Jimmy Sastra

resume & design portfolio

JIMMY SASTRA

EDUCATION

University of Pennsylvania, School of Engineering and Applied Science, Philadelphia, PA
Doctor of Philosophy: Mechanical Engineering and Applied Mechanics | August 2011
GPA: 3.63/4.00, GRE: Verbal 570, Quantitative 750, Analytical Writing 5.0
Master of Science in Engineering: Mechanical Engineering and Applied Mechanics | May 2006
Bachelor of Science in Engineering: Bioengineering | May 2004
GPA: 3.52/4.00, Honors: Cum Laude, Dean's list 2003-2004, Minors: Mathematics, Fine arts

ENGINEERING EXPERIENCE

Industrial Design and Mechanical Engineering | September 1, 2011 - Present

Willow Garage, Menlo Park, CA

• User interviews, ideation and prototyping of robots in 5 task explorations.

• Mechanical design of a robot head featuring 2 DOFs for a 3D sensor requiring motor selection and design of sheet metal, machined parts, belts and pulleys.

Robotics Engineering | May 20, 2006-August 31, 2011

ModLab, University of Pennsylvania, Philadelphia, PA

• Designed electronics hardware of a modular robot called CKBot

• Led team of 3 undergrads for mechanical design and team of 10 for manufacturing of 2 generations of 50 CKBot modules to be used in 2 international competitions.

• Programmed asynchronous protocol in Python called Robotics Bus

• Programmed Robotics Bus nodes on CAN bus in embedded C on 8 bit MCUs.

Software Engineering | May - August, 2008

Willow Garage, Menlo Park, CA

• Programmed control software in C++ for 8 wheeled omni-directional moving base of a humanoid robot called PR-2

• Prototyped and tested 8 wheeled omni-directional moving base of PR-2

Bioengineering | Summer 2002 – Summer 2004

Traumatic Brain Injury Lab, University of Pennsylvania, Philadelphia, PA
• Designed a magneto pulling cytometry device to tether cells using ferro-magnetic microbeads
• Performed research in gene transport on neuronal dendrites

TEACHING EXPERIENCE

Teaching assistant, University of Pennsylvania:
MEAM410: Design of Mechatronic Systems | MEAM247: Mechanical Engineering Laboratory | MEAM211: Engineering Mechanics: Dynamics | MEAM510: Design of Mechatronic Systems | 2006 - 2007

SKILLS

Programming: Python, MATLAB, C; Object Oriented Programming, Asynchronous Protocol Design
Electrical Engineering: Eagle, Pads; Printed Circuit Board design
Prototyping: SolidWorks, AutoCAD, Machineshop, 3D Printing, Lasercutting, Fiberglass layup
Multilingual: Speak fluent Dutch, English; Intermediate Indonesian

LEADERSHIP

Manage the CKBot group at Grasp Lab: Guide on average 4 undergrads and 3 masters students each year
Founder of XPLR: A photography club counting 50 members that bikes through the city and takes pictures. Organized two gallery shows. http://xplr-club.com | 2008-2009

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SELECTED PUBLICATIONS

Book Chapters:

M. Yim, P. White, M. Park, and **J. Sastra**, Encyclopedia of Complexity and System Science, New York: Springer, 2009

J. Sastra, S. Chitta, and M. Yim, Dynamic Rolling for a Modular Loop Robot, 2008.

Journal articles:

J. Sastra, S. Chitta, and M. Yim, "Dynamic Rolling for a Modular Loop Robot," The International Journal of Robotics Research, vol. 28, iss. 6, pp. 758-773, 2009.

Conference articles:

J. Sastra, W. G. Bernal-Heredia, J. Clark, and M. Yim, "A Biologically-inspired Dynamic Legged Locomotion with a Modular Reconfigurable Robot," in Proc. of DSCC ASME Dynamic Systems and Control Conference, Ann Arbor, Michigan, USA, 2008.

M. Yim, B. Shirmohammadi, **J. Sastra**, M. Park, M. Dugan, and C. J. Taylor, "Towards Robotic Self-reassembly After Explosion," in P IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), San Diego, CA, 2007, pp. 2767-2772.

B. Shirmohammadi, C. J. Taylor, M. Yim, **J. Sastra**, and M. Park, "Using Smart Cameras to Localize Self-Assembling Modular Robots," in Proc. of ACM/IEEE International Conference on Distributed Smart Cameras, Vienna, Austria, 2007.

J. Sastra, S. Chitta, and M. Yim, "Dynamic Rolling for a Modular Loop Robot," in Proc. of International Symposium on Experimental Robotics, Rio de Janeiro, Brazil, 2006, pp. 421-430.

PRESS

Newspaper articles:
J. Sastra and B. Shirmohammadi, "A Modular Robot That Puts Itself Back Together Again," The New York Times, July 28, 2009.

Interviews:
British television: The Gadget Show | September 11, 2009
German national radio: DRadio Wissen | October 5, 2009

Demos:
IIT Mumbay TechFest, Mumbai, India | January 25, 2009
Product Development and Management Association, Anaheim, CA | October 21, 2009
Wired Magazine NextFest Chicago, IL | September 26, 2008

AWARDS

Ben Wegbreit IFRR Student Fellowship Award at the 10th International Symposium on Experimental Robotics, Rio de Janeiro, Brazil | July 2006

Voted most persuasive speaker by panel of venture capitalists and entrepreneurs in Entrepreneurship II | May 2004

OTHER

Photography: Part-time events and fashion photographer. http://www.intersect-designs.com
Fine art Photography: Group Show at 222 Gallery | Dec, 2008
Theatre: Mechatronics supervisor of a theatre play by Pig Iron Theatre Company consisting of humans and robots | May, 2010
Multicultural: Of Chinese-Indonesian descent; have resided in The Netherlands, Japan and USA. Dutch citizenship, currently in US on OPT.

DESIGN OF CKBOT: A MODULAR ROBOT

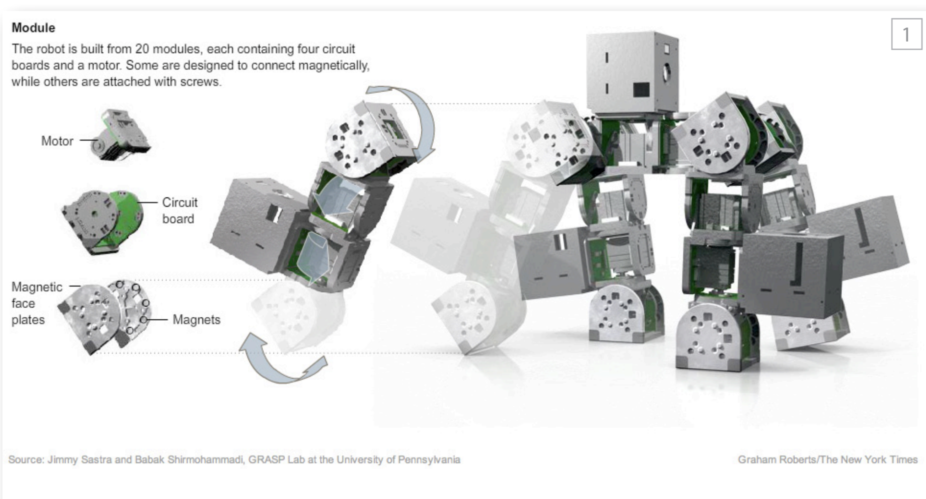
OBJECTIVE AND ROLE

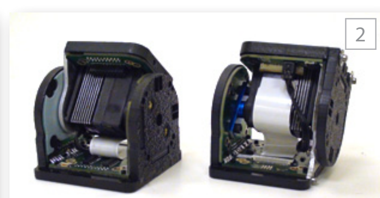
The idea behind Modular Robotics is to build many identical modules that can be put together to from a bigger robot. In comparison to traditional robots that are designed with a limited set of tasks in mind you have a system of modules that can be put together in different ways to achieve many different tasks. Modular Robots promise to be versatile since configurations allow different morphologies, robust due to redundant degrees of freedom and inexpensive because of economies of scale.

My role was to design the electronics and oversee two masters students for the mechanical design and a team of undergraduates for the final manufacturing. I was also the engineer behind the core Python software that runs on the host and as well as responsible for the embedded code on the modules. By now we have manufactured around 200 modules and have had 2 design iterations.

SOLUTION AND OUTCOME

CKBot is designed to be easy to manufacture. While most Modular Robots are heavily geared down CKBot had to be fast enough for dynamic locomotion, the main interest of my thesis. The module case is made out of Acrylonitrile Butadiene Styrene (ABS) which is tough and easy to lasercut. Hobby servos are used as the actuators. They are cheap and have really high power density (torque divided by size and weight). CKBot has been used as the platform for many projects and is the base of tens of scientific experiments, papers and viral videos on YouTube. It has been featured in the New York Times newspaper and tons of technology websites such as Engadget and Gizmodo.





1 *CKBot in quadruped configuration;* 2 *3/4 view of CKBot modules;* 3 *CKBot cluster of modules*

CKBOT ELECTRONICS

SUMMARY

The electronics have undergone several design iterations. The interface to the outside of the modules has remained consistent to keep the modules backwards compatible. It features a 20 pin socket for CANBus communication and 4 mounting holes. Over the years there have been several redesigns:

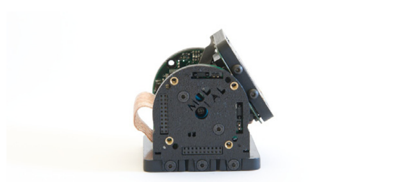
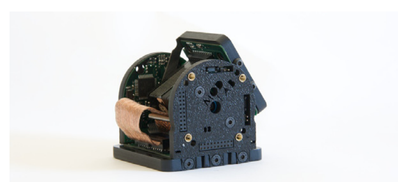
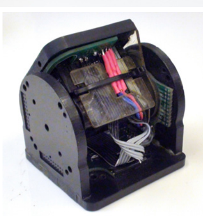
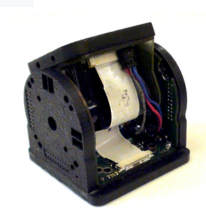
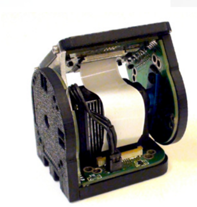
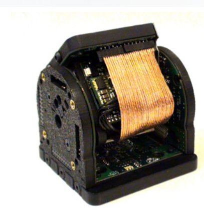
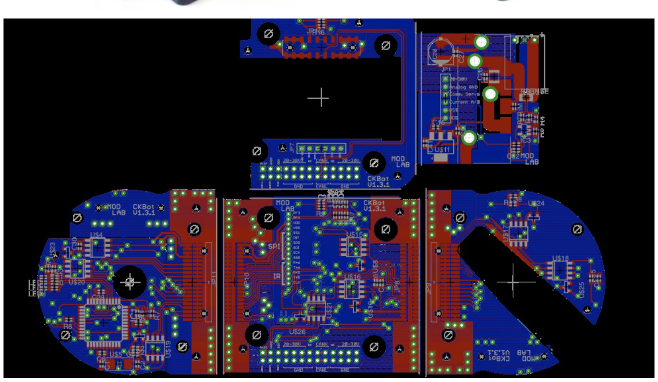
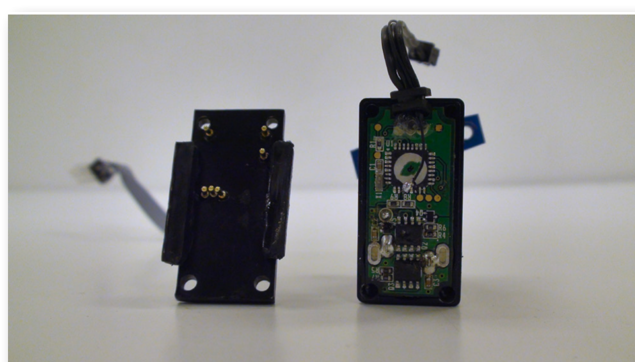
VERSIONS

V1.1: swappable voltage regulators for digital logic and power to the servo
V1.2: muxed IR for local communication and FFC Flex cable for longer life
V1.3: two way serial communication to servo over single wire. Reverse engineered servo circuit and reprogrammed internal MCU.
V1.4: IrDA for long range module to module commication, atxmega with 8 serial hardware ports

PERIPHERALS

ZigBee: bridging the CAN over wireless for remote communication using laptop
Gripper: to manipulate objects, nodes and trusses
Smart camera: with on board graphics and blinking LED. Used to localize other smart cameras.
Battery: Supply onboard power and protection from short circuit.
Motor: Continuously rotating shaft for mounting of wheels or Rhex like legs

Currently we use the Hitec Servo HSR5990TG. We implement a two-way serial communication over a single wire. In version 1.3 we reprogram the servo to run our own control loop which runs at a higher rate and could potentially push the servo further than Hitec is willing.

CKBOT SOFTWARE: ROBOTICS BUS

OBJECTIVE AND ROLE

Controller Area Network (CAN) is a standard used in the automotive industry. It is a low bandwidth bus protocol that is highly robust to noise. We have used this as the basis for the communication inside a cluster of CKBot modules. I have written the core software of CKBot which implements the asynchronous Robotics Bus protocol to take advantage of the multiple processors in a cluster of modules. I also maintain the embedded software that runs on the modules.

OUTCOME

The CKBot IX provides a nice command line and programmatic interface to the CKBot modules. A user can pick up a unknown module and query its dictionary entrees to see what its capabilities are. Setter and getter methods can be generated dynamically during runtime. It is supported across several platforms: Ubuntu Linux, Mac OS X and Microsoft Windows. Robotics Bus is now also used by the Penn Formula Car team.

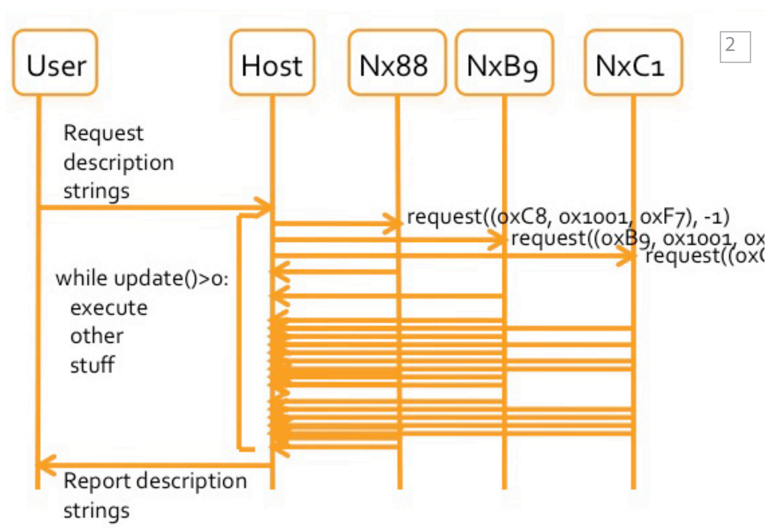
TEAM

Dr. Shai Revzen, Electrical Systems Engineering (ESE) Post Doctoral Fellow
Levi Cai, CSE Undergraduate

1

```
ASYNCHRONOUS
>>> p = Protocol(Bus())
>>> p.request((0xC8, 0x1001, 0x01), 0x01)
>>> p.request((0xC8, 0x1001, 0xF7), -1)
>>> p.request((0xB9, 0x1001, 0x01), 0x01)
>>> while p.update() > 0:
...     pass

INTERACTIVE
>>> c = Cluster()
>>> c.populate()
>>> c.<TAB>
 {Nx88:<V1.3 Servo Module>,
  NxB9:<V1.2 Servo Module>,
  NxC1:<V1.2 Motor Module>}
>>> c.at.Nx88.get_od()
```



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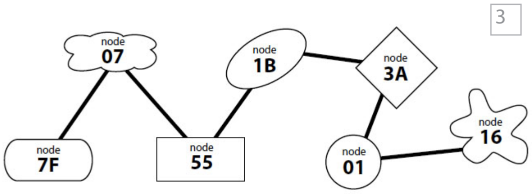

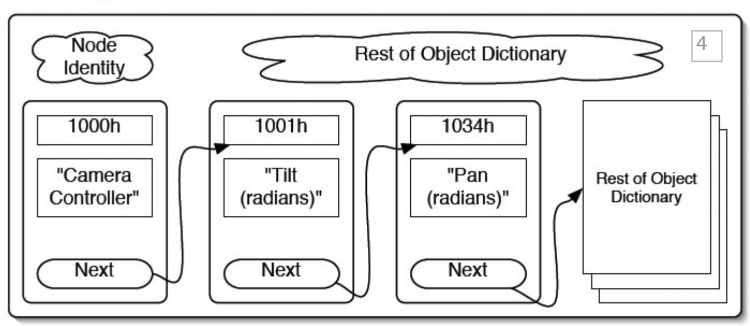

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1 *Command line interactive interface example;* 2 *In an asynchronous protocol the user can put in non blocking requests for dictionary objects. The update() method returns number of outstanding requests. Once update() returns 0, all dictionary objects have been received and the user can read the responses.* 3 *Each node on the Robotics Bus has their own unique ID.* 4 *Each node has a browse-able Object Dictionary.*

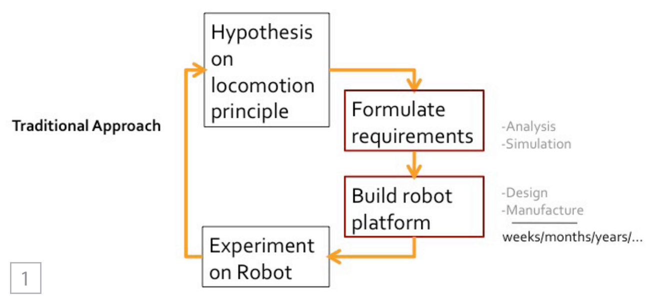
DYNAMIC LOCOMOTION WITH MODULAR ROBOTS

OBJECTIVE AND ROLE

Many dynamic locomotion research projects subscribe to the following process: a hypothesis on a locomotion principle is made, a robot platform is built, experiments are made on the robot and the hypothesis is revisited. The build process may take a long time: months, years, dare I say a whole Ph.D. thesis, before we get to our experiment. I propose to use modular robots to shorten this cycle by taking out the build process and replace it with a reconfigure process. Rather than build a robot from scratch each time, you can reconfigure the robot and shorten the hypothesis-experiment cycle.

OUTCOME

Most modular robots are heavily geared down and slow. In my thesis I have built CKBot modules that are fast enough to perform dynamic locomotoin. I have implemented many dynamic gaits. I will highlight two of them: a dynamic rolling gait in which we show that a rolling wheel that can change its outer shape such that it's center of mass is in front of its ground contact point can move faster and more efficient than a tank tread configuration. This has given us the speed record in Modular Robot locomotion. A second configuration is a centipede like locomotion with compliant legs and the third is a snake like locomotion using passive wheels.



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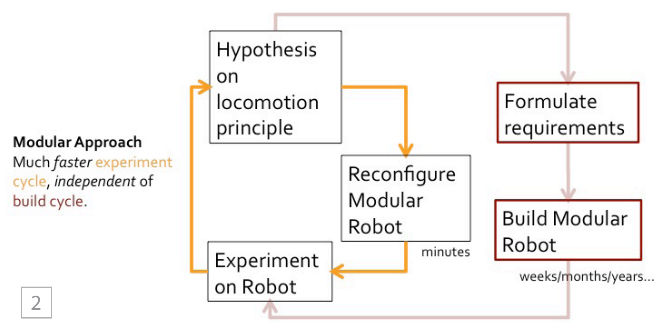

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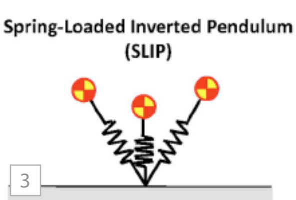

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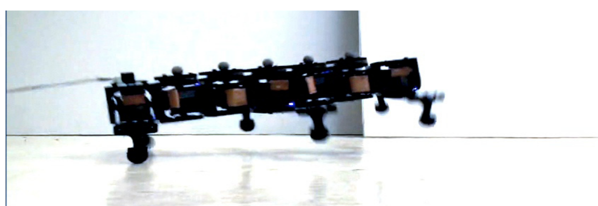

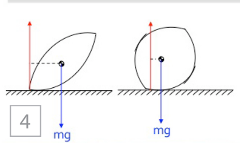

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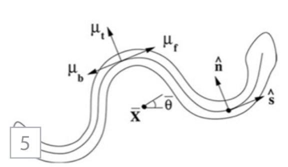
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1 *Research workflow using traditional robots with a fixed shape.*

2 *Research process using a reconfigurable modular robot.*

3 *Locomotion like a cockroach.As the robot runs the leg acts like a spring: energy is stored in the leg at touch down and returned at lift off during each stride.*

4 *The fastest and most efficient gait is the dynamic rolling gait we developed which rolls like a wheel whose rim can change shape such that it is continuously falling forward.*

5 *Using passive wheels to simulate snake skin which has no friction in the fore-aft direction, but lots of friction in the laterally*

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SELF REASSEMBLY AFTER EXPLOSION

PROBLEM

A car bumper is designed to crumple upon impact and protect the driver. A ski boot will detach from the ski to prevent injury to the ankle. Likewise a CKbot assembly falls apart when it is kicked, however CKbot can put itself back together again.

GRAND CHALLENGE

One of the grand challenges of modular self-reconfigurable robots is the ability for a system to repair itself after being exploded into many pieces. The effort to solve this grand challenge pushes the technical ability for integrated systems to plan and execute self-assembling hardware and software under unstructured conditions. Solving the challenge will show an unprecedented level of robustness in a robotic system.

SOLUTION AND ROLE

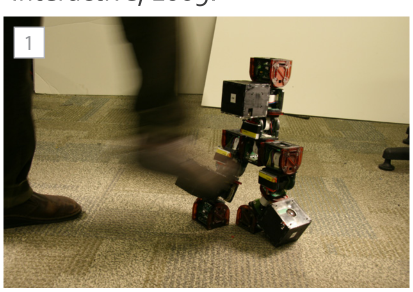
My role was to create the higher level control and distributed algorithm that docks the clusters into the final assemly as well as the hierarhical communication protocol. This required integration of the localization data from the smart cameras, CAN communication within a cluster as well as local infra red communication between clusters.

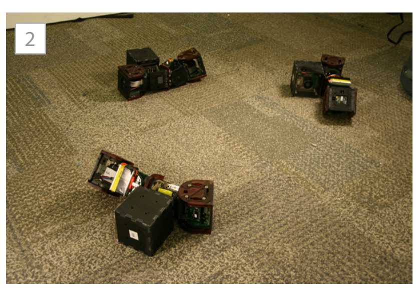
TEAM

Dr. Mark Yim, Mechanical Engineerng
Dr. CJ Taylor, Computer Science Engineering
Babak Shirmohammadi , Computer Science Engineering PhD candidate
Chris Thorne, Mechanical Engineering PhD candidate
Michael Park, Mechanical Engineering PhD candidate

PRESS

J. Sastra and B. Shirmohammadi, "A Modular Robot That Puts Itself Back Together Again," New York Times Interactive, 2009.





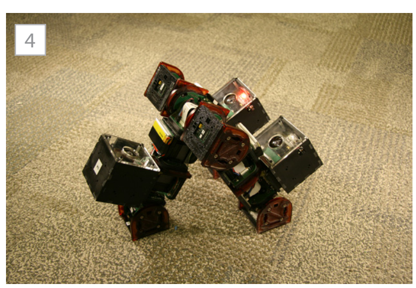
1 *kick to mid-section*

2 *resulting in three clusters of modules strewn randomly*

3 *clusters self-right and dock*

4 *assembly stands up*

5 *assembly resumes walking again*



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PLANETARY CONTINGENCY

CHALLENGE

Imagine that you are on Mars in a space-station and an emergency occurs on the planet surface. You have to solve the task in a limited amount of time, using the limited resources and teleoperated robotics that you carried with you (50lbs suitcase). What would you carry and how would you quickly solve the task? The Planetary Contingency competition blends research in reconfigurable modular robots with inspiration from McGyver and Apollo13.

ROLE AND OUTCOME

The Planetary Challenge simulates a emergency situation at a space station on mars. Competitors have to solve tasks using only what they have packed in their suitcase. The competition has been held twice at ICRA. Both times have been perceived very well by the Modular Robot community. Teams from Univ. of Southern Denmark, MIT, USC, University of Washington, Harvard and Willow Garage have participated. In both years our lab has supplied the modules for the teams with the exception of the Univ. of Southern Denmark team who brought their own hardware. My role was the design and manufacture of modules and lead the operations of the competition. In both years we have successfully succesfully organized the competition and manufactured roughly 100 modules each time.

TEAM

Dr. Mark Yim, Michael Park, Matt Piccoli, Mohit Bhoite, Jaimeen Kapadia

1 *Onlookers watch CKBot save the day by patching up the solar panel that powers the base station*

2 *Roboticists steer CKBot remotely*

3 *CKBot plugs a hole in a leaking air vent*

4 *CKBot raises antenna that fell down during a martian storm.*

PR2 QUICK CHANGE END EFFECTOR

SUMMARY

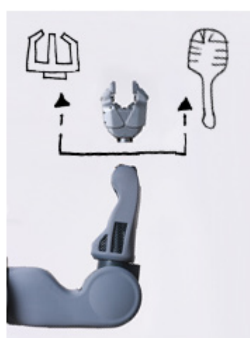
This prototype allows PR2 to change end-effectors on his own. He could trade in his hand for a different gripper, a screwdriver, or even a sensor such as a camera. The quick release mechanism makes it easy for him to attach and detach and it also features electrical connections to transfer power and communication.

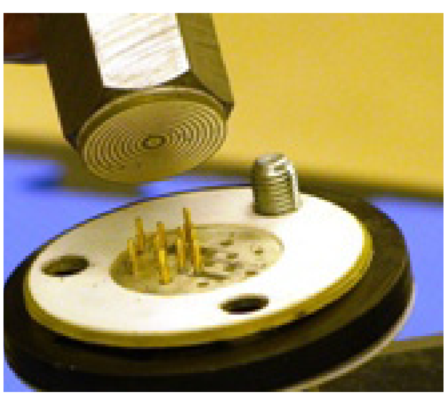
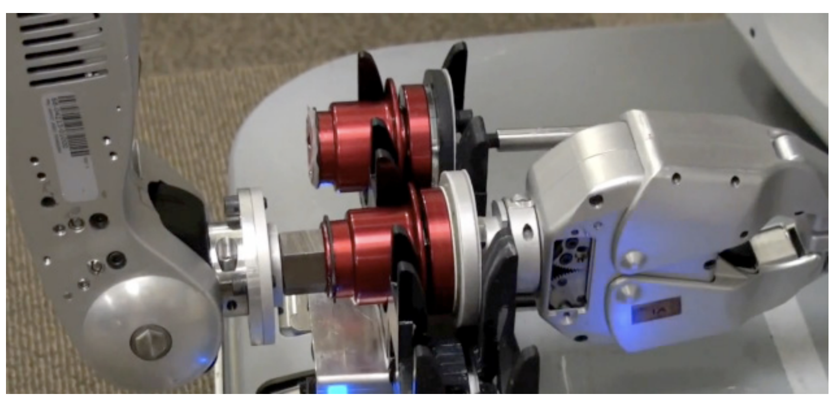
PR2 should be able to quickly attach and detach these different tools. We used a mechanism called a quick release (shown in red) that attaches to a metal stub. The stub connects to the arm of PR2 and the quick release mechanism attaches to the different tools.

The holster has 2 functions. It not only allows to PR2 to carry its tools on his belt for easy access, it also squeezes the quick release when a tool is inserted. By squeezing this mechanism together it retracts pins inside the quick release thereby releasing the stub. The stub contains 10 concentric copper rings which when inserted into the quick release connects to spring loaded connectors called pogo pins. These provide electrical connections that can be used to transfer power as well as communication such as ethercat or CAN.

TEAM

Dr. Mark Yim, Mechanical Engineerng
Matt Piccoli, Mechanical Engineerng

THE ROBOT ETUDES

DESCRIPTION

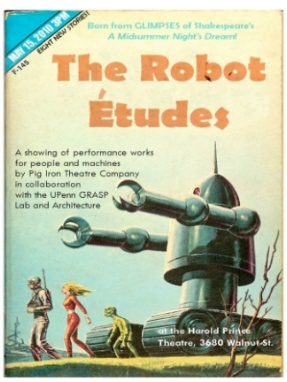
For several months, grad students from UPenn's engineering and architecture program met with artists from the renowned Pig Iron Theatre Company to tinker in the brambles of Shakespeare's Midsummer Night's Dream. The result was a series of performance etudes — thumbnail sketches of an alternate universe where plants are programmed and love shimmers with electric light. Mechatronic devices interacted with human actors in a play called the Robot Etudes. The show was sold out.

TEAM

Dr. Mark Yim, Dr. Simon Kim
11 engineering students
10 architecture students
Pig Iron Theatre Troupe which included a director, actors, a stage manager as well as sound, lighting, stage and costume designers.

ROLE

I initially started of as a student. Later on my role became that of a TA, and at the end of the semester received special billing as "mechatronic supervisor".



XPLR-CLUB - PHOTOGRAPHY/BIKING CLUB

DESCRIPTION

Calling all creative individuals passionate about art and urban exploration! XPLR is a Philadelphia-based photography+biking club.

A camera is your license to explore the world and your relationship to it. Where has your license taken you recently? Part inspiration part perspiration, XPLR (explore!) events seek to unite individuals that are passionate about art and urban exploration. Meetings take place at the Philadelphia Museum of Art (PMA) steps. The actual subject matter and shooting location will be kept secret until the day of the event and will be disclosed at the PMA. Join us in our pursuit of creativity, or just for a fun bike.

OUTCOME

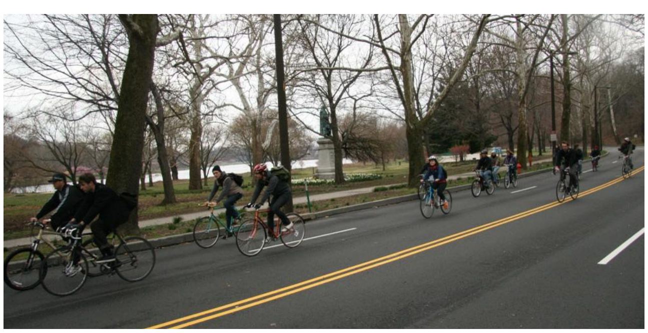
The club grew to about 50 members. While I was in charge we've had two gallery shows and 104 bike rides during which we rode many miles. Pictures were shared using Flickr.

WEBSITE

http://xplr-club.com

ROLE

I started this club and led the group for a year before I passed it down to my friends Jan Baranski and Joe Grogan.



RESTORING VINTAGE BIKES

DESCRIPTION

I have restored 3 vintage bicycles and a moped from the 1970s. The main reason for restoring the moped machine was to study a new actuator and gain experience in working with AC electronics. I already had experience in working with many different actuators: DC motors, stepper motors, and Shape Memory Alloys. In this project I learned how to engineer with 2 stroke gas engines. I find the two stroke engine to be a great example of elegance. It is the simplest combustion engine with incredibly high power to weight ratio.

OUTCOME

Mopeds are generally limited to a engine displacement of 50cc giving them a maximum speed of 30 miles per hour. With the help of Dr. Michael Park as my moped advisor, I attached a 70cc cylinder, a new pipe, a new carburetor and an air filter. It now goes approximately 60 miles per hour, though we're not sure since accurate measurements still need to be verified. The speedometer only goes up to 40 miles per hour.

1 *Malossi PHBG E13 big red foam air filter - angled*

2 *Puch moped 70cc high compression head*

3 *Dellorto PHBG 19mm DS carburetor*

4 *Puch 70cc 45mm reed valve*

5 *Puch proma GRAND PRIX performance pipe*