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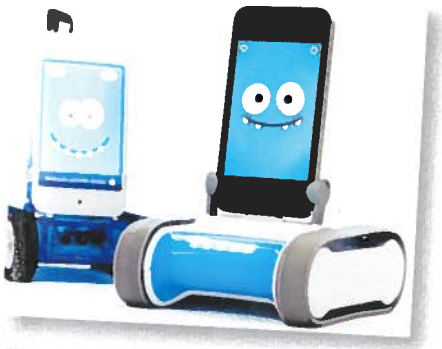

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BAXTER

A ROBOT THAT WORKS WITH HUMANS

by Elaine Chen

Rethink Robotics recently announced the launch of Baxter the Research Robot. It uses common sense to perform a wide range of tasks and is designed to work in human environments and be easily taught tasks by humans, using programming, onscreen menus or by hand (with a human physically guiding the robot's manipulators through a task). Baxter was one of Time magazine's "Best 25 Inventions of 2012", and was hailed as one of MIT Technology Review's 10 Breakthrough Technologies of 2013.

The Baxter Research Robot is powered by a revolutionary new Software Development Kit (SDK) that will enable people to "hack" the robot and create countless uses and applications. There has been an explosion of applications for smartphones and tablets; can we even imagine the possibilities for apps that will be written for a humanoid robot that can perform automated tasks in unprecedented ways? Robot Magazine was curious to learn more and in this presentation we share additional fascinating details on Baxter. We were fortunate to interview Elaine Chen, VP of Product Development at Rethink Robotics and Senior Lecturer at MIT Sloan School of Management. Here's what Elaine outlined.

Baxter picks and places gear assemblies in a factory setting. The robot is adept both at inserting the parts, wrapping the package, and scooting it onto a conveyer belt leading to shipping.

What are the initial tasks that Baxter has performed?

Baxter is an entirely new type of robot that is redefining the way robots can be used in manufacturing environments. It performs a variety of repetitive production tasks – all while safely and intelligently working next to people. Examples include:

- Material handling - Baxter transports parts from one location to another, and can count parts on both input and output locations
- Loading and unloading lines - Baxter can put parts onto moving conveyors or fixed surfaces, or remove them from moving conveyors or fixed surfaces
- Inspecting, testing and sorting - Baxter can be integrated with third-party inspection equipment such as vision systems or scales, and can sort parts based on the outcome of the inspection
- Packing and unpacking - Baxter can systematically pack a bag, box or tray. It can be trained to arrange packed objects in an array and unpack containers

Can you describe the first applications in conjunction with which Baxter has been used?

Our Alpha customers for the Baxter Research Robot have been successfully using this product to achieve disparate goals. WPI is using the robot to modernize an existing industrial robotics course that introduces students to robotics within manufacturing systems. In that course, Baxter will be incorporated as an example of a current manufacturing robotic technology. Additionally, Baxter will be used as an enabling technology for future proposals, including NSF's National Robotics Initiative and Catalyzing Advances in Undergraduate STEM Education programs. Importantly, Baxter will also be used by undergraduate and graduate students in the research on understanding novel grippers, studying human-robot interaction, incorporating touch sensing, and making Baxter mobile.

MIT "recruited" Baxter to assist them with, among other things, 3D object recognition data collection. The Baxter Research Robot holds an Asus RGB-D sensor (Kinect-like camera) in its hand and uses it to scan a person or object to create a 3D model. They plan to use the robot to scan many objects and people, using an adaptively tuned motion strategy, allowing them to build up a library of objects and people. They will also work on having the robot manipulate objects, and to try to "learn" to recognize different objects over time.


baxter
rethink robotics

A developer can task and train Baxter in real time and see the results a few feet away.

BAXTER RESEARCH ROBOT BASIC SPECIFICATIONS

Physical
-Robot height: 3 ft. 1in. without optional pedestal
-Robot height with pedestal: 5 ft. 10 in. – 6 ft. 3 in. (adjustable)
-Arm length to end-effector plate: 41 in.
-Torso mounting plate diameter: 13.3 in. (for mounting on table)
-Body weight, without pedestal: 165 lbs.
-Body weight, with pedestal: 306 lbs.
-Degrees of freedom: 14 (7 per arm)
-Pedestal footprint: 36 x 32 in.

Electrical
-Supply voltage: 120 volts A/C
-Rated current: 6 amps

Environmental
-Protection classification: IP50
-Operating temperature range: 32-104°F (0-40°C)

End Effectors
-Vacuum cup with interchangeable cups
-Electric parallel gripper with interchangeable "fingers" and user-adjustable "fingertips"

Workstation Requirements (workstation not provided)
Ubuntu 10.04 LTS and ROS Electric, with minimum specifications:
-Intel i5 or above
-4GB memory or above
-Min. 2GB of free disk space
-Ethernet port

Tufts' Human Factors Engineering program, led by Professor Dan Hannon, will explore interactions between humans and robots, working in close proximity to examine how to differentially allocate tasks to human and machine that leads to best overall performance, such as sorting and opening medical laboratory specimen containers.

What are the main differences between the original Baxter and the new Baxter Research Robot?
The original Baxter and the Baxter Research Robot share the same hardware platform, but they run different software. Baxter comes with our manufacturing application that allows end users on manufacturing lines to rapidly set up discrete part transfer tasks via the integrated user interface (UI). Baxter Research Robot runs the Research SDK software, allowing developers to program the robot to move and perform new tasks by running custom code on a connected development workstation.

How does one program Baxter to perform tasks?
For Baxter in a manufacturing setting, there is no programming involved - tasks are taught by demonstration, using Baxter as a complete user interface. A very simple pick and place may be trained by putting your hand on Baxter's wrist cuff; this puts Baxter's arm into "Zero G" mode, making it easy to physically move Baxter's arm around with your hands. Now you can physically move Baxter's hand to the pick location. Press the "Grasp" button on the wrist cuff to tell Baxter to pick up the object. With the object in Baxter's end-effector, move its hand to the place location, and press the "Grasp" button again to place the object. The task is now trained

ıd ready to run.

For the Baxter Research Robot, you will evelop and build code on a Linux-based evelopment workstation with ROS stalled. The Baxter Research Robot runs on OS and utilizes the Unified Robot escription Format (URDF), allowing evelopers to rapidly integrate custom plications with our SDK.

you were to project the future uses of ıxter, and I know this is just speculation, hat additional\applications—or categories apps—do you think Baxter may be ited for?

hile we are concentrating on anufacturing applications with Baxter, the ıxter Research Robot SDK allows velopers to pursue other industries that e outside our area of focus - we can agine Baxter working in a medical setting, rehabilitation, in food preparation and any more environments.

hat is your vision of the long-term future r Baxter?

e believe Baxter is going to fundamentally ange how people think of manufacturing d how people think of robots. Baxter will volutionize how people manufacture oducts and will bring us to a new era ıere people get to do meaningful work ıile delegating less challenging tasks to ots.

ABOUT RETHINK ROBOTICS

e Baxter Research Robot is a fully nctional humanoid robot platform veloped by Rethink Robotics that includes ısor suites for research and teaching plications. Based in the Innovation District Boston, Massachusetts, Rethink Robotics funded by Charles River Ventures, ghland Capital Partners, Sigma Partners, aper Fisher Jurvetson and Bezos peditions, the personal investment npany of Jeff Bezos. For more information out Rethink Robotics, please visit hinkrobotics.com or follow Rethink on itter - @rethinkrobotics.

CONCLUSION

e Baxter Research Robot is recommended the National Robotics Initiative (NRI) as a earch platform suitable for funding posals. Designed to work side by side h technicians and researchers without ety cages, the Baxter Research Robot is ilable for $22,000, which includes a vice plan plus built-in sensors such as ıeras, force, sonar and rangefinder. The earch Robot's extremely low price point will allow Baxter to become an integral part of robotics labs in higher education institutions and manufacturers' research centers.

"Universities and other research labs are now able to purchase a fully functional research robot and then use their creativity and programming skills to create never before seen applications," said Rodney Brooks, founder, chairman and CTO of Rethink Robotics. "Tufts University, Massachusetts Institute of Technology and Worcester Polytechnic Institute have already begun working with the Baxter Research Robot and it is exciting to see the kinds of applications they will develop." The SDK will enable researchers to focus on fundamental goals such as object manipulation, human-robot interactions, collaborative robotics, robot adaptation to changes in its environment and arm trajectory planning. Graduate students at Worcester Polytechnic Institute are already working with Baxter and the research team has plans for studying tasks that can be performed using the robot's sensor suite.

"Robot application development could potentially go viral the way software did for PCs and mobile apps did for smartphones," said Scott Eckert, President and CEO of Rethink Robotics. "The Baxter Research Robot's hardware and software platform can be extended in limitless directions through new software applications. This opens up the potential for an enormous and exciting new industry in creating apps for robots."

"Acquiring Baxter has major significance for the WPI community and continues our leading-edge position in the ever-growing field of robotics," said Michael Gennert, director of Worcester Polytechnic Institute's Robotics Engineering program. "The open-source nature of Baxter's software platform allows our research team to make changes and explore further uses for the robot."

(Editor's note: Robot Magazine thanks Rethink Robotics for assisting in the preparation of this article. Images courtesy of Rethink Robotics.)

Links

Baxter as one of Time Magazine's Best 25 inventions of 2012, techland.time.com/2012/11/01/best-inventions-of-the-year-2012/slide/baxter/

Baxter hailed as one of MIT Technology Review's 10 Breakthrough Technologies 2013, technologyreview.com/featuredstory/513746/baxter-the-blue-collar-robot/

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For more information, please see our source guide on page 81.