700 in-lbs of torque at the base of the lifter. To help combat this, a heavy steel gear was used for the drive gear. In addition to the two 1/4" plates for the forks, each fork had an additional 3/4" of aluminum block added and keyed to the shaft to distribute the loads incurred during lifting.

The keyways were partially cut during the waterjetting process, and were finished with a broach after assembling each fork arm to ensure that the keyway slots aligned properly and were square.

The lifter module assembly went very quickly as the design uses a relatively small number of components. There are two identical sets of gears that provide the reduction that were purchased from McMaster-Carr, with the larger gear having a substantial amount of material removed to cut weight since the strength of the gear is not the expected failure point of the system. A combination of shims and shaft collars are used to set the gear and arm alignment.

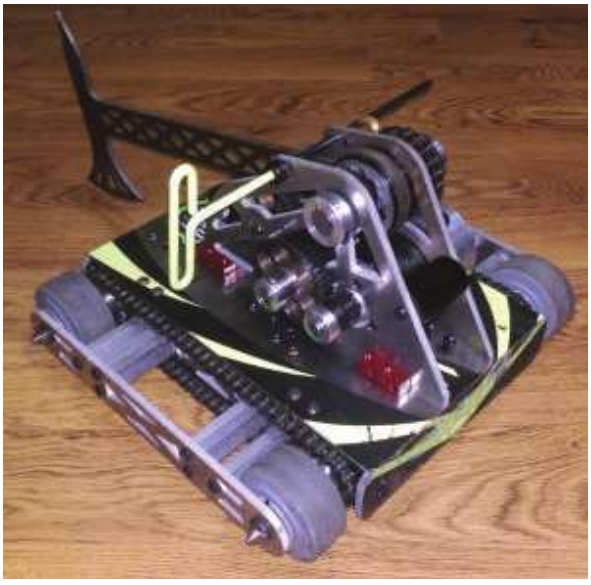
With a smooth assembly process and enough resting torque that the arm can't be manually cycled, the only step that remained was to attach it to the chassis and try lifting something. With the limit set to 50A, the lifter was easily able to pick up the ballasted shell of Nyx v1 and hold it at any position that was desired.

Axe Module

The axe module uses an A28-150 Ampflow motor to power the axe via an 18:1 three-stage reduction. The weapon motor itself has two pairs of brushes. This is used in combination with the dual channel Ragebridge ESC from **e0designs.com** to provide 70A to each set of brushes, effectively current-limiting the weapon motor to 140A. This provides a balance of starting torque and system reliability.

It would be possible to run the axe at higher power. However, that would result in potentially extreme current draw which may damage the motor, the ESC, or the battery after repeated use.

The system also uses a torque-



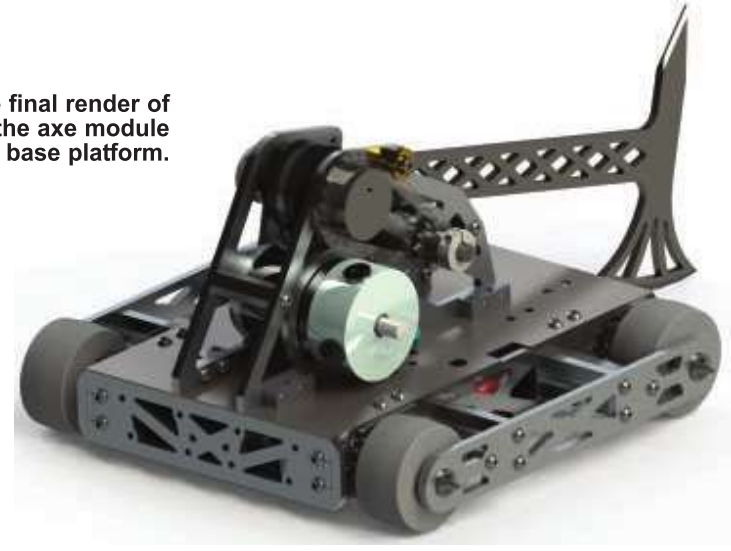
The fully assembled axe module prior to testing.

The completed and mounted axe module.

limiting clutch to protect the gears and motor from the sudden stop at the end of travel. This torque clutch is rated for a maximum of 60 ft-lbs of torque, and at 140A the A28-150 will provide approximately 66 ft-lbs of torque after the gear reduction. This means the extra current would likely be wasted due to the clutch slipping and result in extra stress on the system for little to no gain.

As with the lifter module, the axe module came together quickly. The first two stages of gearing are actually effectively identical between the two systems outside of some slight differences in how many shims and shaft collars are used and where they're located. The output of the two stages of gear reduction is a final stage of chain reduction that takes the 9:1 gear reduction to an overall 18:1 reduction at the weapon shaft.

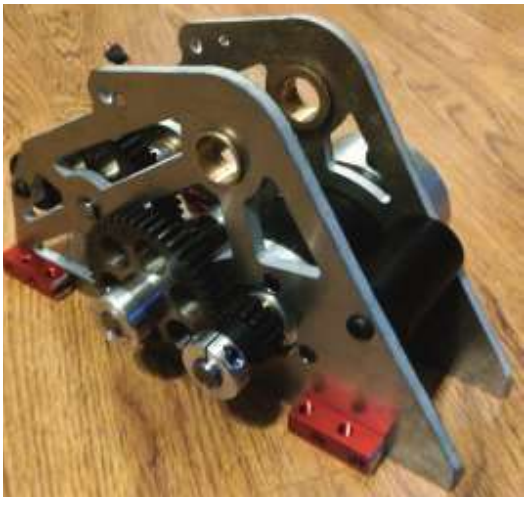
The chain reduction stage uses #35 roller chain and a bronze bushing on a shoulder bolt as a tensioner. The bushing is able to freely spin on the shoulder bolt resulting in very little resistance to the chain moving, and keeps the chain tracking nicely during the hardest swings. The axe arm itself is mounted directly to the torque-limiting clutch and can be reversed should attacking with the opposite side of the axe head be desired, by flipping the torque clutch around after removing the weapon shaft.



The final render of the axe module on the base platform.

With everything installed, it was time to test-fit the module on the robot and do the initial test firing. Everything was working well and the power was ramped up over several tests, with the full power tests nearly piercing and substantially deforming 1/8" aluminum plate.

One element that didn't fully make it into the CAD model that is part of the design is the integration of a mount point for a camera. In this specific case, a GoPro Hero camera. The Hero was chosen due to the low cost



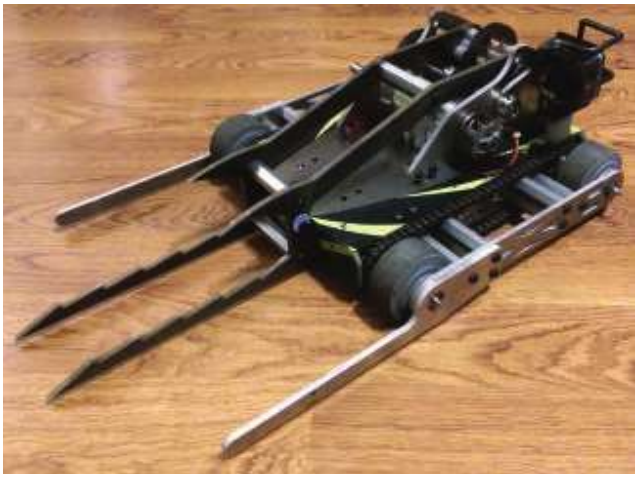
The axe module after both gear stages had been installed.

since it would be put into an extremely hostile environment.

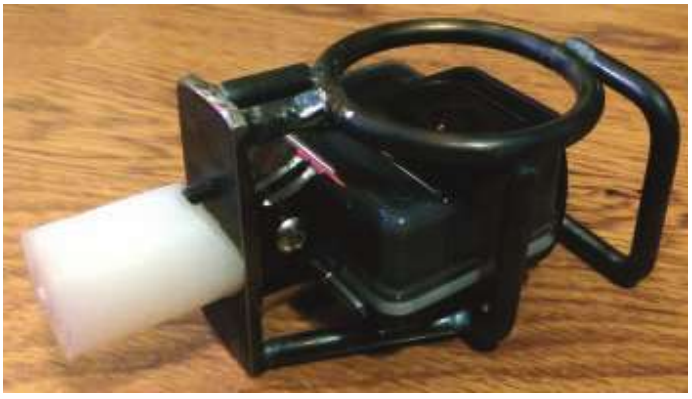
The mount itself uses 1" UHMW rod stock as the base of the mount, with two plastite screws holding it to the base plate. A piece of 1/8" thick steel flat stock was then bolted to the top of the UHMW, and two tapped holes were added to attach a small aluminum mount bracket to the assembly.

From there, a 2" steel ring and some 1/4" diameter steel rod were used to build a small roll cage for the camera. The cage won't protect from a direct piercing blow. However, the mount location should minimize the chances of that style of attack making contact with the camera. The main protection the cage will provide is against a heavy blunt impact that could result from a roll-over or a robot landing on top of it.

With the camera mount and all of the weapon modules completed, this concludes the build for Nyx v2. Test videos can be found at **http://nearhaos.net/?p=135** and I've posted the complete 3D CAD files for Nyx v2 in SW2013 and STEP formats, as well as the 2D drawings that were used for waterjet fabrication at **http://nearchaos.net/NyxCadFiles.rar** should you be interested in taking a more in-depth look at the bot, or be interested in replicating or modifying any of the systems I've designed. **SV**



Nyx with lifter module and GoPro mount attached.



Custom GoPro mount that will attach to the back left corner of Nyx.

Testing the completed lifter by picking up Nyx v1 after adding ballast to bring it up over 30 lbs.

Nyx with all three weapon modules.

Special thanks to Ed McCarron.

EVENT REPORT: Franklin Institute 2014

● by Hugh Savoldelli

The Northeast Robotics Club (NERC) Franklin Institute 2014 event was an action-packed day of robot combat. Established in 1824, the Franklin Institute is located in the Historic Museum district in Philadelphia, PA. Ten Antweights, eight Beetleweights, three Hobbyweights, four 30 lb Sportsman's class bots, three Featherweights, and four 15 lb high school class robots competed.

Team Brain Damage's Zac O'Donnell was victorious in the Featherweight class with Triggo, the result of many iterations on a full body spinner design. Triggo had an absolutely spectacular fight against Team Cookin with Gas' Alex Horne with his robot, Drum Thing Else which is a vertical drum spinner.

For the specific fight against Triggo, Drum Thing Else had a thick piece of UHMW in the front of the bot that covered the drum with the intent to absorb the hits from the shell of Triggo. Triggo managed to spin up to speed and took the UHMW clean off Drum Thing Else. On contact, the UHMW was removed so cleanly that Alex could spin up his drum without any issues, but was left vulnerable to the low stick zone of Triggo.

Triggo proved to be a controllable spinner ... Zac lined up a shot and hit a corner of Drum Thing Else's frame. At that moment, multiple pieces of Drum Thing Else were propelled into the plexiglas on the audience's side. Drum Thing Else bravely fought on, them Triggo hit Drum Thing Else directly on its drum. The fight was over soon after.

Nate Franklin's Slim Pickins — the Antweight champion.

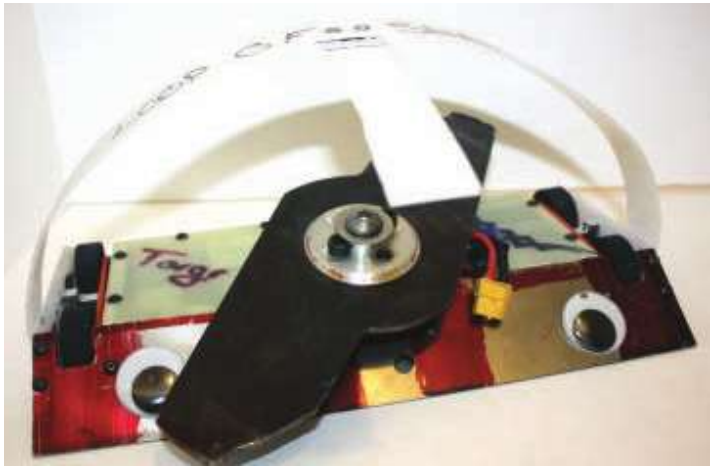
Out of the arena: One bot from The Collective — a three-robot multi-bot — courtesy of A Devastating Moment.

Which one is Magneto?

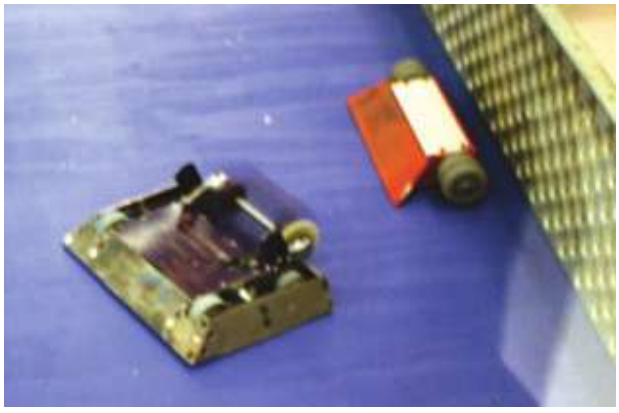
Still 'n Shock 2.

The reactions were priceless, and one of the reasons why the Franklin Institute event is so important to combat robotics became evident. At the start of the fight, a large group of visitors to the museum arrived right as this battle got underway. Exciting matches like these combined with a large viewership will attract more people to the sport. Impressively, Alex

Three-way rumble to decide second, third, and fourth in the Sportsman's class.



Torgr, a devastating spinner in the Beetleweight division.



Robot Ford's Meltdown does a spin test for saftey.

— a seasoned veteran of combat robotics — was able to fix Drum Thing Else and the drum was back in working order. Remember that the majority of your next fight is won in the pits!

In the Antweight category, Team Mutually Assured Destruction's Nate Franklin with his robot, Slim Pickens took home the gold by skillfully winning every match without a loss, going 4-0 in the ring. Slim Pickens sports a grade five titanium wedge.

Nate has competed multiple times at the Franklin Institute, but this was his first gold metal finish. When asked about his first place finish, a jubilant Nate said, "I don't know what I'm feeling. It (the final fight) was close. I took on some pretty tough robots."

Indeed, Nate's final fight against Team Metal Volcano's, Puppy — a low wedge bot driven by Ben Fox — was a very close fight and went to a judge's decision. Ultimately, Slim Pickens managed to control the fight better than Puppy.

In the Beetleweight category, Team Slaughterhouse championed with Speed Wedge 3. A four-wheel low angle wedge bot, Speed Wedge 3 managed to beat Torgr from Team Twisted Sick Robotics — a devastating tilted horizontal bar spinner. In third place, came Devastating Moment from Team Green Machines — a vertical drum spinner based on the Weta kit from Kitbots. Devastating Moment had an excellent fight against The Collective — a three-robot multi-bot from Team Metal Volcano — in which

Team Slaughterhouse's Armada. Speed Wedge 3 took first in the Beetleweight division.

one of the three bots was thrown out of the arena. The three pound category is certainly one of the most violent classes because of the incredible power-to-weight ratio modern brushless motors provide.

In the Hobbyweight division, veteran robot Upchuck — a gorgeous vertical drum spinner from Team Dreadfully Wicked Robotics — took home first place. Upchuck has been competing actively since 2007; the Franklin Institute was Upchucks' 10th event. In second was Robot Ford's Meltdown. A unique type of robot, Robot Ford's Meltdown is a 'melty brain' spinner.

A typical melty brain spinner is in a circular shape with usually one, two, or three wheels in contact with the arena floor. Inside is usually a control board. Robot Ford's Meltdown used a Pololu Baby Orangutan. The entire robot spins while the drive motors inside Robot Ford's Meltdown increase and decrease in their power, creating controlled translational movement.

Despite their complexity, melty brain spinners have the incredible advantage of having one hundred percent of the robot's weight invested in the weapon because the entire robot spins. ReEnforcer came in third.

Al Kindle works on Blacksmith.

A big thumbs-up from the Fox family of Team Metal Volcano.

The 15 lb college category was dominated by Still 'n Shock 2 from Team Don's Robots. Still 'n Shock 2 uses a devastating vertical beater bar. Coming in second was Floppy Wedge from Team Magical Lipo Fire. If an award for best team name at the Franklin Institute existed, I am sure they would take it. "Super Dumb Post Motorama Idea Ar400 Edition" from Alex Horne's Team Cookin' With Gas without doubt had the longest name at the competition, and took third.

The Sportsman's category featured some fantastically inventive entries. Blacksmith from combat robotics legend, Al Kindle took first place. Blacksmith utilizes an electric hammer weapon to knock consecutive blows on opponents. Blacksmith's armor is entirely wood, but this is less of an issue in the Sportsman's category that doesn't allow high kinetic energy spinning weapons. Power of Metal used a low kinetic energy weapon and a bulletproof drivetrain to claim second place.

The most creative, thought provoking, stunning, and startling design was Clawed Crawler from Team Terror which took third place. Team Terror brought their innovative design all the way from Peterborough, Canada to make it to the Franklin Institute.

Clawed Crawler utilizes two large tracks that have open space in between them with a saw blade in the middle. It's such a unique robot, and was always a crowd pleaser — win or lose.

Creebot is a large green robot that uses horizontal grabbing arms that can also be switched out for a low energy horizontal disk. Creebot took fourth place.

The most technically complex robot at the competition, Team Brain Damage's Zac O'Donnell's Magneto, took fifth place. Magneto is a flywheel powered flipper that utilizes a complex system of flywheels and clutches to actuate a powerful flipping arm without using traditional pneumatics.

The trophies were giant bolts, and upon winning his first place award in the Featherweight category with Triggo, Zac O'Donnell said, "I've always wanted to win a giant nut, but now I've won a giant bolt!" The event was certainly a success. So, at the end of the competition, what was on the builder's minds? On to Motorama! **SV**

BUILD REPORT: Slade

● by Matt Spurk

I have been trying — rather unsuccessfully I might add — to build a 150 gram combat robot for several years. It seemed that I just couldn't get a functional robot in that weight class. When my son and I started talking about new designs for a combat robot, the conversation of what weight class came up, and when he said "skeeter weight," I knew I was in trouble.

This robot began as they all do with a 3D model of the components. The first thing I needed to do was to determine if it was even possible. I weighed all the components I had on hand and started working on the 3D model of the assembly. I knew it was possible if I could keep the frame weight down.

When I design my frames, I begin by laying out all the components in their approximate locations and get the spacing and orientation worked out. Then, I go back and build the frame based on the structure I need to support all the parts. I follow that up by rebuilding the virtual assembly, except now everything is referenced off the frame instead of floating in space.

Slade was going to be a robot that incorporated a slanted blade. (SL-anted bl-ADE, SLADE, get it?) The blade began life as a 3-3/8" circular saw blade. Due to weight, I cut off every other tooth with a Dremel tool.

The saw blade was directly mounted to a 1,100 kV brushless motor. I 3D printed a hub that secured the blade. I made certain to print up three spares because I wasn't convinced the hub would survive an entire match and I may need to replace it.

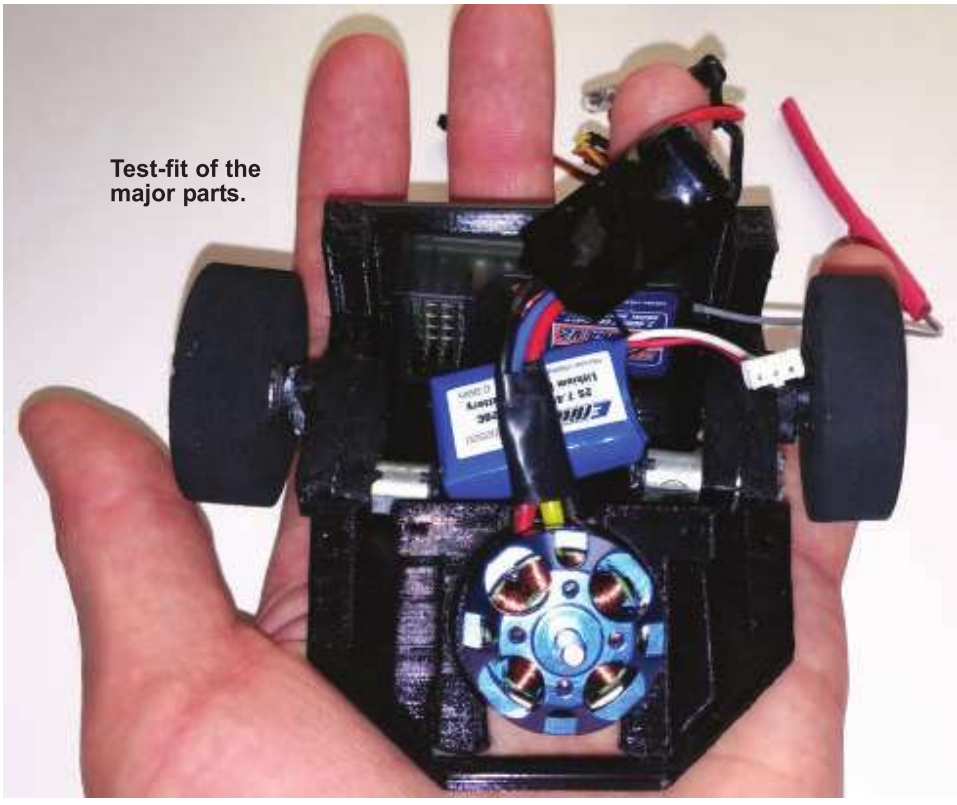
I was very wrong. In one fight, the robot lost an entire tooth (sheared completely off), but through the entire event I didn't lose a single hub.

The frame was also 3D printed. In order to improve the print speed and quality, I decided to print the frame as two components and then glued and bolted them together. I began by printing the weapon motor mount. I printed this part by standing it up on its back to eliminate the need for support material.

Next, I printed the frame. The frame featured a large opening where the motor mount would be installed. Both components combined took about three hours to print with a 45% infill. I probably could have gone with a lesser infill, but again, strength was a concern.

I glued the two frame components together and added two mounting screws to ensure they stayed together. I made the top armor by cutting out a piece of plastic bottle and screwing it into four holes in the frame.

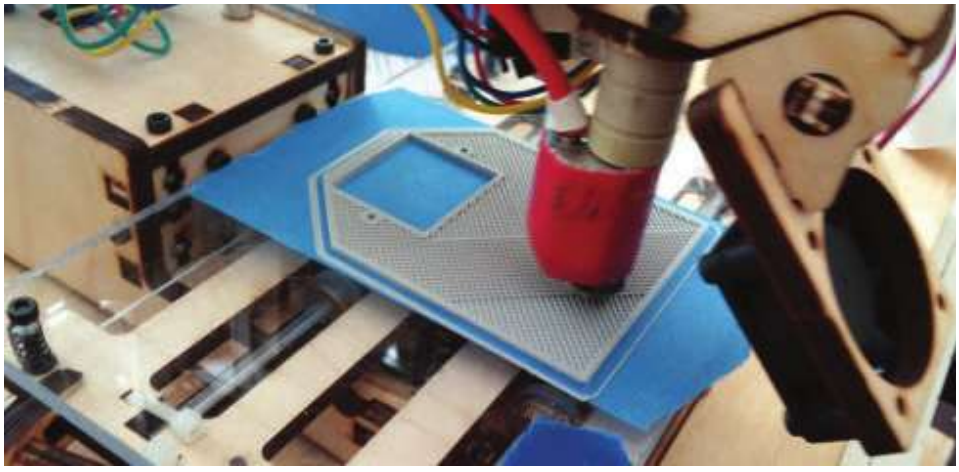
While the frame parts were printing, I soldered up the 7.4V 270 mAh battery pack, the hacked micro servo drivetrain, the servo speed controllers, and the FingerTech robotics on/off switch. By the time I finished all my soldering, the frame was nearly complete. I had a little extra time, so I started giving the saw blade a flame-ish look. I thought it turned out cool, albeit not what I was going for originally.



Test-fit of the major parts.

Overall, I was disappointed in this bot. It didn't fare well in competition, losing its first two matches. The weapon hit suitably hard for my liking, but the hacked servo drives let us down. The servos were older and I had a lot of trouble getting them to function reliably. I had smoked one of the speed controllers about a week before the event, which meant buy a new one. I even paid for expedited shipping. Then, the servo case cracked and that caused alignment problems.

While I was at the competition, I picked up two FingerTech robotics Tiny ESCs (electronic speed controllers) and two Pololu gearmotors. My intention is to upgrade the drivetrain and the speed controllers for a future version of this robot. Not only should this setup be more reliable, I should also have a slight weight and space savings over the hacked servos.



3D printing the frame for Slade. Note the large opening for the weapon motor mount.

In speaking with other competitors at the event, the discussion was that gearmotors are somewhat weak — especially during large impacts — but when supported properly and not directly coupled to the wheel, they can work quite well.

My intention is to 3D print a flexible spider tooth coupler (a.k.a., a love-joy coupler) or use a small length of rubber tube glued to the motor and wheel shaft. We'll see what the future holds for this robot.

My son has already discussed a drum, a wedge, and a flipper, so stay tuned to future issues of *SERVO* to see what we end up with. **SV**

PARTS IS PARTS: Modifying Timing Belt Pulleys

● by Pete Smith

Timing belts are a popular item for power transmissions in combat robots. My favorites are 3 mm HTD x 6 mm wide for Beetleweights and 5 mm HTD x 9mm wide for weapons and drive in Hobby and Featherweights. A wide variety of timing pulleys to match these belts are available from suppliers like **www.sdp-si.com**.

The only problems I've found with these pulleys are the limited range of bore sizes and the rather weak pulley flanges. These flanges are made of a thin and reatively soft aluminum, and are easily damaged (**Figure 1**). This is not much of a problem at the motor end of the belt as these pulleys are usually well protected, but on the weapon end I like to replace the standard flanges with much more robust parts made from UHMW

Figure 2. Replacement flanges.

Figure 1. Standard pulley flanges.

Figure 3. Pulley stock.

Figure 4. Machined stock.

Figure 5. Cut off each pulley.

Figure 6. Drilling out the pulley.

or aluminum (**Figure 2**).

The bore sizes are only really a problem if the smallest bore size is bigger than the motor shaft. One solution is to use a bore reducing bushing which is, in effect, a short tube that has the outside diameter of the pulley's bore and an inside diameter the same as the motor shaft. The second solution is a custom sized pulley. These are available, but only at considerable extra cost and time delay.

I'm working on a new combat robot that requires a 20-tooth 5 mm HTD pulley on the motor and a 40-tooth pulley on the weapon shaft. The motor has a 5 mm shaft, and the smallest size bore available on 20-tooth pulleys was 1/4" (6.35 mm).

I looked at using a bore reducing bushing but I would have had to drill out the pulley to allow the use of a bushing of reasonable thickness, and that would have meant that not enough material would be left for a decent size set screw. I could have ordered custom parts but since I had some time, I thought I would try another solution.

SDP-SI has what is called pulley stock. This is a long extruded bar with an outside profile of a timing pulley and no bore. I bought a 200 mm length of 20-tooth pulley stock (**Figure 3**), so I could make my own pulleys and drill them out to match the motors.

Warning: *Machine tools are not toys and can injure or kill if used incorrectly. Make sure you do not have any loose clothing or long hair that could get caught in the machine. Always wear safety glasses when using any machine tool.*

The pulley stock is easy to mount in a lathe as it has a short shaft on one end and a shallow center bore at the other. I machined it with a square end bit to leave four sections of pulleys and reduced diameter sections long enough to make up hubs for set screws and space for pressed on flanges (**Figure 4**). I protected the teeth with tape and cut off each of the sections in turn (**Figure 5**). I then center drilled the pulleys and

Figure 7. Set of drill bits.

drilled them out to match the motor shafts (**Figure 6**).

Don't be tempted to drill immediately out to the final diameter or you might find you have an over-sized bore. Drills do not create precision diameters (that's a job for reamers), so it's best to slowly creep up to the diameter you want.

A worthwhile investment is one of those large sets of drill bits (**Figure 7**) from Harbor Freight or Northern Tool. Start about 0.020" under the desired diameter and work up, testing each time with the actual motor shaft until it's a close fit (**Figure 8**).

Timing pulleys need flanges to make sure the belt stays on the pulley. In combat robots, it's best to have larger flanges than standard ones since the bot takes stresses far in excess of what would be expected in most other applications.

I made up some flanges (**Figure 9**) that had an internal bore about 0.005" smaller than the diameter of the bosses on the pulleys. I then pressed the flanges onto the pulleys using my bench vise (**Figure 10**). Each pulley was then drilled and tapped to take two big 10-24 set screws at 90° to each other (**Figure 11**).

I had completed three 20-tooth motor pulleys to my exact requirements and can make more if I need spares — all for less money than standard parts would have cost.

The larger 40-tooth

Figure 8. Good fit with motor shaft.

Figure 11. Added set screws.

Figure 12. Large 40-tooth pulley.

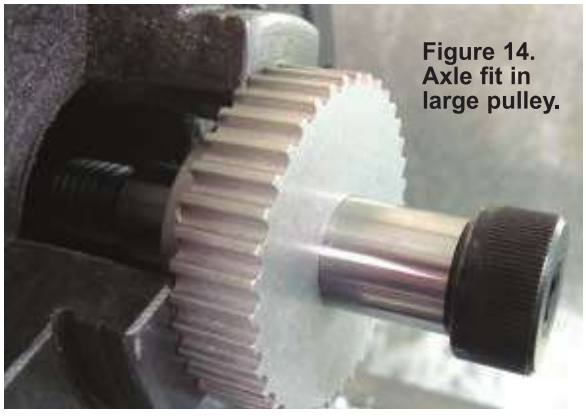


Figure 14. Axle fit in large pulley.

Figure 9. Flanges.

Figure 10. Press-fit.

Figure 13. Boring out large pulley.

Figure 15. Removing hub.

Figure 16. Set of broaches.

Figure 17. Press.

Figure 18. Broaching a keyway.

pulley (**Figure 12**) also needed modifying for my new project. I would be using a 3/4" shoulder screw as a live axle, and it would have keyways to lock both the blade and pulley to the shaft.

This pulley came with a 3/8" bore, so it was first drilled out to 1/2", then I used the boring bar (**Figure 13**) to increase it to 3/4" of the axle. I was careful to make very small cuts as I neared the correct size, and used the axle to check each time until it was a near perfect fit (**Figure 14**). The hub was useful for locating the pulley during this machining operation, but would not be required in the final application. So, I wrapped a piece of tape around the teeth and positioned it as accurately as possible, then machined off the boss (**Figure 15**).

I have had keyways added to parts by friends but had never actually cut one myself. I bought a basic set of broaches (**Figure 16**); this set included the size I needed — a 3/4" bore with 3/16" wide keyway. The other sizes will no doubt prove useful in the future.

I used a press (**Figure 17**) to push the broach through the pulley (**Figure 18**), then repeated the process with the small provided spacer to cut the slot to the correct depth (**Figure 19**). This all proved easier than I had expected, and I think you could use a drill press if you didn't have access to a press like the one I used.

Next time you are designing a bot and can't find the exact timing pulley you need, don't give up! You can probably make your own or modify one to suit. **SV**

Figure 19. Completed large pulley.

BattleBots - the 15th Anniversary Panel

● by Andrew Norton

Over the summer, a fairly important landmark for many of us passed almost without notice — except in Atlanta, where the 15th Anniversary of BattleBots was celebrated at DragonCon with a special panel.

Builders past and present gathered to share and discuss knowledge, but more importantly, it became a memorial panel, as Brett "Buzz" Dawson had died a few days before the event. As well as being part of the 3.0/5.0 Middleweight team Moebius, Dawson was also the host of *Robot Rivals* on the DIY network. Of course, with this in mind, there were going to be more builders than could be contained on a panel, but in the end it was whittled down to six BattleBots competitors and one CrewBot:

(From Left): Marc DeVidts, Chris Williamson, Valerie Hill, Michael Macht, Simon Arthur, Grant Imhara, Fon Davis, Brian Nave, and Andrew Norton.

- Valerie Hill and Michael 'Shaggy' Macht, who were Buzz's teammates with Moebius.
- Simon Arthur, who competed at 3.0, 4.0, and 5.0, starting with the Superheavyweight, Neptune.
- Grant Imhara. Probably best known now for *Mythbusters*, but has competed with Deadblow at all six BattleBots events for Middleweights.
- Fon Davis, a former co-worker of Imhara's and competitor with Mouser Catbot and its successors; also a competitor at all BattleBots events.
- Brian Nave, the primary of Team Logicom; competed at 3.0-5.0 with bots like the Heavyweight Phrizbee, as well as co-host of *Robot Rivals* with Buzz Dawson.
- Andrew "K`Tetch" Norton (me), also known as CrewBot Beatle, working four of the BattleBot events (LB99, 1.0, 2.0, and 4.0).

This, for me, was going to be a bit unusual in many ways. While I'd like to think I was a big part of the scene 10-15 years ago, I'd barely touched it in the past decade. I hadn't spoken to almost all of the panel in 12 years ... some I'd never even met before and if I had, I don't remember — a problem mostly rectified by the vivacious Bunny the night before, helping guide me to the group in the mad party that is DragonCon at night.

The number of builders that attend DragonCon is high, and not just for the robotics track. Some of the builders come to the event for other reasons (including myself) where, having retired from the world of robot combat, I now work on the Electronic Frontier Forums track, while Fon's there for model making and Grant for his Mythbuster and Star Trek Continues work.

One of the main focuses early on was how the events have helped us all move on in jobs and careers, but conversely, how much it costs and how even with merchandising no team has ever really broken even. It would seem that by being crew and thus having my expenses covered, I may have been the only one there that didn't end up at a loss from BattleBots.

The discussion then went on to public perceptions, including the biggest problem: size. It's a problem that's transatlantic, now and then, to which it would seem the answer would be "a refrigerator" (at least, according to Brian), so there's both a sense of scale and energy levels. It's a common problem with this sort of thing — there's no real sense of

perspective on TV, no suitable frame of reference for a TV viewer to use to grasp the size of things.

It segued then into a general Q&A session, with questions ranging from Mars missions to the post-TV event fight scene. There was quite a lot of focus on inspiration and getting others involved with robotics — directly or indirectly. Let's be honest though, this stuff is all cool; when you see it in person, how are you *not* going to be inspired?

After roughly 30 minutes of Q&A, the focus shifted back to the builders and what was the 'defining moment' for each of them. No two answers were even remotely similar. I had my own feeling of awe seeing Ziggo going full speed over my head as I was under the arena floor during matches at Long Beach, to Fon's feeling after Mouser was launched by a saw 15 ft+ and finding that it still worked.

Brian's defining moment was stopping to appreciate the spectacle of the event at 5.0 'just in case this was the last time' (which it was, the jinx!), while for Grant it was the Biohazard-Vlad grudge matches (and on the converse side, Biohazard vs. Megabyte at RoboGames shattering that).

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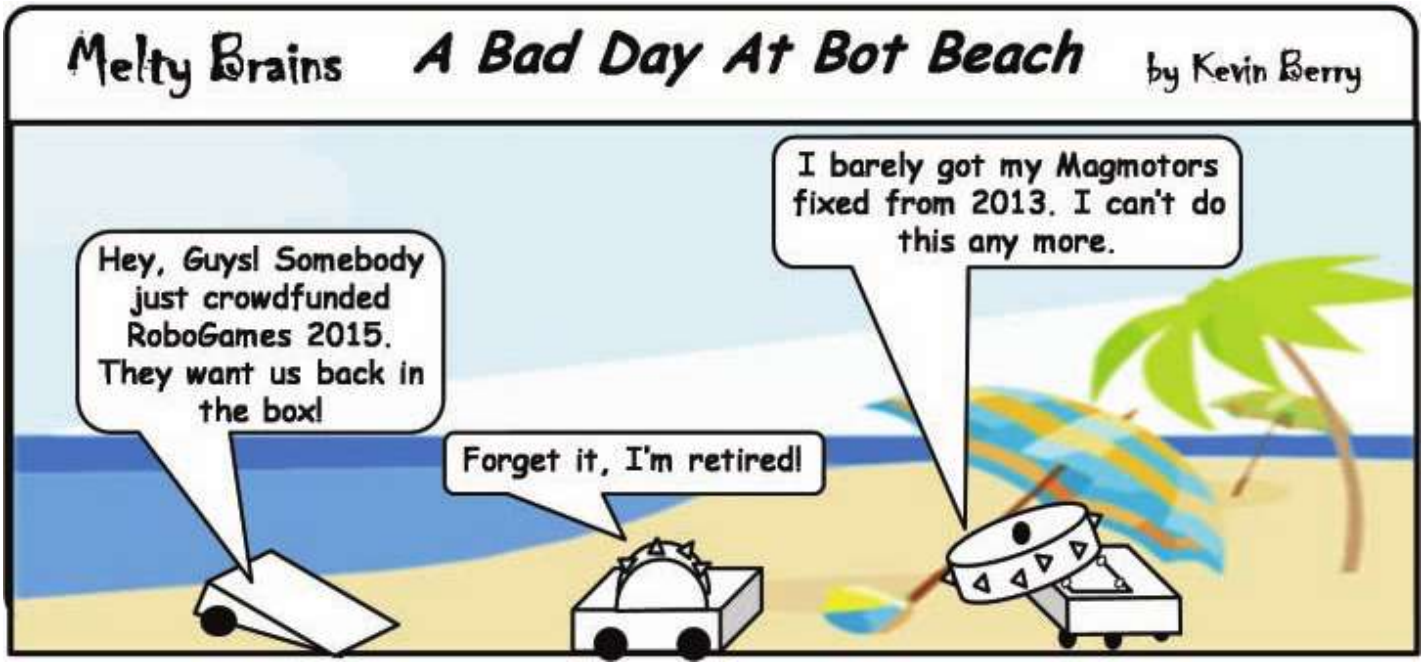


For Simon, it was a mix between the interpersonal camaraderie outside the arena, with the in-arena moment being the Nightmare Tooth incident at 5.0's Heavyweight rumble. Finally, both Valerie and Shaggy agreed that for them it was about crowd participation, Shaggy being applauded by Supreme Commander Tilford ('a robot god') among others, and Valerie going with the "guilty" following for Jasha Little's The Judge, along with BotKnocker's spinning top impression.

Sobering things up a little, the tribute to Buzz followed, led by Shaggy and a clip reel showcasing the man and the mind that gave so much. It was interspersed with a few amusing anecdotes about the man who was often better known as Dr. Boom, and who brought real theater to the battle box. I, for one, didn't have the chance to meet Buzz. I took 3.0 off to get engaged, and my son was born during 5.0, but I felt both a kinship and a sense of loss that still paled in comparison with what Buzz's wife, Alexis (sitting in the front row) must have felt.

With only a short amount of time left, we got a few more amusing anecdotes about Grant and Fon's time at Industrial Light & Magic (and the dangers of metal slivers) before it was time to wrap up.

At times, it seems like BattleBots was a lifetime ago, and sometimes it feels like just yesterday. During that panel, it didn't feel like 15 years ago, it didn't even feel like 15 hours ago. It felt like 15 seconds ago. Like we were still "live" and in the thick of it. When I walked out of that room, I wasn't about to go do a panel on the aftermath of Edward Snowdon, but that I was about to go back to the box and wrangle some robots.

Let's be honest, what more could you want from such a panel? The entire video of the panel is at **www.youtube.com/watch?v=PBayJ79MdwA**. SV

The Robot You've Always Wanted

Part 1: Physical Construction

By John Blankenship and Samuel Mishal

Are you tired of robots that look like toys? If cost was not a consideration, wouldn't you prefer a robot with some human-like features and capabilities? This series shows how you can have the robot you've always wanted, at a price far less than you might expect.

Figure 1.

I talk with a lot of hobbyists, teachers, and students, and often ask them what they want in a robot. Even though my survey was informal at best, it definitely showed a pattern. Most everyone wants to build something that *looks* and/or *acts* like a *real* robot. Many commented that friends and relatives were seldom impressed by a remotely controlled robot and that the amount of programming needed to make a small toy-like base follow an irregular line or avoid obstacles in a cluttered environment is rarely appreciated.

When asked what a *real robot* should be able to do, most robot builders I talked with were very realistic in that they did not expect to create anything as capable as what they see in the movies. They did, however, generally seem to dream of something more *lifelike* than the typical hobby or educational robot — but most assume such a machine would be far beyond their budget.

Based on the advances in both mechanical and electronic modularity, all that has changed. Now, you can assemble the robot you've always wanted mostly from off-the-shelf parts at a price far less than you might expect. Before delving into the details of this robot, I want to emphasize that it will *not* be able to wash your dishes or engage in truly intelligent conversation, but it will look like a real robot and can be programmed to do things that are truly impressive.

The robot will have a face that can express emotions, and arms and hands that can manipulate small objects.

Post comments on this section and find any associated files and/or downloads at **www.servomagazine.com/index.php/magazine/article/january2015_Blankenship**.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.

It will be able to navigate through your home in response to verbal commands, and find its way to its nest or a charging station when its batteries are getting low. Its capabilities are beyond that of many other robots primarily because of its sensors.

Numerous perimeter sensors, a compass, and a beacon detector provide the information needed for real world navigation. A camera and sensors on the grippers allow objects on an integrated tray to be found and picked up far more intelligently than typical pick-and-place behaviors.

There are limitations, though, that keep costs down. Don't expect this robot to open the refrigerator and get you a drink. It certainly could be programmed, however, to respond in a reasonable manner to your verbal request for a Coke. It could, for example, find its way to the kitchen, ask anyone there to place a Coke on its tray, and then transport it back to where you originally were. It will be able to smile at you if you say thank you, and it can look sad if it has to tell you that no one was in the kitchen to help with acquiring your drink.

This is a platform worthy of your programming efforts — a platform

Figure 8.

Figure 9.

Figure 10.

Figure 11.

capable of embodying new and exciting ideas for years to come. And, since the platform is easily duplicated, it encourages collaboration with others to share their innovations and code.

Figure 1 shows the robot described. It stands four feet high which is tall enough to be impressive but not imposing. If the neck and head are removed, it easily fits in most SUVs, so you can even show it off at your local robotics club. Many of the robot's navigational sensors are located in the base, but others are mounted on the turret positioned in front of the neck.

An integrated tray provides a convenient surface for holding small objects being manipulated by the arms. The robot's face is a graphical rendition displayed on a tablet computer. The face shown in **Figure 1** is only a prototype. The final version will have larger, more expressive features that will display a variety of emotions. These and many other topics will be discussed in future articles.

It can be difficult to find a base suitable for a robot this size. The Parallax Arlo system (**www.Parallax.com**; shown in **Figure 2**) was chosen because it is a high quality rigid platform with strong motors with integrated wheel encoders. The base is 18 inches in diameter — large enough for stability, yet easily able to pass through standard doorways.

The two structural additions needed to give Arlo a more human-like appearance are shown in **Figure 3**. The main body support is made from a two foot piece of four inch PVC pipe. An 18 inch piece of 1x2 lumber along with four short pieces of molding provide mounting for the shoulders and arms.

Various holes were cut in the pipe to route wires to keep the finished robot tidy. Creating these parts is not overly difficult, but it does require a few skills and appropriate tools. I suspect many schools

and hobbyists would purchase similar items if they were available as part of the Arlo kit. If this interests you, let Parallax know.

The support for the head (a tablet PC) is a piece of plywood mounted on two four inch to two inch PVC couplings that form the neck. **Figures 4** and **5** show the details of how a toilet flange connects the neck to the plywood.

A four inch hole is cut in the top plate of the Arlo base to allow the PVC pipe to pass through and seat in a second flange bolted to the bottom plate as shown in **Figures 6** and **7.** The flange plus the support from the upper deck creates a solid structure. Note the HB-25 motor control modules in **Figure 6** (also available from Parallax).

The rest of the robot's head and body consist of ornamental parts customized to your liking. The pieces I built (**Figure 8**) were all made from foam board — which means the only tools needed are an X-Acto™ knife and glue. **Figures 9**, **10**, and **11** show the robot's shoulders and head during early construction to help demonstrate the simplicity of building with foam board.

Remember, these pieces are strictly cosmetic, so you can make your robot look anyway you like.

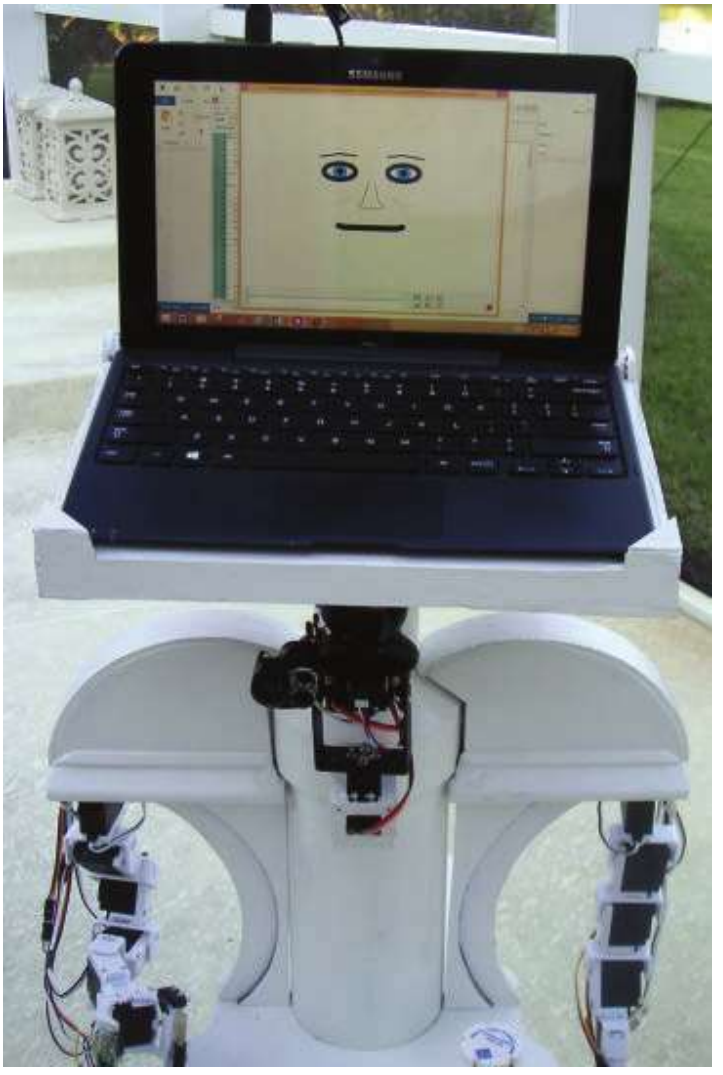
Figure 12 shows the robot's head with the decorative covers removed from the computer so that programs can be easily modified during the development stages. There are many advantages to controlling your robot with a tablet PC (see the series on this subject in *SERVO* starting in the December 2013 issue).

The robot's arms are from EZ-robot (see the article Mechanical Modularity in the December 2014 issue of *SERVO*). They are inexpensive and easy to assemble (the servos just snap together).

Unfortunately, like most arms currently available, they have no sensory capability. Adding four sensors to each gripper as shown in **Figure 13** gives them the capabilities needed for more interesting projects. Details on these sensors and how the arms will be controlled will be provided in a future article.

As you can see, Parallax's Arlo platform makes it easy to construct a large impressive robot capable of carrying everything needed to make the robot you've always wanted. Part 2 of this series will discuss the electronics needed to control the motors and communicate with the sensors. **SV**

Figure 12.



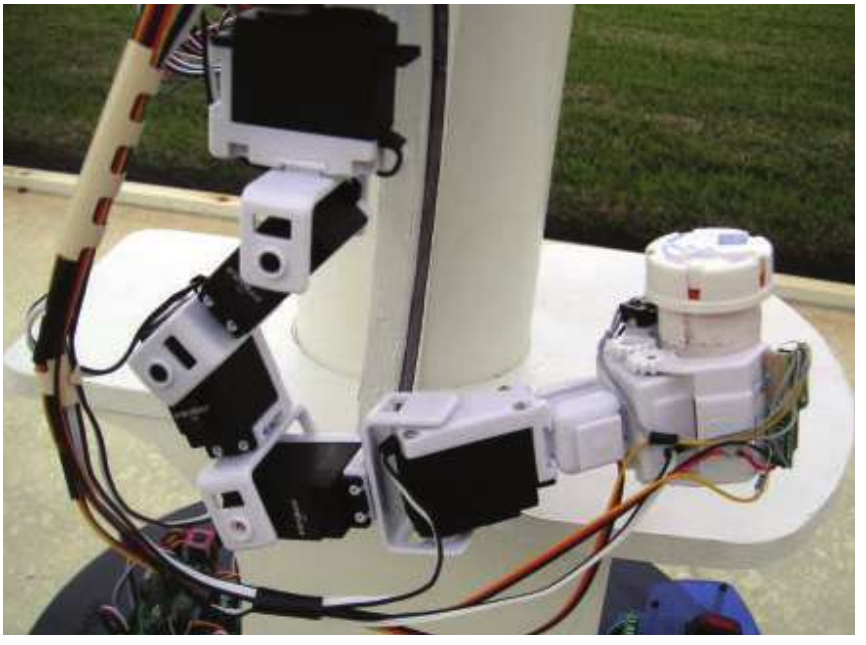


Figure 13.

So, What is a Maker Con?

By John Iovine

I attended MakerCon back in September of last year in Queens, NY. If you haven't been to one of these events, it is a unique and rewarding experience. It is a conference of sorts "By Makers, For Makers," and it is lending a hand in the "maker movement" to help folks realize their dreams of bringing products to market ... like cool robot platforms or modules, for example.

Primarily, it's for people who make things — from items created from arts and crafts to high-end technology do-hickies.

MakerCon provided an insightful two-day education. The event started off with an introduction by Dale Dougherty, CEO of Maker Media. The primary emphasis of MakerCon was on the business of making, but it also highlighted the innovative tools available to develop ideas, bring them to life, and then decide if you want to go further and offer it as a new product or service.

Lectures were given by successful makers telling their stories — where they believe our technology is heading, how they developed their ideas, and how they ultimately brought them to the marketplace. It's always best to learn from people who have already walked down a path and are willing to share what they have learned along the way.

I'd like to discuss just some of the ideas that were great take-aways for me. Maybe they'll inspire you too.

Bringing an Idea to Market

So, you've got an idea. Great! Is it a good idea? That's always hard to tell, since there's a tendency to cloud your own judgment. You may think it's the greatest widget or service since Stonehenge was built, but ...

What exactly should an entrepreneur do? Let's look at a few steps to take an idea from conception to possible market entry. The path I am outlining is certainly not the only one, but made sense to me.

First step: Take your idea out of your head, put it onto

paper, and then put it in concrete form. In other words, build it. Does the widget work? Yes? How well does it work? If you're afraid to have anyone touch it, refine the idea and build a production prototype. Or, at least get close to what a production unit may look like.

Many of the tools now available for prototyping didn't exist five years ago for the individual such as 3D printing, for example. There are a number of 3D modeling software programs available both online and offline. For online, take a look at TinkerCad (**https://tinkercad.com**). While this is a basic 3D modeling software, it will get you up and running quickly to create prototypes.

You don't need to purchase a 3D printer to create a model since there are 3D printing services available, such as Shapeways (**www.shapeways.com**). Of course, there are advantages and disadvantages to 3D printing. For example, say you created a nifty 3D printed enclosure (or part) for your product. Be sure this part can be manufactured by conventional means.

If not, you may be forced to mass-3D print your new widget. Also, sometimes 3D printing can turn out to be expensive and time-consuming, and that could drive your costs up on the final product.

Be sure and ask yourself if your "invention" works better, is more efficient, or less expensive than what's already available. If not, rethink your product/design.

Will it Sell?

If you have gotten this far — hooray! You took your great idea, tested it by building it, prototyped a production model, and it's better than anything currently on the market. So, now it's time to actually mass-produce your product. Even a small production run requires funding. And, what happens if after you have invested the money into producing your new gizmo, you still don't know if they will sell. Wouldn't it be great if you knew *before* mass-producing your widget that there is a market for it? Enter crowdfunding sites.

Crowdfunding sites like Kickstarter can solve both initial funding and marketing issues. You begin by figuring out what it will cost to bring your product to fruition and at what quantity. Add in a "fudge factor" and this becomes your funding goal.

Make a video of your prototype. In it, explain the benefits and offer incentives for people to fund your project. Many times, getting the product itself is the main incentive. If you reach your funding goal on Kickstarter, you must make good on any incentives you promised.

You can run your campaign on the Kickstarter website anywhere between one and 60 days. You decide the length of the campaign. While the Kickstarter website has a global reach for an audience, it doesn't hurt to promote your campaign to drive traffic.

The crowd (people) viewing your Kickstarter project decides whether your product is a good idea or not. They basically vote, with their support being the funding. This process is great to jump start your business. Is this the only path to market?

No, not at all. It's just one of many. There are strategic partnerships, joint ventures, and investments from venture capitalists to name a few.

Speaking of Speakers ...

It is impossible to see all of the lectures and speakers at MakerCon because there are simultaneous events occurring, so you need to choose which presentations you want to see. One of my favorite speakers was Yancey Strickler, who is the CEO and co-founder of Kickstarter (**www.kickstarter.com**). His talk began with the history of Kickstarter; how it moved from a concept, into development, and where it is now. He provided some great insights into what makes a successful Kickstarter campaign. Their website provides easy to follow instructions on creating a campaign.

Daniela Perdomo, co-founder and CEO of Gotenna (**www.gotenna.com**) began her talk by explaining how Hurricane Sandy was the inspiration for her decentralized smartphone communication. Gotenna is a hardware start-up company which, as she explained, is more expensive and a dicey venture when compared to the software start-up companies she had worked with previously. She shared a lot about the obstacles and pitfalls she encountered on the way to market.

Jesse Genet is the CEO and founder of LUMI (**http://lumi.co**). Jesse created a photosensitive dye for clothing. With it, you can print images and patterns onto cloth. She built a successful company providing a service, then realized that instead of offering the service, she could sell the dye to other makers. Her business grew and expanded successfully from providing a service and products, to providing the tools for *others* to create and provide services and products.

Final Thoughts

One thing that was really cool about MakerCon was that the speakers were accessible. Many times at the end of their talk, they would tell the audience where they would be and at what times, so that if anyone had any questions or comments they could speak to them directly.

There were many other lectures given that I have not touched upon. Some of the talks are available for viewing on YouTube; search under "MakerCon NYC 2014."

Events such as MakerCon really do play a key role in the maker movement, providing a community, education, and support system for us kindred spirits who want to bring that next big thing to store shelves everywhere — whether it's a robot or something else. **SV**

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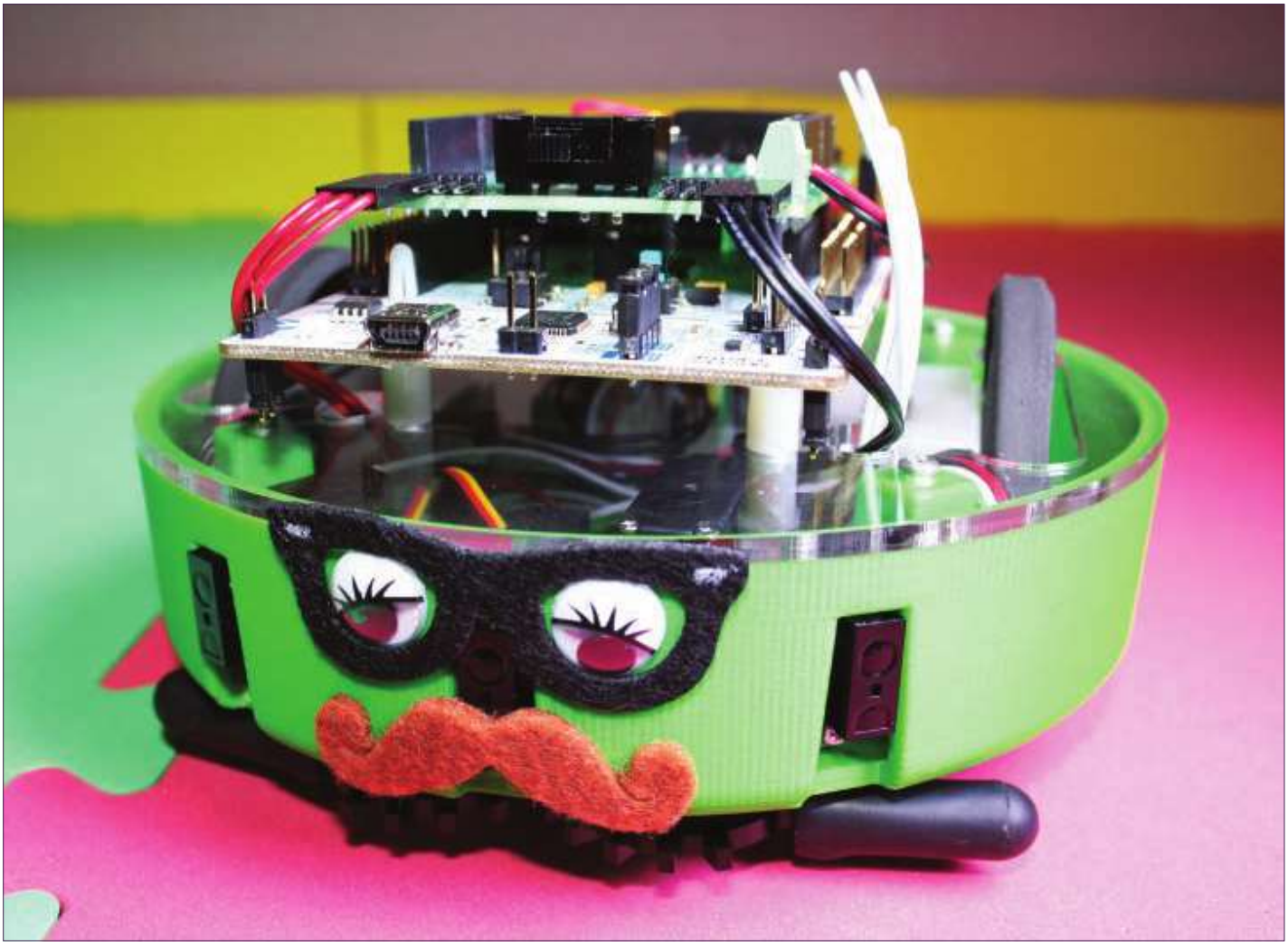

By Abraham L. Howell, PhD

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Most commercially-available robot platforms are proprietary in nature, and as a result the end user is forced into a "black box" device paradigm. I believe that exposing the end user to the true design's intent — along with real world design artifacts such as prints, schematics, source code, and 3D models — opens up the world of possibilities with respect to learning opportunities. I created Apeiros to help support the idea that a fully open source robot can provide significant educational value, while also proving to be a viable product path from a business perspective.

A Next-Generation, Fully Open Source Educational Robot

Part 1

My doctoral research was primarily focused on using robots as a tool for teaching Science, Technology, Engineering, and Mathematics (STEM). After graduating in May 2012, I started to work on a design for a new robot — Apeiros (pronounced "ah.pay.ross"). Apeiros is Greek in origin, and means infinite or boundless.

The vast majority of low cost robots and robot kits possess bodies that are made from flat sheets of plastic or wood. Entirely open source off-the-shelf robots are limited in number. Something deep within me wanted to design a low cost, expandable, fully open source robot with the ability to sense, navigate, and manipulate its environment.

Through this article, I will introduce Apeiros while providing relevant insight into some of the design details. Future articles will probe deeper into various design aspects within the context of Apeiros. I hope that people find this inside view both inspirational and educational in nature.

Figure 1. Top view of injection molded base.

Select a Manufacturing Process

Throughout the last 10 years, I have designed numerous robots, but most have been constructed of parts that were made by laser cutting flat sheets of acrylic or machining bars or blocks of aluminum, PVC, and steel. Both of these manufacturing processes are relatively expensive and do not scale with volume. This means that the piece-part cost will not drop significantly even as production quantities increase.

Laser cut parts limit the overall geometry of your robot design. Machined parts can possess complex geometries, but piece-part cost increases in proportion to complexity. In order to reign in cost while maintaining a high degree of complex geometry, I decided to design for the injection molding process. A top view of Apeiros' injection molded robot body is shown in **Figure 1**.

Injection mold tooling costs vary depending on part size and complexity. In general, you can expect to pay approximately $5,000 to $10,000 for a simple straight-pull mold tool that can produce a part similar to Apeiros' body. If you are considering injection mold tooling, then I would recommend checking out ProtoMold® because they provide design guidelines along with an online quoting system.

After receiving and reviewing multiple mold tooling quotes, I decided to work with a local supplier: Eck Plastic Arts. I was able to utilize 3D printing as a means of prototyping multiple body designs and also used these parts for functional testing.

Functional testing involves building up a test unit that can be exercised in ways that replicate how the device will be used by customers. Functional testing helps to identify

Figure 2. 3D printed prototype.

Figure 3. Servo gripper mechanism.

design issues well before production parts are produced.

An early body design supported two front and two rear infrared (IR) sensors, but this configuration (shown in **Figure 2**) created a center blind spot. In the final body design, the blind spot is eliminated by the addition of a third IR sensor.

Sensing and Manipulation

Most robots can sense and navigate within their environment, but may not be capable of manipulating objects. Apeiros' molded body has been designed to accept an off-the-shelf Hitec HS-81 hobby servo and custom gripper components as shown in **Figure 3**. With a servo gripper, Apeiros is able to grab hold of objects and move them around while navigating

Figure 4. Custom motor shield.

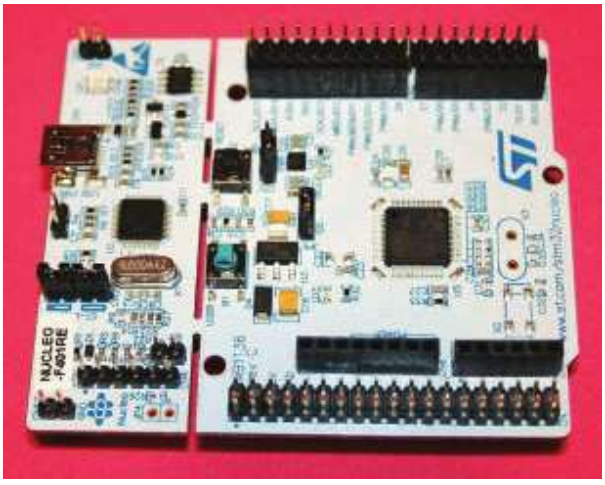

Figure 5. Nucleo development board.

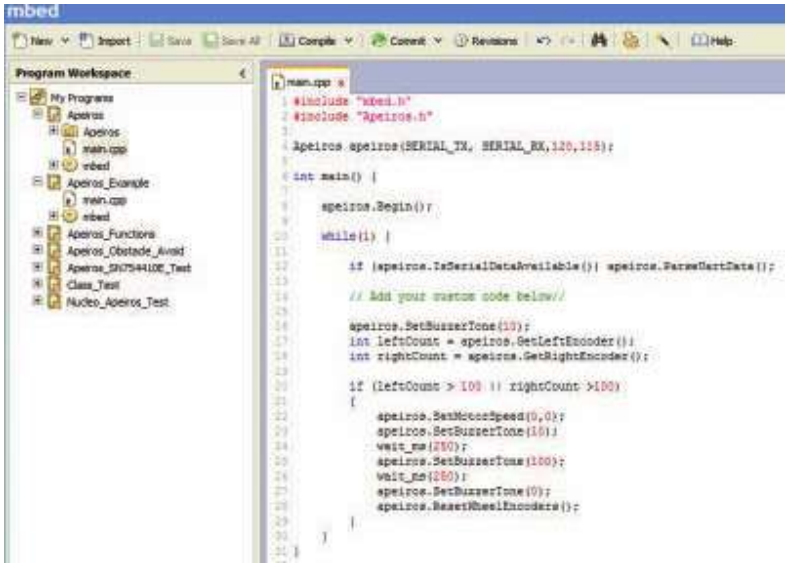

Figure 6. ARM mbed.

through its environment.

Objects are detected by up to three front-facing and two rear-facing Sharp GP2Y0D805 or GP2Y0D810 infrared sensors. Both of these sensors produce a discrete output (logic 0 or 1) that is easily interfaced to a digital input on most microcontrollers.

The GP2Y0D805 has a range of 0.2 to 2 inches, and the GP2Y0D810 has a wider 0.8 to 4 inch range. I selected these sensors based on their small size, low cost, and relaxed signal processing requirements.

Apeiros is powered by six AA batteries and a two-wheel differential drive system generates robot motion. My custom motor shield provides connection points for up to five infrared sensors, two gear motors, two wheel encoders, one HS-81 servo, and a battery pack (**Figure 4**). Apeiros can be turned on/off via a front-facing slide switch. A piezo buzzer has been integrated so that tones can be generated. This means that Apeiros can be programmed to let you know when it is nearby. Or, maybe you can program your very own security robot, for example.

Give Me a "Brain"

In order to minimize the development costs, an off-the-shelf microcontroller board was selected and integrated as the "brains" of Apeiros. A 32-bit STM32 Nucleo F401RE development board by STMicroelectronics (shown in **Figure 5**) was chosen. It should be noted that I have intentionally designed Apeiros to be forward compatible with a future custom controller board (to be designed) that will mount directly to the top of the molded base. This custom controller board would eliminate the need for an off-the-shelf microcontroller board and custom motor shield, while reducing the cost of goods (COGs).

The Nucleo boards expose a set of Arduino compatible headers along with a set of "Morpho" connectors that bring out the remaining input and output (I/O) pins. No additional hardware programmer is required because this circuitry is already built in. Simply install the drivers and connect to a computer via a USB cable and the Nucleo board shows up as a drive. Just drag and drop new programs and Apeiros will spring to life!

There's no need to purchase an expensive compiler because STMicroelectronics has joined the ARM mbed™ project. This means that you can freely develop and compile your own programs online at **http://mbed.org** and then transfer them to your robot via USB (**Figure 6**). I have already developed all of the low level functions that take care of initializing hardware, controlling the gear motors, opening and closing a connected gripper servo, reading

Figure 7. Bluetooth wireless shield.

connected sensors, and generating piezo tones along with transmitting and receiving serial data.

Import the Apeiros Class Library into your mbed project and all these functions will be available within your program so that you can make Apeiros do something truly amazing.

Make it Wireless

A custom wireless shield (in development) shown in **Figure 7** provides Apeiros with the ability to communicate with a paired Bluetooth device such as a smartphone, laptop, or tablet computer. The wireless shield simply stacks on top of the motor shield. A pair of front-facing light sensors measures the amount of incident ambient light. You can add a second pair of rear-facing light sensors to the wireless board if needed.

Create various light tracking and avoidance behaviors by leveraging the light sensors. Reset an improperly configured Bluetooth module to factory defaults via a built-in jumper.

A simple Bluetooth control graphical user interface (GUI) has been created for Android-based smartphones (**Figure 8**). Once fully developed and debugged, the simple Bluetooth control GUI executable and source code will be made available so that anyone can use and modify it as needed.

Final Thoughts

At this time, I am working towards a production release so that I can get this great little robot out into the world. Apeiros will be released as entirely open source as mentioned, with my software released under GPL V3 and my hardware designs released under Creative Commons Attribution-ShareAlike 4.0 International License. I chose this release strategy in order to maximize the educational benefits. In this way, end users can delve into the software, mechanical, and electrical design details, and learn why or modify as needed.

For example, mechanical engineering students can explore the detailed drawings of the injection molded base and examine the Geometric Dimensioning and Tolerancing (GD&T). Dig deeper and learn why thread forming screws were used in this design, and why draft is required on injection molded parts (**Figure 9**).

Apeiros will be released as a build-it-yourself kit, but I also plan to offer a basic body kit for the Do-It-Yourself (DIY) robot enthusiast who wants to design their next robot creation around a low cost, rugged injection molded base. At this time, I am doing my best to target a sub $100 introductory price point for a Servo Gripper Apeiros kit. A Bill of Materials (BOM) is available for those who want to procure

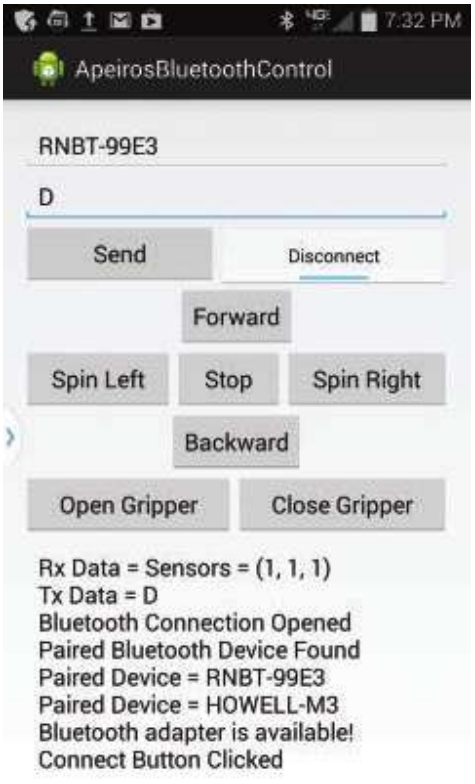

Figure 8. Bluetooth control GUI.

RESOURCES

ProtoMold
www.protolabs.com/protomold

Hitec HS-81 Servo
http://hitecrcd.com

Eck Plastic Arts
http://eckplastics.com

Pololu Robotics & Electronics
www.pololu.com

STMicroelectronics
www.st.com/web/en/home.html

ARM mbed
https://mbed.org/

Microchip RN42
Bluetooth Module
www.microchip.com

Abe Howell's Robotics
www.abotics.com

Abraham L. Howell received his BSME, MSME, and PhD in Mechanical Engineering from SUNY Binghamton University. For the past 15+ years, he has worked as a mechanical engineer and engineering manager in industry within the areas of pharmaceutical and plant automation, and most recently high speed automated circuit board assembly equipment. He is the owner and founder of Abe Howell's Robotics, a researcher, a designer, and a manufacturer of low cost educational robot kits. His research interests include engineering education assessment, K-12 Outreach, embedded hardware and software design, computer vision, and educational robot hardware and software design.

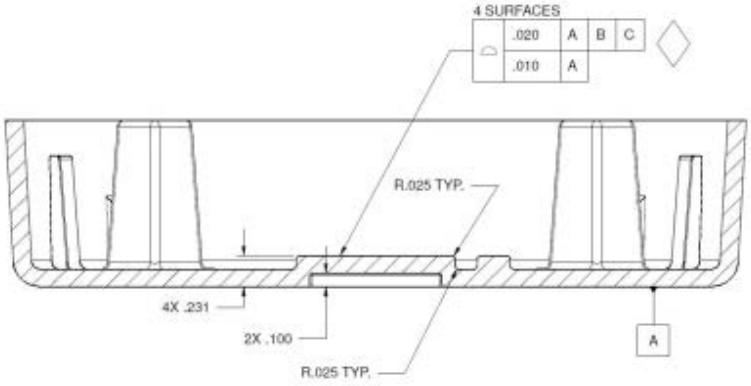

Figure 9. Detailed drawing.

their own parts and build Apeiros. If you have access to a 3D printer, then go ahead and download the stereolithography (STL) file of the injection molded base and print your own robot body.

I truly hope that Apeiros will help to ignite a passion for STEM within the minds of future engineers, technologists, scientists, and educators! I have big plans for Apeiros, so stay tuned for upcoming articles.

Next time, I will provide an introduction to programming Apeiros for obstacle avoidance, generating tones with the piezo buzzer, and controlling the servo gripper for object manipulation. **SV**

Taking a Look at the Jade Robot

By Camp Peavy

Post comments on this article at **www.servomagazine.com/index.php/magazine/article/january2015_Peavy**.

I got a Jade Robot from the Mimetics Digital Education folks recently. I was anticipating receiving it after my good friend, Vern Graner with *SERVO Magazine* asked if I wanted to review a new educational robot. I've built robots as a hobby for over 30 years, and currently make a living as a robot technician with Neato Robotics. Plus, I am very active with robotic events in Silicon Valley, generally in conjunction with the HomeBrew Robotics Club.

So, just how was this new platform going to stand up ...

When the box arrived, I was a little disappointed there were no instructions or some sort of Quick-Start guide (but then again, instructions are for wimps). However, poking around and figuring stuff out is a fine art and a survival skill, so I took Jade out of the box and moved forward (**Figure 1**).

The Jade robot lends itself to self-exploration. It's kind of like stuff from IKEA or LEGO. After a few minutes of staring and fiddling, you don't really need instructions. Jade's Graphical User Interface (UI) is bright and intuitive, and provides even an attention-deficit professional hobbyist like me hours of fun. It's the proverbial onion ... you peel it off one layer at a time, and then you weep. No, no, no! That's not it ... cakes. Cakes have layers and everybody likes cake! Anyway, the point is I found the Jade robot delightfully deep, The more you explore, the more you discover. Of course, as a last resort, you can always get the instructions online.

Figure 1. The box is wonderful! It's simple, attracts interest, and keeps the robot safe. Instructions, IDE, and community are online.

Figure 2. The Jade robot UI. The icons are called panels, and they are available for your custom programs ... it's a real embedded robot coding experience right out of the box.

The UI is graphical and something you naturally want to poke. The little icons from which you choose with the UI buttons are called "panels" and are available to developers, teachers, and students to create custom icons for their own individual programs. You get a real embedded robot programming experience right out of the box (**Figure 2**).

The first panel is "Tools" (shaped like a wrench). It contains the Bluetooth configuration (On or Off), Name the robot (I named mine "Mimi" for Mimetics), Remote Control Setup (choose your remote), Volume Control, Version Info, Calibration, etc. To go back to the previous screen, you select the return panel which is shaped like a U turn.

The second panel is the "Spectrometer" (looks like a graph). This is where you simply press the center red button (**Figure 3**) to get spectrometer readings in graph form — something that kids can learn from by playing with it. The third panel, "Remote Move" (looks like a remote control) is where you can either control the robot with the white buttons on the robot's right rear quarter (refer again to **Figure 3**) or you can drive the robot remotely with a DVD remote.

Next, the "Moth" program is where the robot follows light like a moth. There's the obligatory "Line Following" program, then under that is "Logic Demo," a "Wall Following" program, "Program Demo," and "Object Avoidance." Some of my favorite activities were obstacle avoidance (yes, I'm easily amused) and wall following around the box. There's a lot of stuff to do and learn without a keyboard.

There is even a full file system on the UI where you can download programs and execute them from the UI. In fact, the last program transferred from Jade Support (either Scratch or Jade C) is available by default.

After playing around with the built-in programs, I moved to the computer. The programing language is Jade C, which is a simplified version of the C standard programming language in professional robotics. So as not to overwhelm the beginner, an integrated development environment (IDE) is provided called Jade Support.

Three cool features of Jade Support are that it lives on Chrome Apps, so you can access it from any computer anywhere (anywhere with Internet, that is); you program the robot wirelessly with Bluetooth; and you don't have to start with C. There's a fun graphical language available called

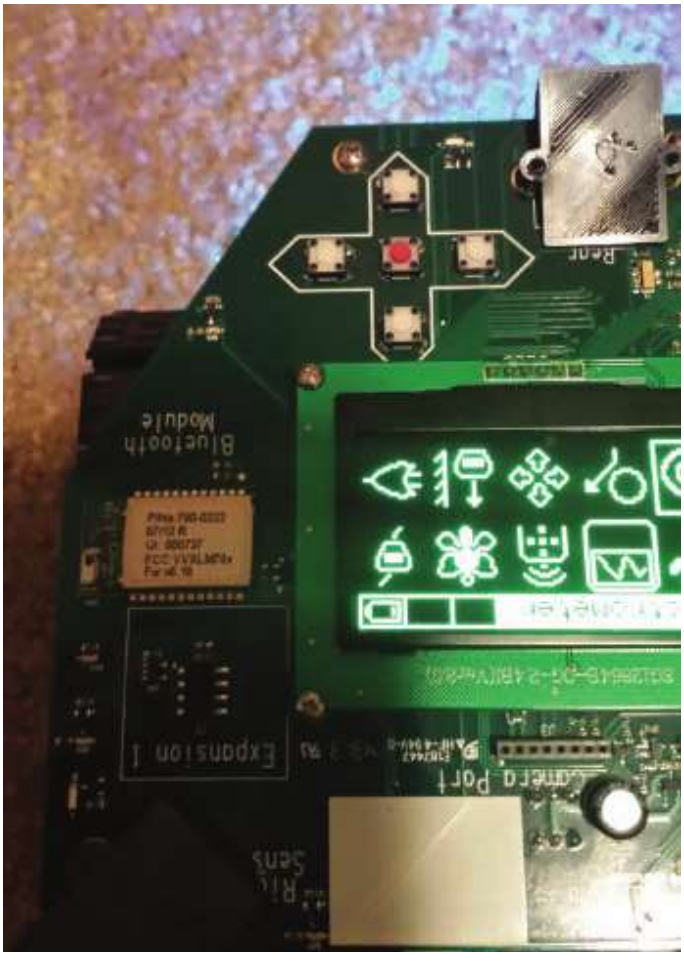

Figure 3. This is the keypad where you choose your function on the UI or drive the robot in "Remote Move." Even driving the robot with the onboard pushbuttons teaches the basics of differential drive.

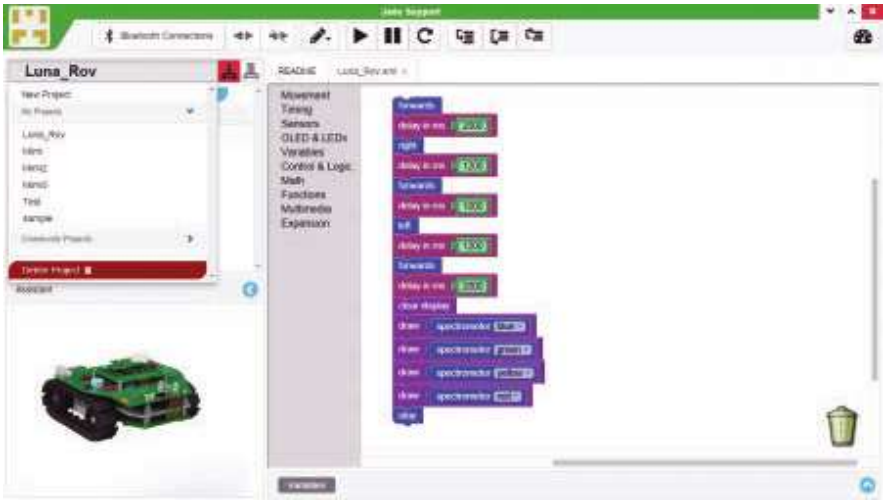

Figure 4. "Scratch" is an easy to use block-based language ... even small children can understand it. Here, the Scratch program drives the robot in a zigzag pattern and then takes a spectrometer reading.

"Scratch" where you program with "blocks" in a "playground." Yep. it's simple enough that even small children get it (**Figure 4**).

I should mention Jade tech support is fabulous! Granted, I have the email address of the chief roboticist but I found a problem with Scratch where the spectrometer block wouldn't drop into the delay container and they had it fixed in a day. (Let's not get ahead of ourselves here.)

Again, no computer is required, and it even works with a DVD remote control. So, you can not only move the robot remotely, but control the UI remotely. For example, you can drive the robot over various colors or materials and take spectrometer readings. This is a great way to teach science while having fun with robots.

Mentally, I compare this with other hobby robots like the venerable Boe-Bot, LEGO, or the new Arduino robot, for example. Most of these require assembly, however. The Jade robot comes pre-assembled so you get to the good stuff sooner. This can be especially important in a classroom environment where attention spans are short. Playing with the onboard UI and watching the robot interact with its environment immediately hooks you.

To me, the real star of the Jade robot is the reflective spectrometer (**Figure 5**). Basically, the reflected energy from six very bright LEDs is measured and represented as a percentage on Jade's UI display. This allows wanna-be scientists the capability to analyze the signature of materials directly under the robot's body ... like with a real space rover, for example. The wavelengths of the super-bright LEDs are: Blue - 470 nm; Green - 525 nm; Yellow - 574 nm; Red - 660 nm; and Infrared 880 nm and 940 nm (**Figure 6**). The wavelengths are measured with three Vishay photodiodes (VBPW34S) and displayed on the UI as a graph. This is real science on a hobby robot.

While reviewing the Jade robot, I had the opportunity to talk with Mimetics Chief Roboticist, Myke Predko who told me after going through various industrial designs and consulting with students and teachers, a conscientious decision was made to not cover the robot. That is, the components are exposed and spelled out on the silkscreen so to further illuminate how the robot functions, helping to make electronics less mysterious (**Figure 7**).

As mentioned, Jade Support lives on Chrome Apps. This makes it easy for a class or group environment where programs are in the cloud, so you can use them from any computer anywhere. This avoids locked down system

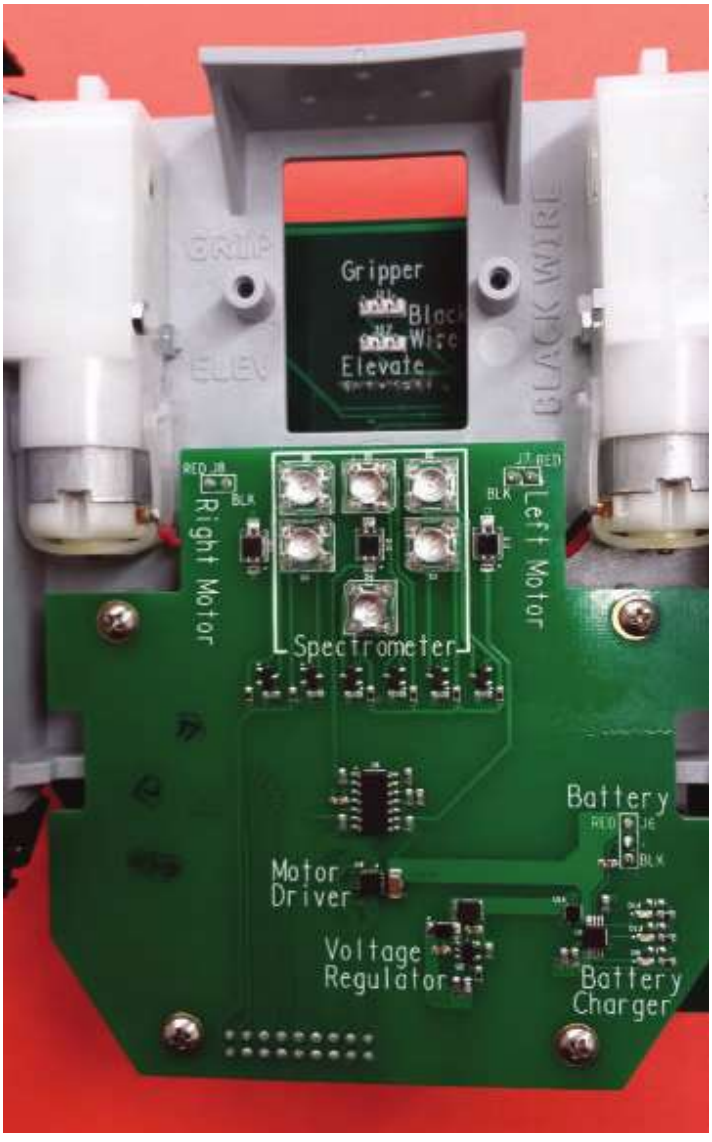

Figure 5. Under the robot, you can see the six LEDs and three photodiodes used for the reflective spectrometer (blue, green, yellow, red, and two frequencies of IR).

hassles where teachers and/or students might not have rights to install drivers or applications.

Jade has a wonderful programming environment with its ability to run Scratch or C and step through code one line at a time. There are options for open source community projects, as well as individual projects. You can even see and modify the code from the programs that come built into the robot (Moth, Line Following, Spectrometer, etc.).

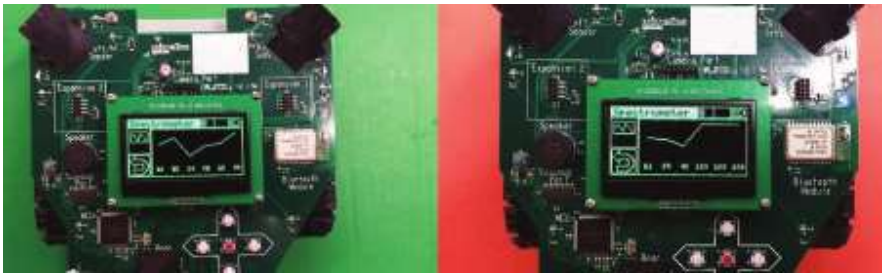

Figure 6. Here, you can see the spectrometer readings. Note the green box is high at the green frequency, and the orange box is high at the red and two infrared frequencies ... real science in a hobby robot.

Built-in Bluetooth allows code to be downloaded wirelessly. This is a subtle feature which encourages creativity, so you'll try one more thing because you don't have to go through the hassle of plugging and unplugging (not to mention the wear and tear on the connector).

There are upgrades coming for Jade, including a video camera and two-servo gripper (**Figure 8**), giving the capability of remote manipulation. Features like this are usually only available on robots costing thousands of dollars. Jade's base price is only $349 (box, robot, and charger). Instructions, software, and community are online for free. Of course, this is not the least expensive robot on the market, but for what you get it's a good value — especially for schools.

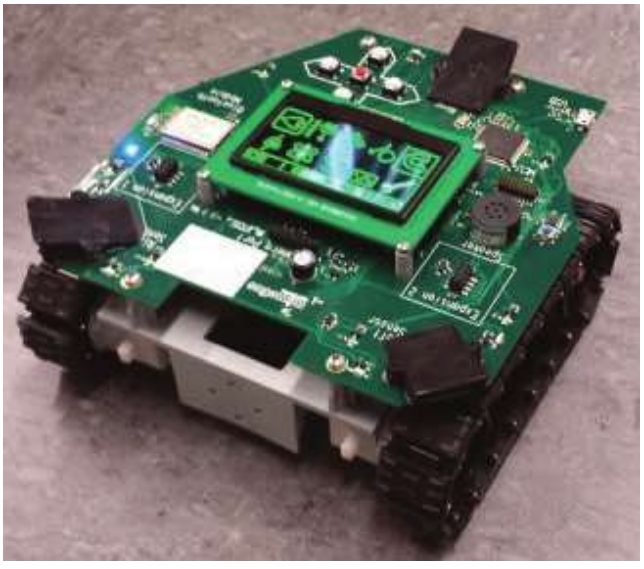

Figure 7. The Jade robot provides even an attention-deficit professional hobbyist like me hours of fun. I found it delightfully deep. The more you explore, the more you discover.

Most other kits need to be built, and experience indicates that after an hour or so of building, the kids get tired and are more likely to lose interest. This is where a prebuilt robot with built-in activities has an advantage. It grabs their attention and lets them learn and do robotic experiments while the interest level is fresh.

So, I'm still itching to do some hardware hacking. Not to worry! There are two expansion ports available, and I'm confident one of the first boards available will be a plain Jane breadboard. So, while it's not homebrewed, think of it as a prepared meal.

Back to the star of the show: the reflective spectrometer. The Jade robot has a well-built chassis and drive system; it is a great electronics system and a good robotics programming trainer. Again, though, I feel it's the reflective spectrometer that really sets it apart to teach not only robot applications but science. In fact, all the schematics are online should you want to add a reflective spectrometer into your own homebrewed robot!

Not only is Jade a great classroom bot, but a good robot for enthusiastic hobbyists who find themselves in front of groups talking about robots. Building your own bot from an Arduino or a Beaglebone might be a better value for a variety of reasons, but for those who are unsure or would just prefer to get in at a higher level, the Jade robot is a perfect choice.

For me, success is do I like the robot? That is, would I want to keep it or not (granted this is not a very high bar). Yes ... I'd love to keep the Jade robot in particular for its usefulness in group settings, but I also want to keep playing Mars Rover Explorer! **SV**

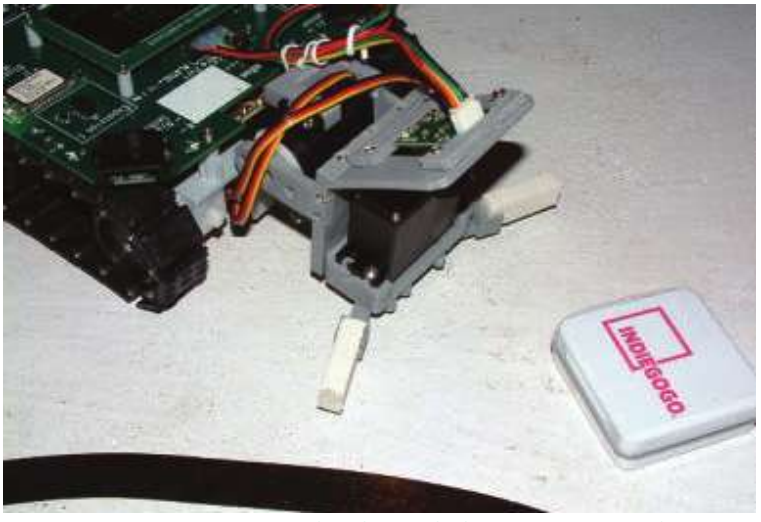

Figure 8. Jade robot with the new gripper and camera. Remote manipulation with a hobby robot!

Robot Blinky Lights Made Easy

By Gordon McComb

http://steeph-k.deviantart.com/art/LED-Rainbow-395233739

www.calce.umd.edu/LED/

They're called blinky lights, blinkenlights, twinkle lights, and all sorts of other names. No matter what they're called, you know them as those flashy, colorful, and bright lighting effects that serve no practical purpose other than to make your robot look absolutely marvelous! So, got an other otherwise boring bot? Dress it up with some pulsating light effects.

There's a new genre of light emitting diode (LED) that makes child's play out of outfitting your robot with pulsating SFX. You get all the colors of the rainbow, with varying intensity no less. What's more, you can string multiple LEDs on a single microcontroller pin, and operate all of them at once. No more using up all the I/O on your controller. No more hassles with port expanders, demultiplexers, shift registers, and the other obtuse techniques.

The LEDs are "addressable," meaning that in your program code you need only specify which light in the string you want to control. Only the intended recipient of the message obeys the lighting command; all the others ignore it, and continue with their last instruction.

Of course, controllable colorful lights go beyond mere pretty looks. They can also be used as indicators. For example, you can easily add expressive eyes to your robot that reveal its mood: green for "everything's dandy," or slowly glowing red for "I'm mad, get out of my way!"

Rather than use a liquid crystal display (LCD) panel which is hard to read at a distance, add a couple addressable LEDs and make up your own sequence of blinks and colors so that your robot can communicate simple messages to you. Alternating flashing purple might mean low batteries. Or, colors cycling through the rainbow might serve as your start-up test each time your robot is powered.

In this article, I'll provide some simple examples for the Arduino on using the most popular make of addressable light emitting diodes. Programming is simple when you use one of the several third-party function libraries that have been developed specifically for these LEDs.

Post comments on this section and find any associated files and/or downloads at **www.servomagazine.com/index.php/magazine/article/january2015_McComb.**

Introducing the WS2812B Serially Controlled LED

If they gave out Nobel prizes to electronics makers, at the top of the list would be Worldsemi with their WS2812 series of "smart" RGB LEDs. While not actually brand new, the WS2812 has recently seen a tremendous uptick in popularity, thanks to the introduction of so-called breakout boards from several online retailers like Adafruit, Parallax, Pololu, and SparkFun to name a few.

Unlike a traditional LED which has solderable thru-hole leads, the WS2812 comes in a plastic surface-mount "flat pack" that's harder for hobbyists to use. The breakout boards make it simple to add the WS2812 LED in projects, and include all the ancillary circuit components recommended by the manufacturer.

An example WS2812 breakout board — this one from Parallax — is shown in **Figure 1**.

(For this article, I'll talk only about the WS2812 series of LEDs that are already mounted on their own ready-to-use boards. If you'd like to construct your own surface-mount boards for bare WS2812 LEDs, be sure to consult the Worldsemi datasheet for example circuits.)

Most sellers now offer the WS2812B — an improved version with a number of enhancements over earlier incarnations. While previous iterations were perfectly fine, many of the libraries and program examples you'll find for the WS2812 are designed with the "B" version in mind. Using an incompatible program version may cause the LED to not function properly.

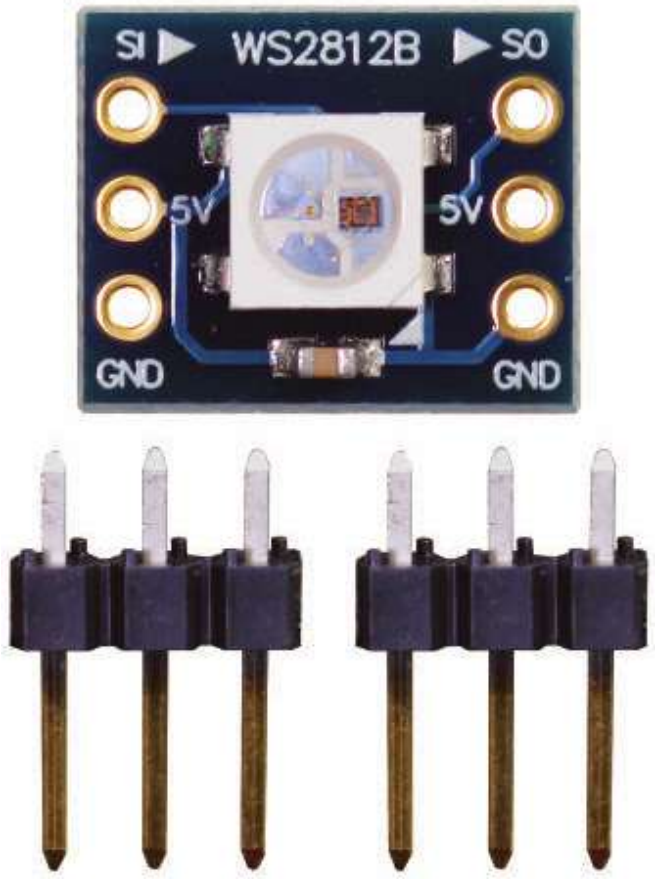

Figure 1. A WS2812B RGB LED mounted on a breakout board. This unit also includes two sets of solderable three-pin headers. *Photo courtesy Parallax, Inc.*

Using Addressable LEDs

Addressable or "smart" LEDs contain their own simple microcontroller that receives input via a single-wire serial connection — you need power and ground as well, of course. The control signal contains the data in 24-bit format to control the individual red, green, and blue diodes in the LED. By altering the value of each diode in 256 steps, you can obtain over 16 million of colors, including white (all colors on).

When viewed at close distance, you can see the individual R, G, and B colors of the diodes. From further back — especially when using a diffuser lens or when the light is projected onto a surface — the rainbow colors are more defined.

Speaking of viewing distance ... these LEDs are fairly bright. Avoid looking directly at the LED for long periods when applying full brightness. Lower brightness levels not only prolong the life of the LED, but they also save on battery power. Unless your application requires full brightness, set the LEDs to a lower output.

In addition to setting color and brightness, the serial communications protocol used by the WS2812B can differentiate signals meant for specific LEDs in a multi-LED strand. This is used when you want to string two or more LEDs from the same microcontroller pin.

How this addressability works inside the WS2812B is somewhat complicated, involving carefully timing of the control signals. Fortunately, you don't need to understand the internal signal format and timing requirements of the WS2812B, as special interfacing libraries are available for the Arduino, Propeller, Raspberry Pi, and many other popular microcontrollers. These libraries do all the heavy lifting for you. You need only to specify the LED you wish to control, and its color and brightness.

Most libraries set the color using the familiar RGB triplet, with values ranging from 0 (off) to 255 (fully on). For example, 0,0,0 is all colors off; 255,255,255 is all colors on at full brightness. A triplet of 128,128,128 sets all colors

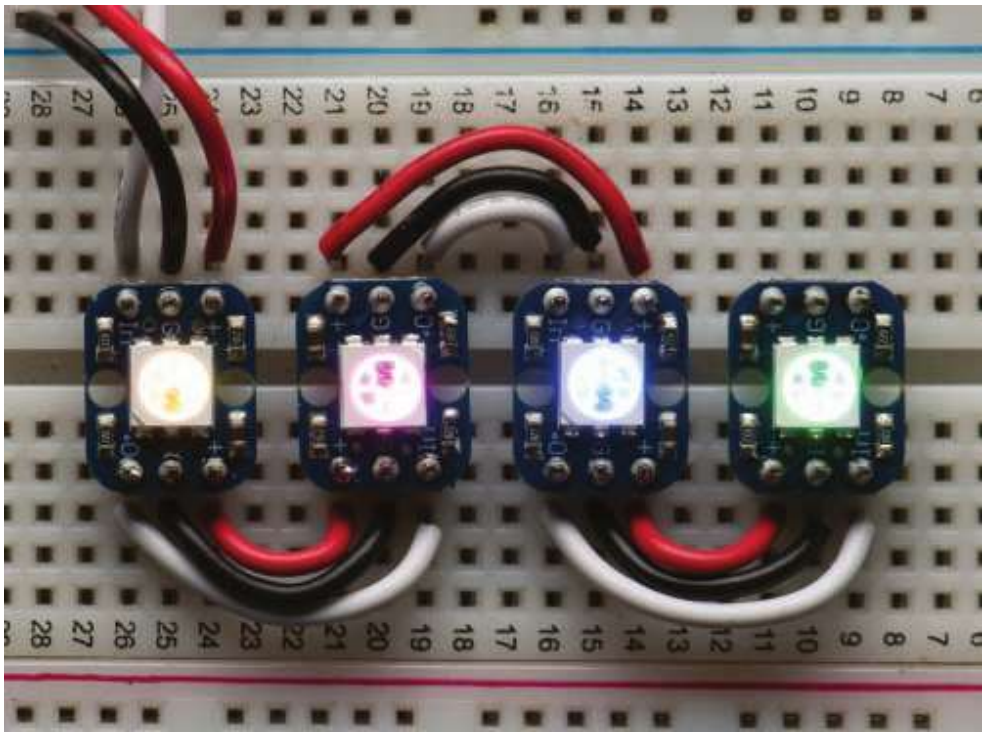

Figure 2. The WS2812B LED can be daisy-chained to make light strings of dozens — even hundreds — of lights. Modules provide in and out pins for connecting them together.
Photo courtesy Adafruit Industries.

on at half brightness — it's white, but not a bright white. To make a color, mix the R, G, and B values: 128,0,128 sets the red and blue LEDs to half brightness, creating a pleasing purplish hue.

Addressing is equally as easy. In the Arduino library provided by Adafruit, for example, you merely indicate which LED you wish to change by referencing its number in the strand, starting at 0. If you have two LEDs, for instance, the first LED is referenced as 0 and the second as 1. Can't get any simpler than that!

The number of WS2812B LEDs you can cascade from a single microcontroller pin depends on the specific library you are using, as well as the speed of the microcontroller and its internal memory capacity, among other things. A string of a hundred or more lights is readily doable, but in reality this stretches the practical number of LEDs you'd want on a robot. Remember that little thing called battery power.

At full brightness, the WS2812B consumes about 50 milliamps. A string of just 10 LEDs — at maximum brightness — is half an amp (500 mA). That can quickly reduce battery reserves. Of course, when used as blinky lights, it's not typical to run the LEDs continuously and at full output. You're more likely to flash them on an off, and reduce the level of the RGB elements in order to get other colors.

So, in actual use, the current consumption will be less than the typical 50 mA each. However, it's still something to consider when used in any battery-operated project.

Figure 3. One of many pre-fabbed shapes for the WS2912B addressable LED. This ring from Adafruit contains 12 LEDs; other versions are larger with more LEDs.
Photo courtesy Adafruit Industries.

Hooking Up

WS2812B LEDs mounted on breakout board modules are ridiculously easy to connect to your microcontroller of choice. There's only three pins: signal, power, and ground. Due to the nature of the device, the LED should be powered from a regulated 5V source.

The LED can be controlled via a 5V I/O pin. For best results, if your microcontroller is a 3.3V device, you may wish to use a 3.3V-5V level shifter. SparkFun and others sell these as ready-to-use breakout boards. Or, you can construct your own using a MOSFET signal transistor. Do an Internet search for the connection diagram.

Addressable LED modules have both input and output pins. This allows you to daisy-chain the LEDs from one to another to make a string. Power and ground are routinely tied together, but you'll want to take note of the in and out pins on your module, and connect them properly as shown in **Figure 2**.

If you purchase the modules as separates — one module, one LED — you can string multiple boards together using standard hookup wire. For prototyping, consider soldering male header pins to the board, and use three-wire servo extensions to link them up. Though the WS2812B contains its own reverse polarity protection, you should always observe proper wiring to avoid any potential damage.

Adafruit and Pololu are two prime suppliers I know of for smart LEDs mounted on flexible printed circuit board strips. The density — or number of LED units per foot — can vary. A low density strip might have 30 or 40 LEDs per one meter length, whereas a high density strip can contain 125 or more LEDs. Sellers of LED strips typically offer standard lengths in one meter increments; you can then cut to length. For example, a one meter length can yield three separate strands — each a little more than one foot.

Other topologies are available, too. For instance, Adafruit offers their popular NeoPixel line of smart LEDs in numerous shapes, including a ring and matrix panel. Their rings vary in diameter and the number of LEDs attached. Their 12-LED ring module (see **Figure 3**) measures a 1.5" outside diameter, while their 24-LED version measures 2.6" OD.

One advantage of the strip, ring, matrix, and other multi-LED panels is that they provide the daisy-chain wiring for you. You only need to provide a single point for signal, power, and ground. The rest is wired for you.

Basic Arduino Control Examples

Here are some basic examples of using the Arduino to control WS2812B LEDs. These sketches were originally written by me for the Parallax WS2812B LED module, but they'll work with most any other brand of LED breakout board.

Listing 1 shows how simple it is to control one or more addressable LEDs. Of course, "simple" is relative. All

```
#include <Adafruit_NeoPixel.h>      // Include Adafruit NeoPixel library
#define PIN              6          // LED on digital pin 6
#define NUMLEDS          1          // Use total of 1 LED

// Create 'leds' object to drive LEDs
Adafruit_NeoPixel leds = Adafruit_NeoPixel(NUMLEDS, PIN, NEO_GRB + NEO_KHZ800);

int wait = 5;                       // Standard wait delay of 5 ms

void setup() {
  leds.begin();                     // Initialize 'leds' object

  //Make sure LED is off to demonstrate start of sketch
  leds.setPixelColor(0, leds.Color(0, 0, 0));    // Turn off LED
  leds.show();                      // Set new value
  delay(500);

}

// Loop through changing R, G, and B colors
// Each color fades in from off (i=0) to fully on (i=255)
void loop() {
  for(int i=0; i<255; i++) {        // Count up color units, 0- 255
    leds.setPixelColor(0, leds.Color(i, 0, 0));  // Color mix for LED
    leds.show();                    // Set the LED
    delay(wait);                    // Delay for visual effect
  }
  for(int i=0; i<255; i++) {        // Loop through next color change
    leds.setPixelColor(0, leds.Color(0, i, 0));
    leds.show();
    delay(wait);
  }
  for(int i=0; i<255; i++) {        // Loop through next color change
    leds.setPixelColor(0, leds.Color(0, 0, i));
    leds.show();
    delay(wait);
  }
}
```

Listing 1 - WS2812B Demo, Single LED.

the grunt work is done by the Adafruit NeoPixel library, which is provided open source for free download. See the **Sources** box for additional information.

To use this sketch with your Arduino, you must first fetch the Adafruit_Neopixel library from its GitHub repository, unzip it, and place it in your Arduino libraries directory. This directory, named *libraries*, is located under your sketchbook folder — on Windows it's typically *(My) Documents\Arduino\libraries*. If your sketchbook folder doesn't contain a libraries directory, you'll need to create it first.

Important! After the Adafruit_Neopixel library has been copied or moved to the sketchbook libraries directory, you must exit and restart the Arduino IDE (integrated development environment).

The example demonstrates controlling a single LED connected to Arduino pin D6 (digital pin 6). Each primary color — red, green, blue — fades in from off to fully on, and the cycle repeats itself. Changing the LED color is done with two statements:

```
leds.setPixelColor(0, leds.Color(64, 0, 15));
leds.show();
```

In this example, the *setPixelColor* method sets LED 0 (zero, the first one in the string) to the RGB colors 64, 0, 15 (R=64, G=0, B=15).

Note also the *leds.show* method. This is required to actually set the new color value. If you omit it, the color change will be ignored.

Going further, **Listing 2** shows the same basic code; this time, controlling a small cascade of two LEDs. The concept is the same: First, you identify the LED to control — either 0 or 1 — and change its RGB component values as desired.

In both sketches, you'll notice some defined values at the top. You'll need to modify these if you change the Arduino pin connection, or the number of LEDs being controlled:

```
#define PIN          6
#define NUMLEDS      1
```

- *PIN* indicates the Arduino I/O pin connected to the first LED. Here's it's pin 6, which was chosen arbitrarily. You can use any unused Arduino pin,

```
#include <Adafruit_NeoPixel.h>      // Include Adafruit NeoPixel library
#define PIN              6          // First LED on digital pin 6
#define NUMLEDS          2          // Use total of 2 LEDs

// Create 'leds' object to drive LEDs
Adafruit_NeoPixel leds = Adafruit_NeoPixel(NUMLEDS, PIN, NEO_GRB + NEO_KHZ800);

int wait = 5;                       // Standard wait delay of 5 ms

void setup() {
  leds.begin();                     // Initialize 'leds' object

  //Make sure both LEDs are off to demonstrate start of sketch
  leds.setPixelColor(0, leds.Color(0, 0, 0));  // Turn off LED0
  leds.setPixelColor(1, leds.Color(0, 0, 0));  // Turn off LED1
  leds.show();              // Set new values
  delay(500);

}

// Loop through changing R, G, and B colors
// Each color fades in from off (i=0) to fully on (i=255)
void loop() {
  for(int i=0; i<255; i++) {       // Count up color units from 0 to 255
    leds.setPixelColor(0, leds.Color(i, 0, 0));  // Color mix for LED0
    leds.setPixelColor(1, leds.Color(0, i, 0));  // Color mix for LED1
    leds.show();                   // Set the LEDs
    delay(wait);                   // Delay for visual effect
  }
  for(int i=0; i<255; i++) {       // Loop through next color change
    leds.setPixelColor(0, leds.Color(0, i, 0));
    leds.setPixelColor(1, leds.Color(0, 0, i));
    leds.show();
    delay(wait);
  }
  for(int i=0; i<255; i++) {       // Loop through next color change
    leds.setPixelColor(0, leds.Color(0, 0, i));
    leds.setPixelColor(1, leds.Color(i, 0, 0));
    leds.show();
    delay(wait);
  }
}
```

Listing 2 - WS2812B Demo, Dual LED.

though I'd advise avoiding pins 0, 1, and 13 as these have additional hardware functions you'll want to preserve (specifically, pins 0 and 1 are for the serial communications with your computer, and pin 13 controls the Arduino's built-in LED).

- *NUMLEDS* specifies the number of LEDs in the strand. Don't forget to change this if you add or subtract LEDs. If you have 10 LEDs, but only indicate nine, the last LED will not turn on.

Experiment and Explore!

Because blinky lights don't serve a critical function to your robot, you can use them any way you'd like. You're free to experiment with your own designs and applications. Eyes are an obvious choice, but you might also use a ring or ellipse of LEDs to form a flashing animated mouth. Change the colors as your robot speaks or sings.

There's no need to limit smart LEDs to just your robot. If your bot is remote controlled, add some LEDs to its controller to show direction of travel, speed, power, battery life — you name it.

Plus, since the WS2812B LEDs sport a fairly high brightness, they can serve as headlights for robots used in dark places, landing and directional lights for quadcopters and other autonomous flying machines, and as alarm indicators for sentry and patrol bots. **SV**

Selected Sources for WS2812B Modules, Libraries, and Additional Code Examples

Adafruit
www.adafruit.com

Adafruit NeoPixel Library
https://github.com/adafruit/Adafruit_NeoPixel

Parallax
www.parallax.com

Pololu
www.pololu.com

SparkFun
www.sparkfun.com

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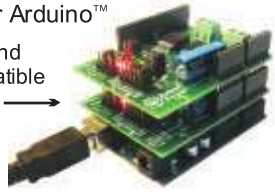

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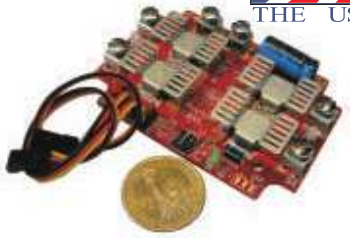

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Even for beginners, unmanned areal vehicles (UAVs) can be a useful, fun, yet challenging robotic platform. Ground based RC and autonomous robots move forward, backward, left, or right, while touching the ground. The ground provides a stable surface that resists movement. Adding upward and downward directions, gravity, and full freedom of movement makes this platform much more challenging.

Even so, there are low-cost ready to fly RC hobby UAVs. Many are for picture taking. One can also purchase or build fully autonomous UAVs, powerful and fully capable. What is great, is that there are companies and communities of people ready to help you get started.

For starting info, DIYDrones.com is great, & 3DRobotics.com has great open source, flight software and hardware.

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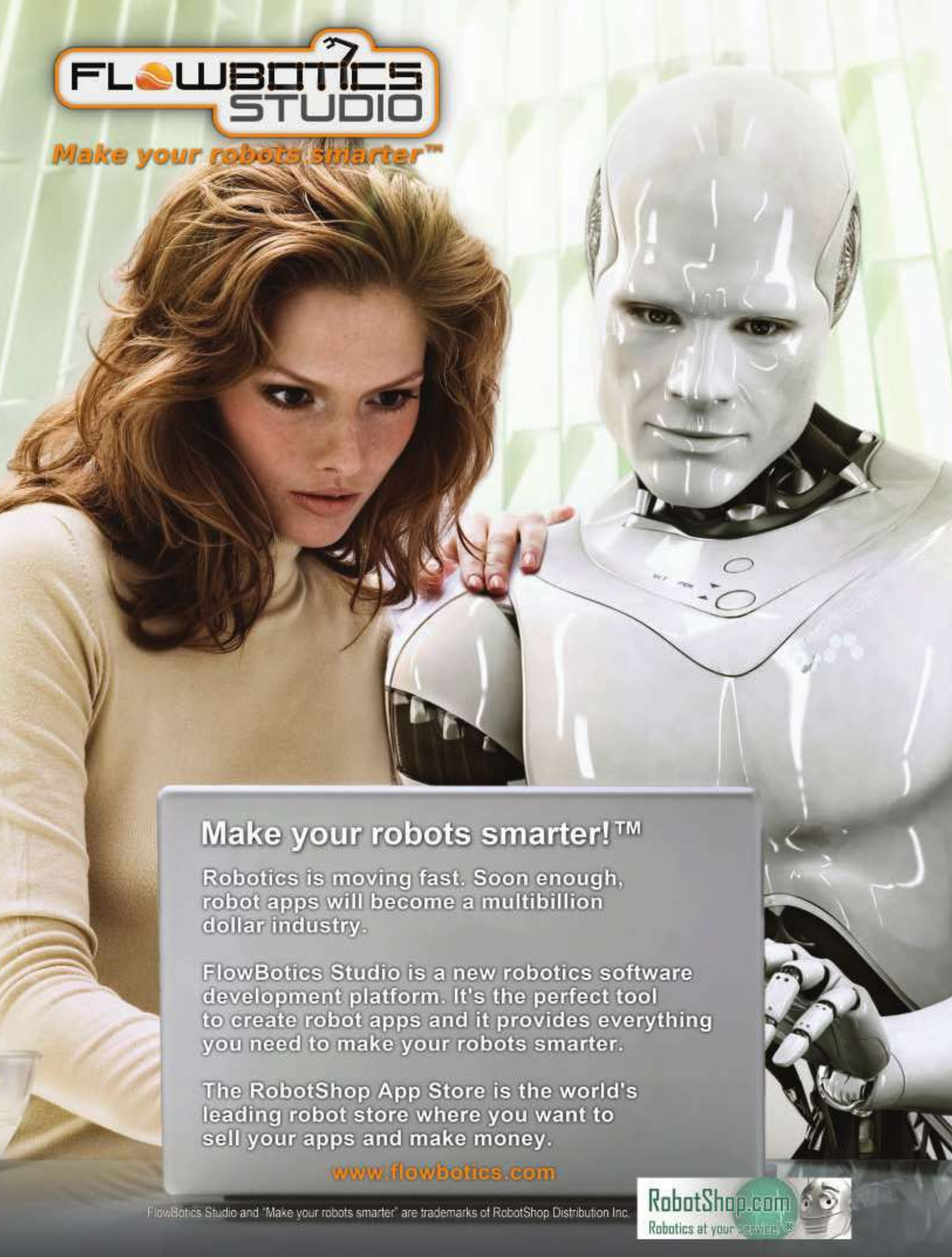
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RoboCup at 17 ... Robots vs. Renaldo?

By Holden Berry

Go to **www.servomagazine.com/index.php/magazine/article/january2015_Berry** to comment on this topic.

Soccer has been a sport that — although it has always been popular around the world — is now beginning to take off exponentially in the United States. Through the past 10 years, the country has been united through two exhilarating World Cup appearances, plus a rise in popularity of the domestic soccer league: the MLS. Teams like Seattle and Portland have broken attendance records and provided atmospheres that rival the greatest stadiums in the world, like Old Trafford in Manchester, or the Azteca in Mexico.

I have been a soccer fanatic ever since I was able to stand. As soon as I could run, I could dribble a soccer ball, and I take every chance I can to play and watch it. I have marveled at the rise of soccer in America, especially when Orlando City — the soon-to-be new addition to the MLS — sprung up just miles from me.

The growth of the sport has not only brought along change in the way us humans play and enjoy the game, but has brought about bold new goals in the minds of robotics experts.

In 1997, the world chess champion, Garry Kasparov was defeated by IBM's Deep Blue — an AI supercomputer. Scientists marveled at this accomplishment since chess has always been seen as an intense test of strategy and intelligence. Soon after, a group of robotics engineers and scientists met up in Japan for the International Joint Conference on Artificial Intelligence to set the next goal for AI robots. They aimed to create a team of humanoid robot soccer players that could beat the reigning World Cup champions by the middle of the 21st century — a seemingly farfetched idea that may be closer than we think now, 17 years later.

A participant checks his Teen Size robot at the 2014 RoboCup German Open tournament. (*Photo by Jens Schlueter/Getty Images.*)

Since the first RoboCup in 1997, the annual competition has taken off. The first event was comprised of 40 teams, but now 40 separate countries are represented, with well over 2,500 people participating in various challenges ranging from rescue missions to challenges in a living room setting. However, the soccer leagues remain the most popular events of them all.

There are five distinct leagues that participants can chose from: the Simulation league, Small Size Robot league, Middle Size Robot league, Standard Platform league, and the Humanoid league. The Simulation league has no actual robots involved; it aims to develop the artificial intelligence and strategy side of the game. It pits 11 autonomous software programs that represent players vs. another 11, which then compete on a central server.

The Small Size and Middle Size Robot leagues use robots with wheels and air cannons that work together to compete against another team. All objects on the field are tracked by a standardized vision system that processes the data provided by two cameras which are attached to a camera bar placed several meters above the field.

Two middle sized robots play at the 2014 RoboCup in Brazil.

Fans gather to watch two middle sized league teams play.
(*Photo courtesy of robocup2014.org.*)

A participant poses with his middle sized robot.

A team of Standard Platform league robots downloading their software.

www.RoboCup2014.org

http://thebangladeshtoday.com/featured-page/science-technology/2014/07/RoboCup-2014-is-the-world-cup-for-robots/

Photos courtesy of Valdecir Becker unless otherwise noted.

The vision system (called SSL-Vision) is an open source project maintained by the league's community. Off-field computers are used to send referee commands and positional information to the robotic players. These computers typically also perform most of the processing required for coordination and control of the robots. Communications are then wirelessly sent through commercial FM transmitter and receiver units. The Small and Middle Size leagues differ only in the height of the robots; the middle sized are 80 cm tall, which is roughly twice the size of the small version.

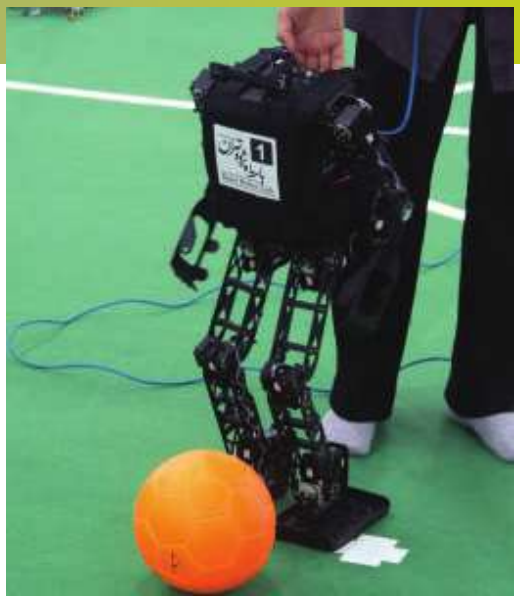
The Standard Platform league is where robots start looking a bit more human-like. Every team in this league competes with the same type of robot; the only difference is the software each team develops. These robots that creep along the field standing on two legs operate fully autonomously, only communicating with their teammates through wireless connections through which they can also receive refereeing decisions.

Currently, the standard platform used in this event is the H25 NAO which is manufactured by Aldebaran Robotics. These robots have five joints in each arm and leg, along with one in each hand and two in their necks. Two cameras are installed in their heads so they can perceive the environment around them, and a sonar sensor placed in the chest is used to measure the distance to other objects on the field — like other players or the ball. The Humanoid League is where we see developers take more liberties with their robot's design.

In this group, robotics experts must design the human-like body and the software that goes into it. This group is further split up into three divisions: Kid Size, Teen Size, and — you probably guessed it — Adult Size. There are few differences between the divisions.

The Kid Size division is made up of teams of four robots, and they must be between 40 and 90 cm tall; in the Teen Size division, the teams are cut down to two, but the robot's height can be anywhere between 80 and 140 cm. The Adult Size league consists of the most human looking robots. They are 130-180 cm, but instead of competing

Two Standard Platform league teams compete in the 2014 RoboCup in Brazil.



A Kid Size robot in the Humanoid league kicks a ball.

Two participants tweak their robot and software to get an edge over opponents.

All the robots that participated in the Humanoid League, ranging from Kid Size to Adult Size.

with each other, they go head on, taking turns shooting and goalkeeping. Although these robots are still slow moving and seemingly unstable while walking, the technology is worlds ahead of where it started back in 1997.

So, at this point you may be thinking "Great. Robots can play soccer. How is that relevant to me?" Well, of course, soccer playing robots aren't exactly the most useful application of technology, but the individual concepts and mechanisms that go into each of these humanoids can be applied to many aspects of human life.

At an annual symposium succeeding every RoboCup, scientists present many of their findings and developments that came with the creation of their robot. These include advances in AI, motion tracking, general mechanics and fluidity of motion, and countless others. These technologies can then be applied to further the development of things like automated cars, search and rescue technology, and AI programs like Siri. So, if robots eventually can beat the reigning World Cup champions in a game of soccer, what would this mean for all the passionate soccer players like me around the world? Would this spell the end of human sports as we know it?

Don't get so worried. First off, these robots have years and years of development to go still before they'll even be able to keep up with the speed of the likes of Raheem Sterling, Ronaldo, or Gareth Bale, and that's just the beginning of soccer. With such a fast paced sport — including some split second strategic decisions and general cheekiness and trickery — robots won't be able to compete with humans for quite some time.

When they are able to take us on, I suppose that may just drive us humans to be even better. You can already see how Messi and Ronaldo drive each other to delve into further greatness, each trying to claim the informal household title of "greatest player alive."

If one was to add robots into the mix, humans would have to adapt and evolve their game to even further levels, possibly improving the tactics and strategy of this beautiful game. SV

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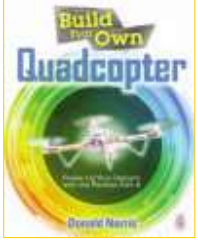

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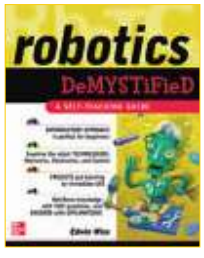

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by Ulrik Pilegaard / Mike Dooley

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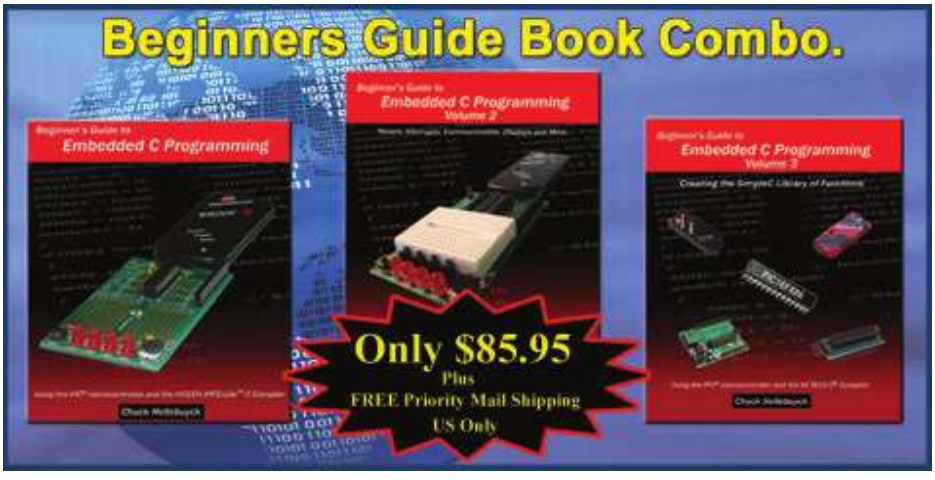

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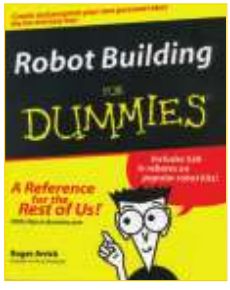

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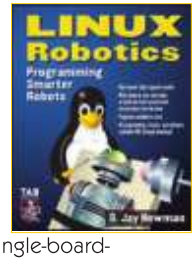

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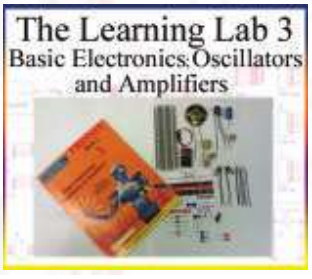

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Continued from page 21

types of materials such as plastic components, steel chassis, and other materials that normally would utilize the conventional micro threaded inserts while using a patch screw as the means for locking.

Spiralock micro threaded inserts can be produced in various materials such as brass, carbon steel, or stainless steel ultrasonic inserts or press-in inserts. Brass ultrasonic inserts resist corrosion and are ideal for use in plastics. Steel pressed-in inserts are typically made of carbon steel, often with an electroless nickel coating that resists corrosion and satisfies salt spray requirements. These inserts can be installed into aluminum materials to eliminate the risk of stripping and shearing.

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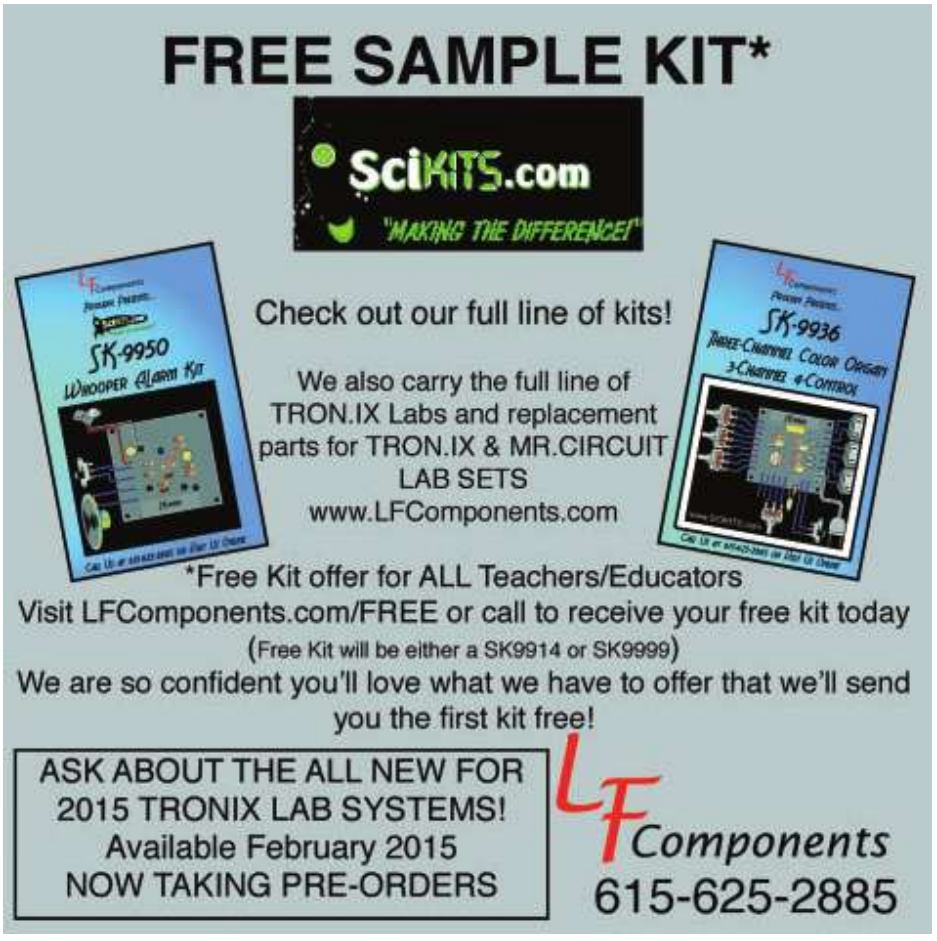

MLG Automation Light Grid Detects Transparent, Small, and Fast Moving Objects

SICK has announced the launch of their MLG-2 automation light grids. The speed, resolution, and optical features of the MLG-2 enable it to detect and measure transparent, small, and fast-moving objects even under harsh conditions.

A small beam spacing of just 5 mm ensures the thinnest objects are detected while a new "Transparent Mode" function provides measurement, location tracking, and hole tracking on transparent materials. A durable aluminum housing with an enclosure rating up to IP 67 makes the MLG-2 resistant to glare and ambient light. In addition, commissioning can be easily completed using the intuitive display or SICK's SOPAS software tool.

Available in two variants — Prime and Pro — the MLG-2 provides a durable, functional, and high quality solution for the most demanding detection tasks. The MLG-2 Prime features two analog outputs, up to three switching outputs, and optical synchronization.

The MLG-2 Pro — a more advanced variant — includes transparent, high speed, and high resolution modes, wired synchronization, IO-Link 1.1, and troubleshooting via SOPAS software.

The MLG-2 — which includes the IO-Link interface — is designed for high resolution and high speed measurement applications in the logistics, traffic, robotics, machine building, and food and beverage industries. Its advanced application capabilities also make it ideal for dusty, dirty, or outdoor environments.

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by Tom Carroll
TWCarroll@aol.com

Should There Be a Robot in Every Home?

How often have we seen the title "A Robot in Every Home" in newspapers, magazines, on the Internet, and even for one of my articles three years ago? Everyone — both the media and the public — feels that robots will become commonplace in our homes, much like Rosie on the old TV cartoon series, The Jetsons. Most of us who are reading this magazine are not searching for factory applications for our robot designs. In fact, other than a robotic sideline interest, several of us are not even looking at UAVs, or drones as they are often called. ROVs (remotely operated vehicles), search and rescue robots, and combat robots are not at the top of the list of the majority of robot builder's interests. When it comes down to it, most of us would rather have a robot in our home to not only be a companion, but to perform as many tasks and chores as we can design and program into them — much like the cartoon in Figure 1 from the sciencemag.org site. However, the question remains: Will there be, or better still, *should* there be a robot in every home?

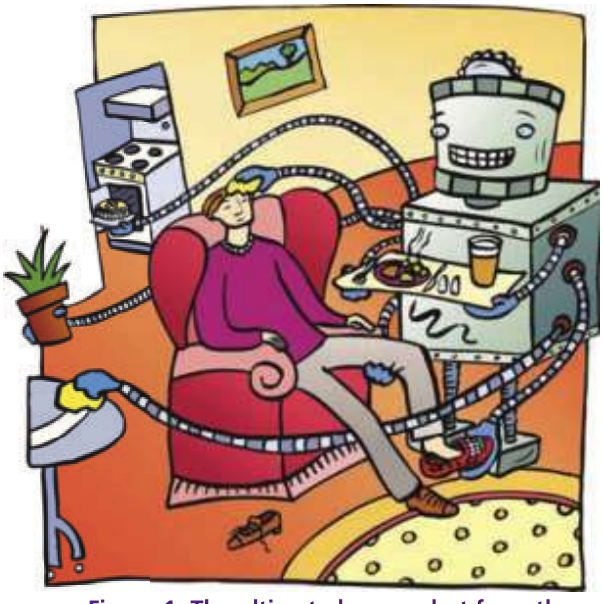

Figure 1. The ultimate home robot from the *sciencemag.org* site.

Figure 2. November 2014 *Popular Science* — Robots, Your Next Best Friend.

Fifty years ago, if you had asked someone about a robot in every home, they would have envisioned a bipedal humanoid that was just a bit smaller than a person with a duster in one hand and a towel over the other arm. Maybe the robot had wheels — a more sensible design, but nonetheless, a household servant. The November 2014 issue of *Popular Science* shown in **Figure 2** shows the robot, Curi (also called Simon) developed at Georgia Tech's Socially Intelligent Machines Lab by Andrea Thomaz. Note the PrimeSense sensor on the chest. The title of the article is, *"Will Your Next Best Friend Be a Robot?"*

Though the robot has two fully functional humanoid arms that are mixing a bowl of salad in the photo inside, the key feature is the robot's ability to interact socially with humans — not necessarily as a physical housekeeper or cook. Should social interaction rather than performing physical tasks be the key feature of our home robot? In the past, one might have envisioned a robot pushing a standard upright vacuum cleaner as shown in **Figure 3**, or flipping pancakes in the air as it was frying bacon for the

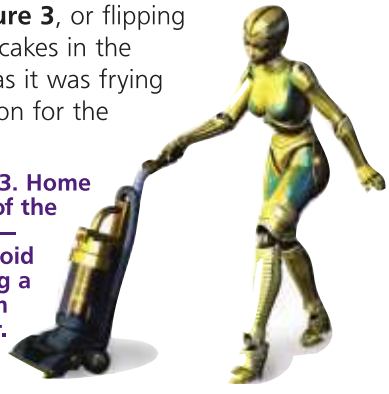

Figure 3. Home robot of the future — humanoid pushing a vacuum cleaner.

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Figure 4. Honda Asimo serving a person breakfast.

Figure 6. Tandy Trower of Hoaloha Robotics.

family breakfast. **Figure 4** shows a staged photo of Honda's Asimo serving a woman coffee. Outside, a robot might have been seen pushing a standard lawn mower or raking fall leaves. Is this *your* idea of a home robot? Are today's large corporations looking to diversify into robots for the home? Who will be designing and building robots for the home? How are the 'big players' in the field responding to the changing dynamics in the field of personal robotics?

I'd like to examine one major company's venture into robotics, and how the founder's dream of a 'robot in every home' slowly slipped away.

Microsoft Sheds its Robotics Group

This past September, I read a notice on the IEEE Spectrum's website stating that Satya Nadella, Microsoft's embattled CEO has added their entire Robotics Group to the company's personnel chopping block. Out of the 18,000 that Nadella has slated to be laid off worldwide, 2,700+ of those were in the Seattle area, including the remainder of the Robotics Group that was focusing on robotic manipulation and navigation using the Kinect as a sensor.

In a changing business world, drastic measures must be taken for a company to stay profitable, and newly elected top officers quite often take drastic measures to cut costs and increase profitability. However, this latest measure does not seem to reflect the long-term vision of the company's founder, Bill Gates as was stated in his great article in the December 2006 issue of *Scientific American* (**Figure 5**).

Figure 5. December 2006 *Scientific American* — the Age of Robots.

Tandy Trower's Vision of the Future of Robotics

I visited with Tandy Trower last October at his Hoaloha Robotics offices in Seattle. Tandy (shown in his office in **Figure 6**) was an initial member of Bill Gates' strategic staff who was later asked by Gates to lead Microsoft' robotics initiative and to later form Microsoft's Robotics Group in 2005.

Tandy was working for Atari back in 1981 when he recommended to his management that they license Microsoft Basic for their products, and it was young Bill Gates who came to Atari and Tandy to negotiate the features. Gates later hired him as one of the early employees of Microsoft.

It was not surprising that Gates later chose Tandy to form and grow the Robotics Group, as he had a good grasp of the robotics community and understood the necessary steps to meld Microsoft's expertise in software with the growing needs of advanced robotic systems. In June 2006, his group brought out the Microsoft Robotics Studio dedicated to advanced university and hobbyist robot experimenters.

Steve Ballmer had been CEO of Microsoft since 2000, and worked hard to develop particular products and technologies that he felt would be profitable; Microsoft became quite profitable under his direction. The Robotics Group was never a 'favorite' of Ballmer's as he could not see far enough in the future to visualize the tremendous potential of robotics, as could his mentor, Gates who at the time was chairman of the board.

When Gates stepped down as Chief Software Architect in 2006, Tandy began to see the writing on the wall. Gates was still chairman of the board, but CEO Ballmer did not share

his vision. He immediately wanted to know how robotics could become a billion dollar business segment for Microsoft. Gates' (and Trower's) passion for new product development seemed to be missing from the Robotics Group.

The name was later changed to Microsoft Robotics Developer Studio (RDS) in 2008 with the release of 2.0. RDS updates and software development kits followed. When I first talked with Trower, I began to sense that his true interest — robotics to assist the disabled and elderly — would not be met at Microsoft. He left the company in 2009 to form his own business, Hoaloha Robotics. (Hoaloha is the Hawaiian word for caring companion).

After Trower's departure, in my later conversations with the Robotics Group's staff, I sensed a great departure from Trower's direction as well as Gates' overall intentions and goals behind the original formation of the group. Possibly Ballmer was right. Robotics was too large and too much of a departure from Microsoft's original business goals.

I am left to wonder if other major industries are stepping away from the complexity of robotics and turning to one of the newer 'hot' fields like photovoltaic solar energy or electric cars.

Hoaloha Robotics

Let's talk about Trower's Hoaloha Robotics as his company is developing a socially interactive autonomous robot. Personal robots such as these can be of great assistance to not only elderly and disabled persons, but also those with complex neuro development disorders such as Asperger's Syndrome and autism — diseases that are characterized by social impairment.

Unlike the personal assistant robot design I have worked on over the years that can assist a person who has fallen or needs physical assistance, Trower's robot design does not present the design challenges and legal liability aspects of a physical robot/human interaction.

During my visit to Hoaloha Robotics, Trower spent quite a bit of time describing his robot's design issues and what he intends for the robot to accomplish. I saw three different working prototypes that displayed the evolution of his thought processes in the robot's development.

"The present design evolution is heading towards an inherently safe, useful, usable, and affordable robot for the home." Trower also stated that the "hardware is an enabler, but it is not where we believe our success can come from. In some sense, anyone can build a robot, but creating a useful and usable robot (at a reasonable price) is still the hard part."

This is not to say that the 'hardware' he demonstrated does not exhibit sophisticated mechanical systems and software. In several demonstrations, the robots used visual, verbal, manual, and autonomous commands to perform many required tasks. If what I saw at Hoaloha is any indication of what is to come, a truly usable and useful socially interactive robot will soon be living among us.

Figure 7. PR2 folding laundry.

Task Importance for Home Robots

Before examining some other home robots, I would like to discuss the true importance of certain tasks that people might ascribe to their home robot. Needless to say, everyone has a certain number of tasks they would like for their robot to perform, and will place certain tasks higher on the list than others. Many people might look first at tasks they personally hate but fail to think about their complexity and the few minutes per week that are actually required for the task.

Some of these most hated tasks require a lot of manual dexterity, like folding laundry — something that is expensive to design into a robot. The $400,000 Willow Garage PR2 took up to a half hour just to fold a single already washed and dried towel as shown in **Figure 7.**

It has a sophisticated vision system with associated software and some amazing arms. However, why use this same robot to vacuum the carpets when it could be easily accomplished by a $400 Neato robot.

Nobody would really want to have a home robot that was tasked to dust around fragile figurines or serve guests with a tray of sloshing hot tea in an expensive china teapot with teacups. Designing a robot to traverse an outdoor lawn as well as polish hardwood floors in also difficult as the required outdoor tires would certainly mar the floors.

The manual dexterity required to place dishes in a dishwasher *correctly* as well as removing them to stow in cabinets *correctly* requires manipulating arms that reach from almost floor level to five feet high or more. On top of the mechanical requirements is an advanced vision system to guide those extremities.

Remember the extremely advanced PR2's difficulty with a towel? The use of a housekeeper

twice a week for two hours each to do laundry, empty the dishwasher and stow dishes, and perform simple house cleaning tasks is far cheaper than trying to have a robot do it. A far less complex robot can simply socially interact with the occupant.

In a few years, a more sophisticated robot can assist a senior after a fall, into and out of bed, etc., all by verbal commands. All of this will become autonomous after a few more years of advancements.

Figure 8. Carnegie Mellon's Herb — a potential home robot.

Figure 10. Willow Garage PR2-SE.

Figure 9. Home monitoring robot at Shanghai Expo 2010.

Human Robot Compatibility

Appearance, both visually and even in subtle ways — such as the sound of the robot's voice and types of movements — is very important to a prospective customer. Can you imagine how the advanced robot named Herb developed at Carnegie Mellon's Robotics Institute (shown in **Figure 8**) might appear to a senior who was unaware of its presence? No doubt a blood-curdling shriek would be heard for blocks around!

A seasoned Navy Seal might whirl around and rip the arms off this '200 pound praying mantis' before realizing that it was just a benign robotic helper. (I can visualize the robot lying mangled on the floor saying, "I just wanted an Oreo.")

Or, how about the dual five DOF armed robot in **Figure 9** that looks a bit like an escaped 200 pound grub. With a stunning modern appearance, this advanced robot has vision, an interactive screen, lidar for navigation, and is a very functional robot for the home. However, its visual appearance may require some softening.

These two robots are just prototype platforms the groups use to refine their capabilities. Both are sleek and high performance robots; their final iterations will be a bit more human-interface friendly, and certainly less expensive to produce than the initial models. Multiple DOF (degrees of freedom) articulated arms such as those on these two robots are expensive to build as they utilize specially molded or machined arm segments with costly joints and internal motor/encoder assemblies.

Figure 11. Bicentennial Man — a newer "ultimate" home robot played by the late Robin Williams.

To give an example of the cost of advanced robot arms, Willow Garage offered a one arm PR2 Special Edition shown in **Figure 10** for $285,000 — $115,000 off the version with dual arms. A fully functional home robot with dual articulated arms certainly cannot cost anywhere near $285,000 to $400,000 to be affordable in even a high-end home.

My research has shown $10k-$15k probably to be the max for an average household. This cost will certainly drop as the number of units sold rises in numbers and competition increases.

Unlike most electronic devices such as computers and smartphones, electro-mechanical devices such as robots and large appliances will remain relatively expensive due to the more complex and labor-intensive assembly required. External shells and internal structure, as well as robust arms and drive systems utilize many fasteners and metal cutting operations during manufacturing.

Home Robot Design Hurdles

Robots for the home as depicted in movies such as the *Bicentennial Man* featuring Robin

Figure 12. Popular CMUCam 5.

Figure 13. Chinese home robot posed in modern kitchen.

Williams (**Figure 11**) or the robot in *Robot and Frank* are far more adept at household tasks than anything in today's advanced robot labs. They operate for days on a 'nuclear power source' (whatever *that* is), whereas actual advanced robots such as Honda's Asimo are lucky to have an hour of operation from a heavy lithium-ion battery.

We have made some incredible advances in battery technology in the past few years, but the actual power density required for a mechanically useful robot in the home is still lacking.

Lithium-iron phosphate and other chemistries are proving to be a better bet, but we still have a long way to go. Motors, actuators, and other power-draining robot components are becoming more electrically efficient, but not enough yet to compensate for inefficient power sources.

Truly intelligent and interactive vision capability for a home robot is also lacking. The Microsoft Kinect and PrimeSense sensors, as well as the CMUCam series of cameras have given robot experimenters some amazing visual capabilities, but none of them can approximate the complex visual feedback required for even simple home robot manipulative tasks such as folding laundry or food preparation.

Figure 14. Home education robot from Grandar Robotics.

Many of these sensors are now available for under $100, like the CMUCam 5 in **Figure 12** for $69.

Our human eyes in conjunction with our brains can analyze complex scenes in real time, and instruct our arms and hands to perform complex manipulations required in our daily lives. Robots are slowly making use of this technology. The Neato robot vacuum cleaner that utilizes SLAM navigation via a rotating lidar laser sensor is another 'vision' approach that experimenters have used in conjunction with other sensors for basic navigation within a home environment.

I have just touched upon the usefulness of articulated multiple degrees of freedom arms and functional grippers or hands, and then mentioned just how expensive they are. Well, these types of 'end effectors' (as they are called on industrial robots) will become very important as home robots become more prevalent.

With this in mind, robot designers will have to develop useful grippers and associated arms that cost a lot less. Not only must they be affordable, they should also be user-friendly and safe, as they are the main interface between the robot and the human.

Assisting a person off the floor who has fallen has been one of the most difficult design issues that I have encountered. Safety is paramount, but the safety aspect comes at a stiff liability penalty as any 'medical device' that comes in contact with a human presents a possibility of injury. The FDA Code of Federal Regulations describes "Physical Medicine Therapeutic Devices" in part 890.5050, or a "Daily Activity Assist Device" (i.e., a Personal Assistant

Figure 15. Samsung KIST Mahru assistant robot.

Figure 16. IRT AR assistant robot in simulated home environment.

Robot) that all manufacturers must adhere to.

It will be the extensive prototyping and testing to meet these regulations that will add to much of the cost of a home robot that physically assists a human, but these robots will eventually happen. A large part of our society really needs them.

Some Interesting Home Robot Concepts

I've discussed some very interesting robots that exist today that could be used in homes. Their costs range from several hundred dollars to $400K and more. Every designer had their own particular design features. I've seen the home robot shown in **Figure 13** on several Asian sites that give no particulars on the robot. It has dual anthropomorphic arms but lacks any sort of grippers.

The robot in **Figure 14** is from Grandar Shanghai Robotics and is reputed to be able to recognize facial expressions, as well as Chinese writing. With two DOF arms and a touch screen, it is presently in the research and development mode.

The Samsung Mahru humanoid robot developed in conjunction with the Korea Institute of Science and Technology (KIST) is shown in **Figure 15**. First debuted to the public back in 2008, there have been numerous improvements in the past few years. The human-sized bipedal humanoid is said to be Korea's answer to Japan's Asimo.

The robot has the ability to recognize faces, voices, and objects. Having built and worked with two of the most popular humanoid robots from Korea — the Dongbu Hovis Lite and the Robotis Bioloid — I can attest to the capabilities of the Korean robotics industry and their ability to bring cutting-edge robots to market.

Japan is certainly not being left behind in robots that work around humans. Their Asimo robot from Honda is world renown. The AR Assistant robot shown in **Figure 16** from the University of Tokyo is an amazing humanoid robot specifically designed for the home environment.

"The prototype measures 5 ft in height, weighs 287 lbs, and has 32 degrees of freedom. Currently, the robot can clean the floor, clear the table, collect things to put them in the garbage or even put them back where they go, collect your dirty laundry and put it in the washing machine."

It has six wheels and five cameras with laser and ultrasonic range finders for navigation. Like all of the human-sized robots, the battery can only last about an hour.

The research on this and other robots is being financed by Toyota, Fujitsu, Panasonic, Mitsubishi, and other major Japanese companies.

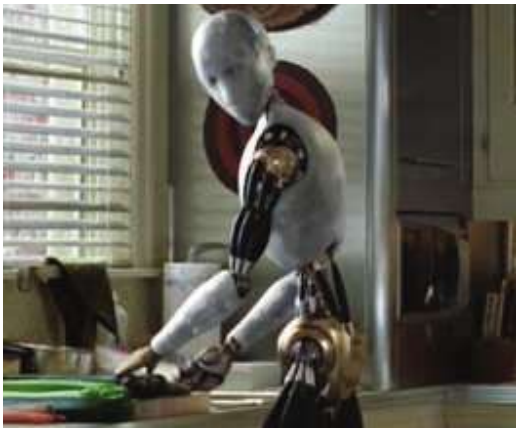

Figure 17. US Robot NS-5 in the kitchen, from the *iRobot* movie.

Final Thoughts

As you've seen, home robots are in the forefront of the minds of key people in the robotics industry. We are not quite at the point where we can have a fully functional robot serving in our homes, but we are getting closer. The robot shown in **Figure 17** from a scene in the Will Smith movie, *iRobot* supposedly takes place in 2035. We probably will not have a bipedal humanoid robot even at that time, but a truly functional and intelligent wheeled robot will be serving some of us then.

Unfortunately, Tesla and Spacex founder, Elon Musk feels that artificial intelligence is what he calls "our biggest existential threat."

Yes, it will be the early adopters who first purchase these machines, but it will probably be some of you readers who actually develop them. SV

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