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

Mechanical Engineering | October 1, 2012 - Present
Open Source Robotics Foundation, Mountain View, CA
• Dynamic modeling of a robot arm and motor selection
• Stress calculations of teeth at differential gear
• Finite Element Analysis
• Python scripting for analysing used range of motion and velocities from recorded PR-2 arm ROSBag datasets
• Cad design of differential wrist

User Experience and Mechanical Prototyping | September 1, 2011 - September 30, 2012
Willow Garage, Menlo Park, CA
• User interviews, ideation, market research and prototyping of robots.
• 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
• Designed ABS and sheet metal frames
• Led team of 3 undergrads for mechanical design and team of 10 for manufacturing of 2 generations of 100 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; Asynchronous Communication 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

267-987-5154 | jimmy.sastra@gmail.com | http://jimmysastra.com

JIMMY SASTRA

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.

SELECTED 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

SELECTED 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

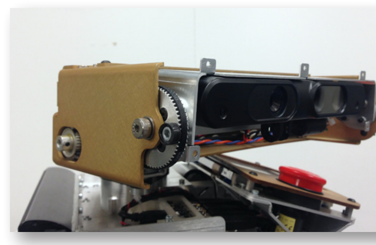
Photography: Part-time events and fashion photographer.
Fine art photography: Group Show at 222 Gallery | Dec, 2008
Theatre: Mechatronics supervisor of a theatre play by Pig Iron Theatre Company consisting of humans and robots | May, 2010
Multicultural: Of Chinese-Indonesian descent; have resided in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

267-987-5154 | jimmy.sastra@gmail.com | http://jimmysastra.com

PRODUCTION LEVEL PROTOTYPES

OBJECTIVE

- **Design differential gear wrist and fore arm enclosure using plastic bevel gears and absolute magnetic encoders**
- **Design pan tilt robotic head with ASUS Xtion Pro sensor**



ROLE

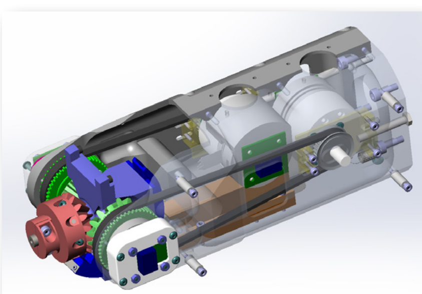
- Mechanical engineer

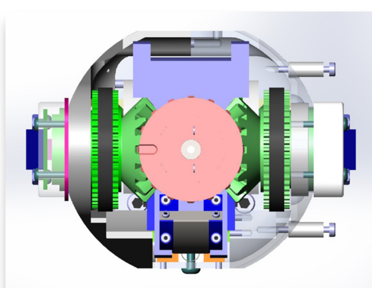
ANALYSIS

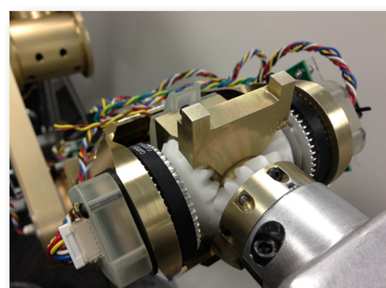
- Finite Element Analysis
- Stress on gear teeth calculations
- End stop forces
- Motor, gearbox, belt sizing and sourcing
- Bearing stackup and tolerance design

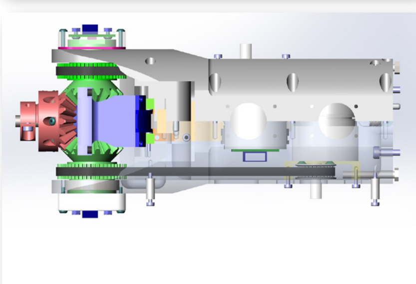
SOLUTION AND OUTCOME

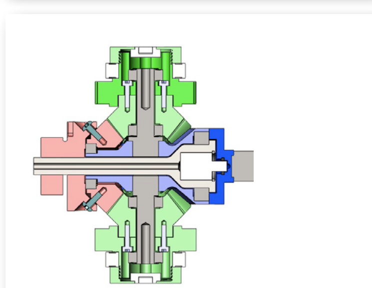
- Acetal gears able to fit within dimensions and force requirements
- Very little backlash
- Design for sheet metal, machining, 3d printing
- Mounted absolute encoders on sun gears which mapped to pitch and roll of the wrist
- External review board with members from NASA, Tesla and DLR gave very favorable reviews of the wrist design

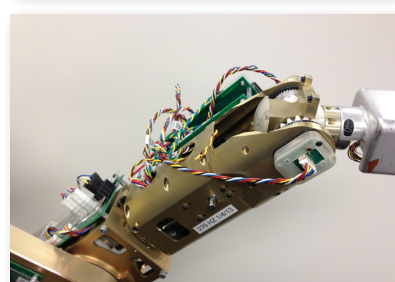












JIMMY SASTRA jimmy.sastra@gmail.com | www.jimmysastra.com

QUICKTURN PROTOTYPES

OBJECTIVE

- **Turn over physical proof of concepts in days/weeks**

ROLE

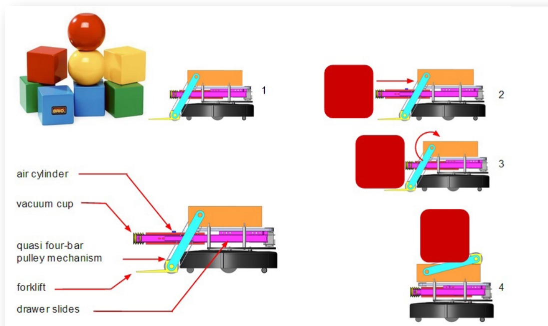
- Mechanical engineer
- Robot integrator

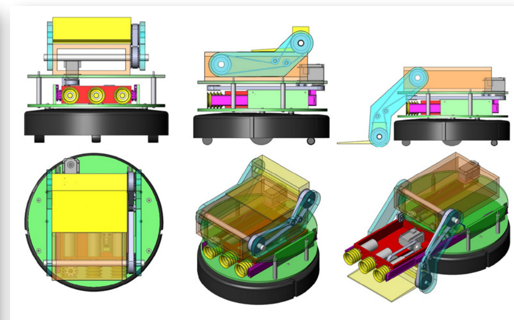
SOLUTION AND OUTCOME

- Lasercutting, 3D printing, CNC machining, machining by hand
- EE/SW Integration
- Used ROS for autonomous demos
- I've built tens of prototypes like these. Only a selected few are shown here.

Tidy toys

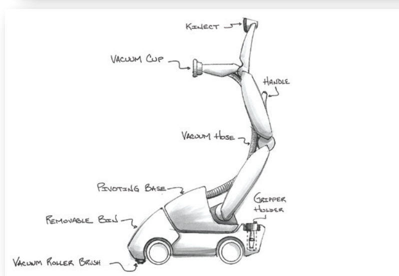
- 3DOF mechanism to pick up objects
- transport objects within robot's base footprint
- suction cup actuated by custom air cylinder
- using belt design for four bar mechanism avoids singularity





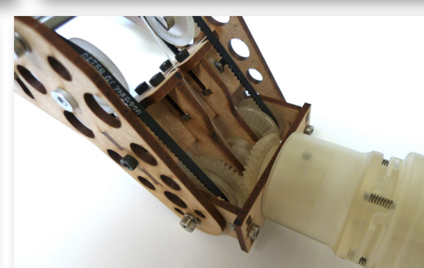
Tidy vacuum

- robotic vacuum cleaner and manipulator with suction cup
- programmed demo to autonomously pick up objects using Hokuyo laser scanner



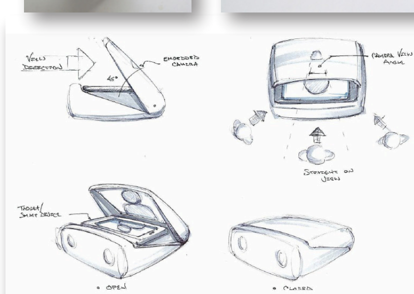
Fore arm and wrist

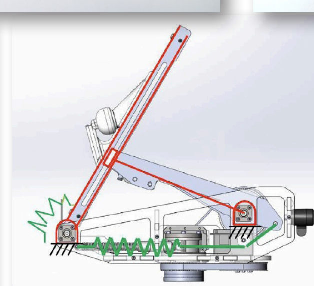
- dual pulley inside differential wrist to transfer actuation for tendon to actuate gripper
- belt mechanism actuates wrist allowing motors to be placed high up on forearm

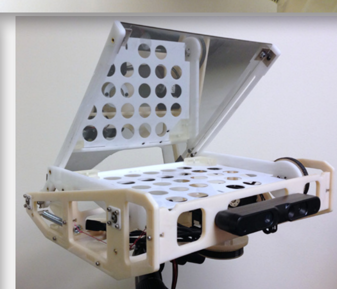


Remote presence head

- fixes eye gaze problem by mounting camera behind transparent mirror while video conferencing
- crank slider mechanism allows for compact design
- gravity compensation of mechanism using zero length spring







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DESIGN OF CKBOT: A MODULAR ROBOT

OBJECTIVE

- **Design a Modular Robot as a hardware research platform for Upenn's GRASP lab**

ROLE

- Principal Engineer

MODULAR ROBOTS

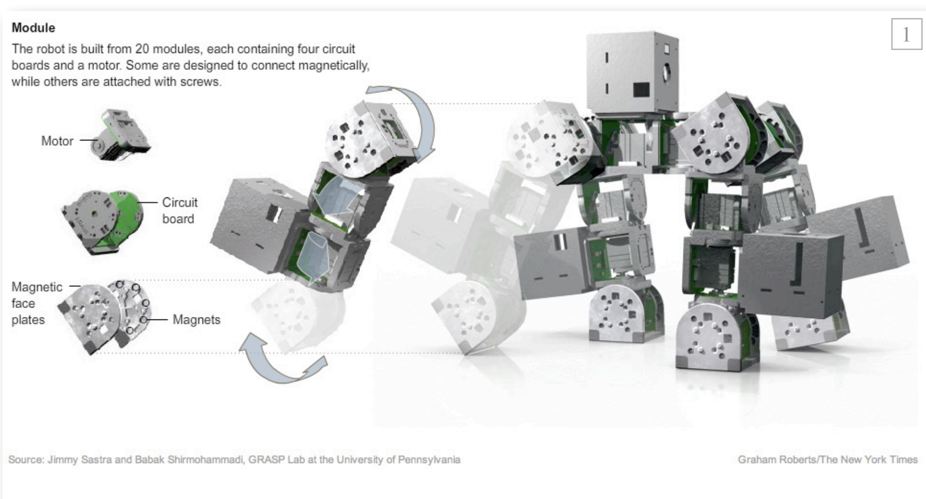
- Identical modules that can be put together to from a bigger robot.
- Traditional robots are designed with a singular task in mind. A system of modules can be put together in different ways to achieve many different tasks.

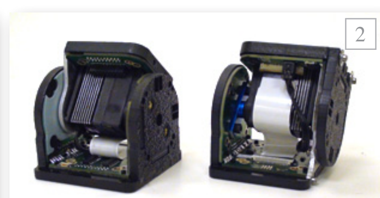
THREE PROMISES

- Versatile: configurations allow different morphologies
- Robust: due to redundant degrees of freedom
- Inexpensive: through economies of scale.

SOLUTION AND OUTCOME

- Principal engineer behind electronics
- Principal engineer behind the core Python software that runs on the host (laptop)
- Principal engineer on embedded code on the modules.
- Lead on average two masters students for the mechanical design and a team of undergraduates for the final manufacturing.
- Manufactured around 300 modules; 5 design iterations over 5 years





1 *CKBot in quadruped configuration;* 2 *3/4 view of CKBot modules;* 3 *a cluster of 5 connected CKBot modules*

CKBOT ELECTRONICS

SUMMARY

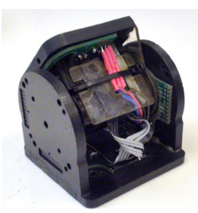
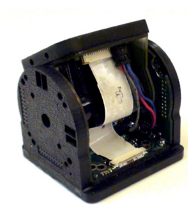
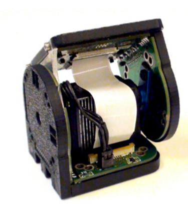
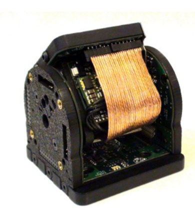
5 design iterations.
Backwards compatible up until version 5
Each face has PCB with electrical connections for CANBus communication and power, 4 mounting holes

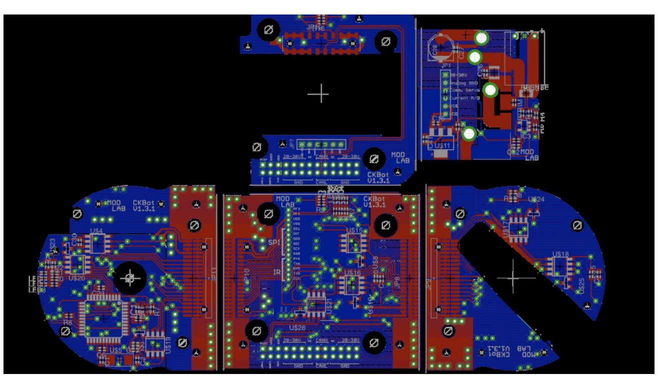
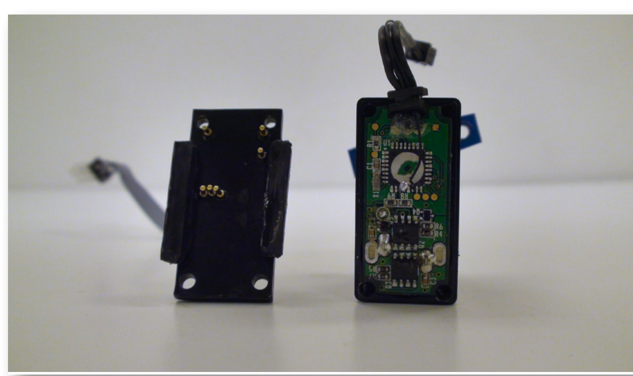
VERSIONS

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
V2.0: Sheet metal design with ModLock manual quick change mechanism

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

OBJECTIVE AND ROLE

- **Communication using Controller Area Network (CAN) between modules**
- **Develop core client software of CKBot which implements the asynchronous Robotics Bus protocol**
- **Maintain the embedded software that runs on the modules.**

OUTCOME

- Takes advantage of the multiple processors in a cluster of modules
- Provides a nice command line and programmatic interface to the CKBot modules for querying unknown modules about its dictionary entrees to see discover capabilities
- Setter and getter methods can be generated dynamically during runtime
- 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

```
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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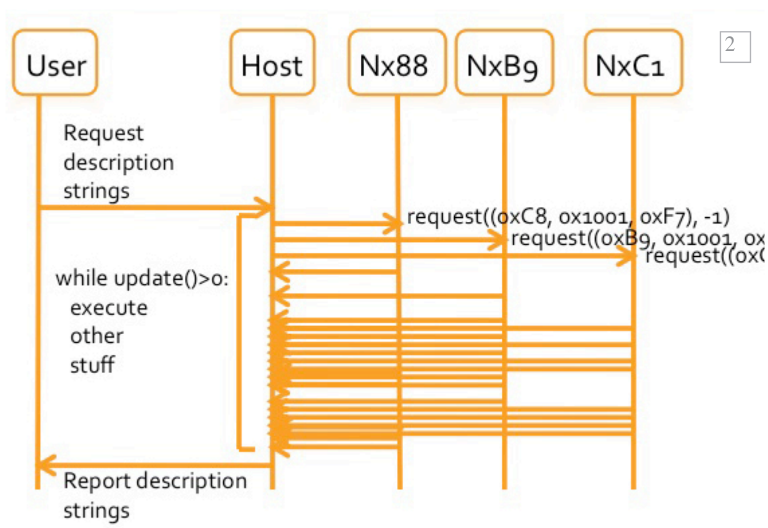

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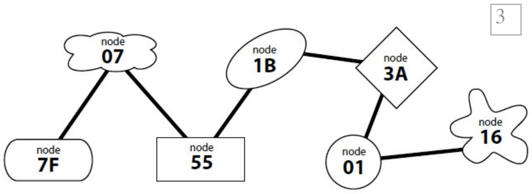

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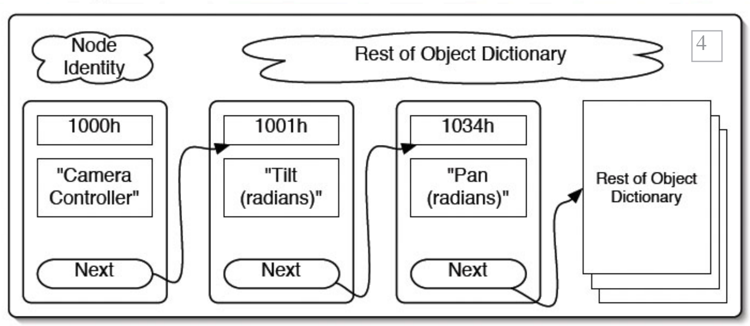

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1 Command line interactive interface example; 2 In an asynchronous protocol the user can put in non blocking requests for dictionary objects. The update() method returns number of outstanding requests. Once update() returns 0, all dictionary objects 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 browseable Object Dictionary.

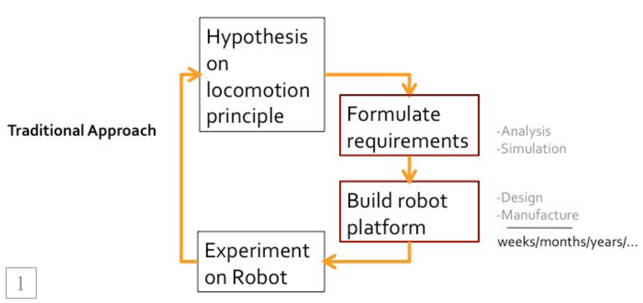
DYNAMIC LOCOMOTION WITH MODULAR ROBOTS

THESIS

- **Modular robots as a tool to shorten the dynamic locomotion research cycle by taking out the build process and replace it with a reconfigure process**

OUTCOME

- Built CKBot modules that are fast enough to perform dynamic locomotion
- Showed rapid implementation of many dynamic gaits in a short amount of time: hours/days/weeks
- In depth dynamic analysis of a dynamic rolling gait
- In depth dynamic analysis of a dynamic hexapod gait
- Still hold speed record as fastest modular robot



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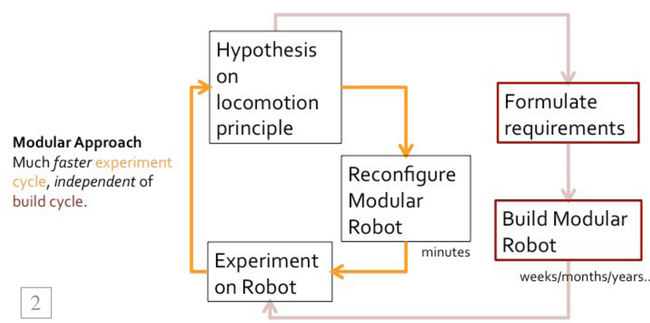

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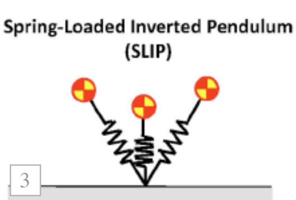

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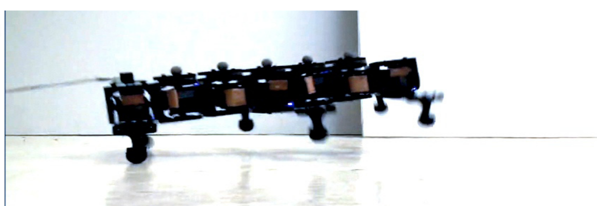

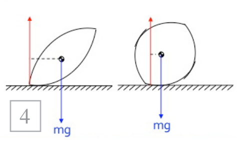

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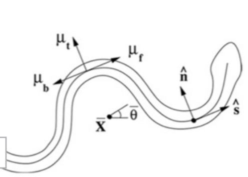

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1 *Research workflow using traditional robots with a fixed shape.*

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*

OBJECTIVE

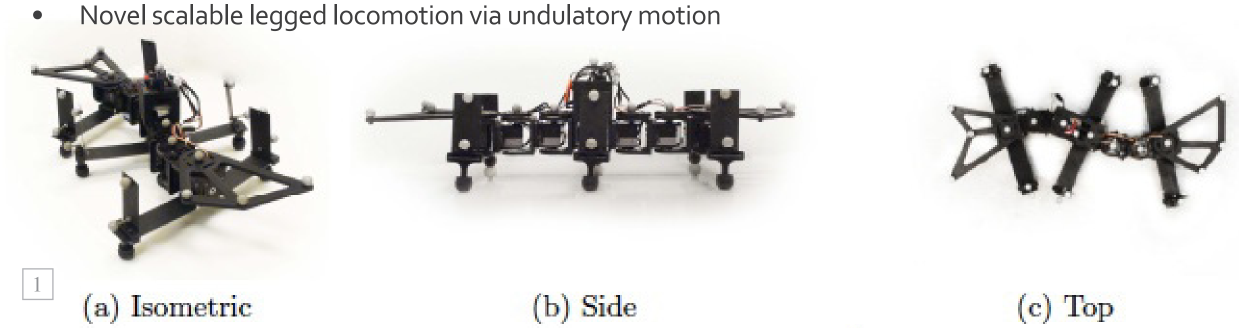
- **Develop and analyze a compliant six legged running gait**

ROLE

- Designed hardware -- tuned relative leg stiffness to what is found in animals
- Implemented double Buehler clock controllers and Neldermead gait optimization
- Analyed large data set, using Phaser algorithm and Fourier Series to average data and represent a typical model signal to plot ZMP and COM motion

OUTCOME

- First to show a physical instantiation of a robot exhibiting LLS like dynamics
- Novel scalable legged locomotion via undulatory motion



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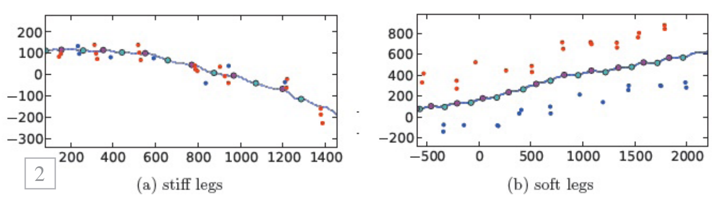

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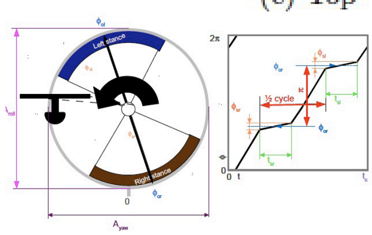

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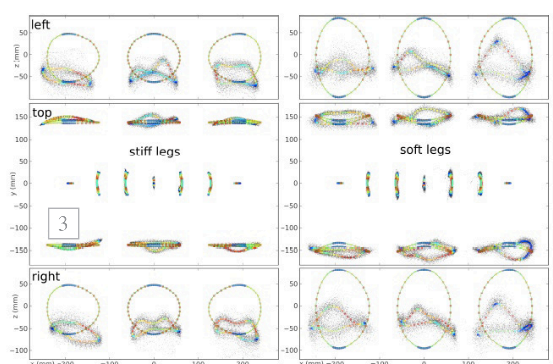

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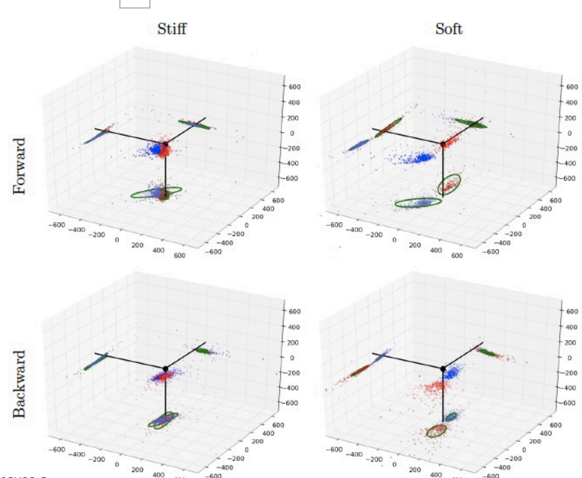

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1 *Compliant hexapod configuration*

2 *Center of Mass (COM) and Zero Moment Point (ZMP) in world frame*

3 *Buehler clock controller with two slow phases*

4 *Leg and body marker trajectores in robot frame obtained with Vicon MoCap system*

5 *COM and ZMP in robot frame from analyzed Vicon marker dataset*

SELF REASSEMBLY AFTER EXPLOSION

OBJECTIVE

- **Develop a robot that can put itself back together again after being kicked apart**

ROLE

- Develop higher level control and distributed algorithm that docks the clusters into the final assemly
- Develop hierarchical communication protocol
    - Localization data from the smart cameras
    - CAN communication within a cluster
    - Local infra red communication between clusters.

TEAM

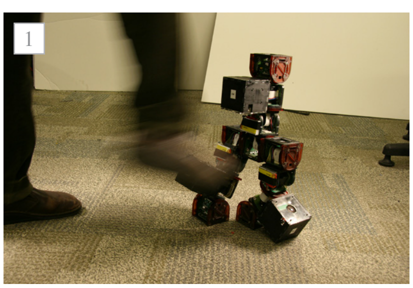
Dr. Mark Yim, Mechanical Engineerng
Dr. CJ Taylor, Computer Science Engineering
Babak Shirmohammadi , Computer Science Engineering PhD candidate
Chris Thorne, Mechanical Engineering PhD candidate
Michael Park, Mechanical Engineering PhD candidate

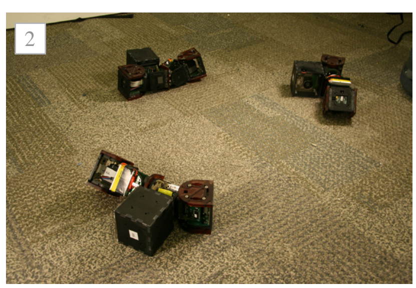
OUTCOME

- Viral video with over 1 million YouTube hits
- Half page spread in New York Times

PRESS

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





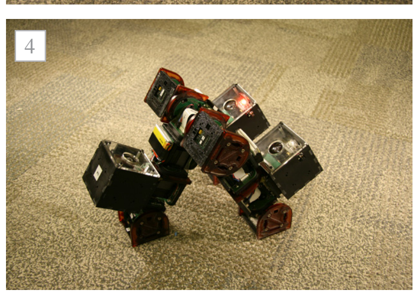
1 kick to mid-section

2 resulting in three clusters of modules strewn randomly

3 clusters self-right and dock

4 assembly stands up

5 assembly resumes walking again



PLANETARY CONTINGENCY COMPETITION

OBJECTIVE

- **Hold competition which explores effectiveness of Modular Robots as a tool for developing robots and solving robotic tasks quickly**

ROLE

- Design and manufacture of 100 modules for each competition
- Lead the operations of the competition.

COMPETITION DESCRIPTION

- The Planetary Challenge simulates a emergency situation at a space station on mars.
- Teams pack a suitcase a priori
- Once arrived they are given the task (e.g. repair a antenna) to solve using only what they have packed in their suitcase.
- Held twice at ICRA. Teams from Univ. of Southern Denmark, MIT, USC, University of Washington, Harvard and Willow Garage
- My lab has supplied the modules for the teams with the exception of the Univ. of Southern Denmark team who brought their own hardware.

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

OBJECTIVE

- **Develop quick change end-effector for PR2**

ROLE

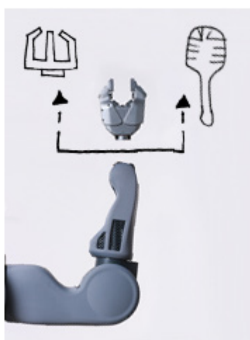
- Mechanical and electrical engineer

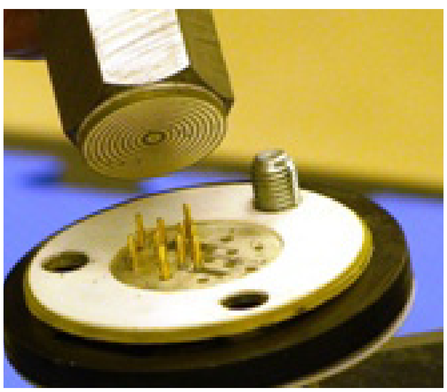
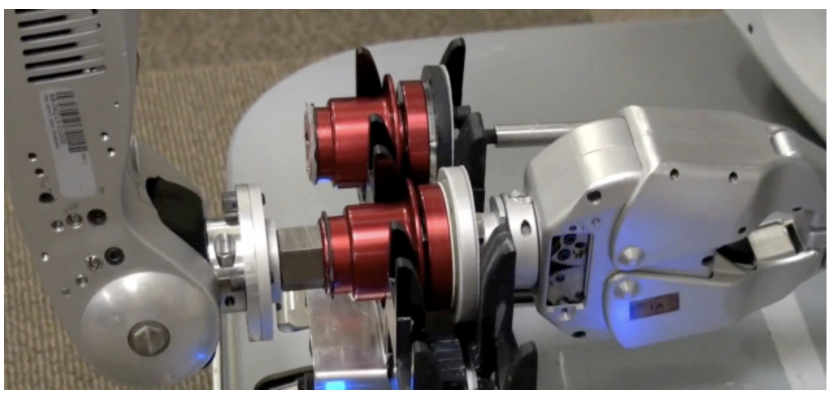
SOLUTION

- 10 concentric copper rings and pogo pins transfer power and ethercat communication
- Quick release (shown in red) attaches to a metal stub.
- The stub connects to the arm of PR2
- Quick release mechanism attaches to the different tools on the holster

TEAM

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

THE ROBOT ETUDES

OBJECTIVE

- **Set up a play with robot and human actors**

ROLE

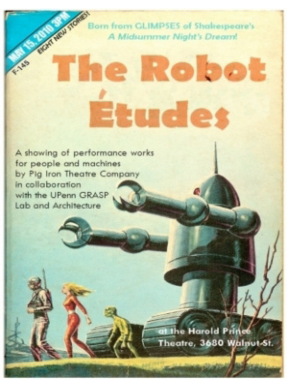
- Student then teaching assistant, and eventually special billing as "mechatronic supervisor".

OUTCOME

- A series of performance etudes of Shakespeare's Midsummer Night's Dream.
- Annenberg theatre with 211 seats 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.



JIMMY SASTRA jimmy.sastra@gmail.com | www.jimmysastra.com

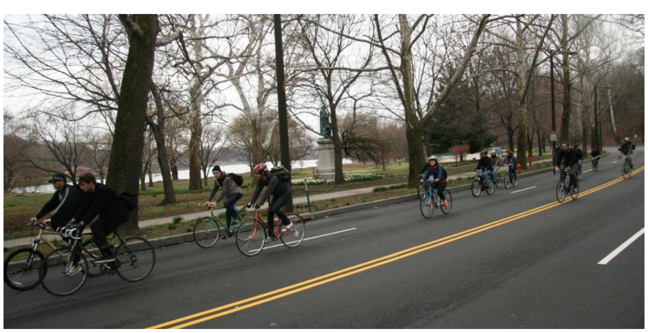
XPLR-CLUB - PHOTOGRAPHY/BIKING CLUB

OBJECTIVE
- **Start a photography+biking club.**

ROLE
- Founder

OUTCOME
- 50 members, 2 gallery shows, 104 bike rides, ~700 miles.
- Pictures shared using Flickr.

WEBSITE
http://xplr-club.com



RESTORE VINTAGE MOPED

OBJECTIVE

- **Restore a 1970s Puch moped**

OUTCOME

- Attached a 70cc cylinder, a new pipe, a new carburetor and an air filter.
- New speed: 60 miles per hour (this is a guesstimate since the speedometer only goes up to 40 miles per hour). Mopeds are generally limited by law to a engine displacement of 50cc giving them a maximum speed of 35 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*