Self-reconfigurable Modular Robots

- MODBOT -

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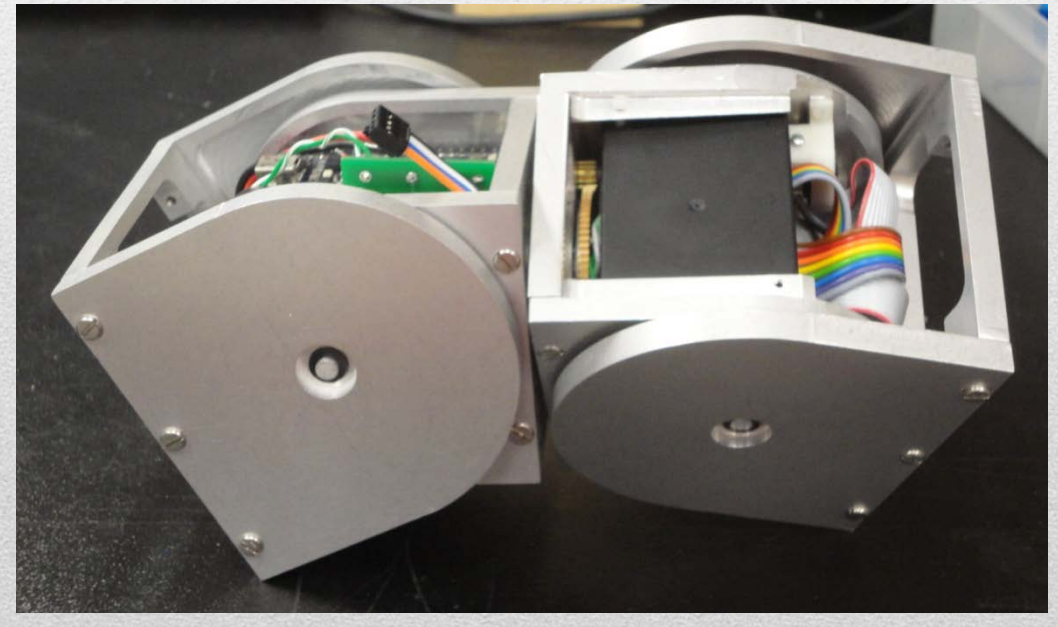
Outline

- Project statement
- Prior Art
- Design
  - Housing
  - Connection Mechanisms
  - Electronics
- Control Strategy & Programming
- Project Accomplishments

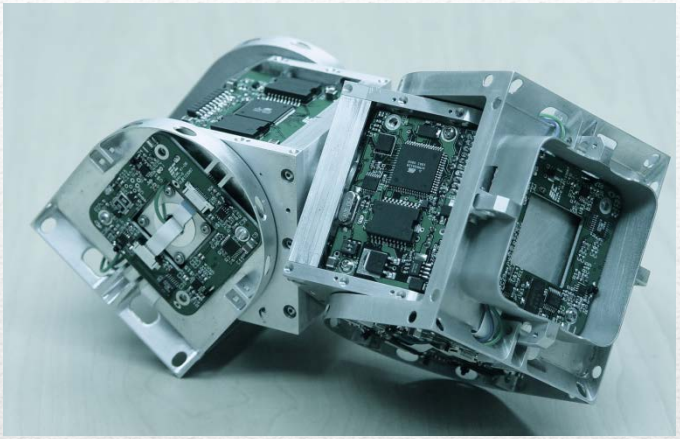
Project Statement

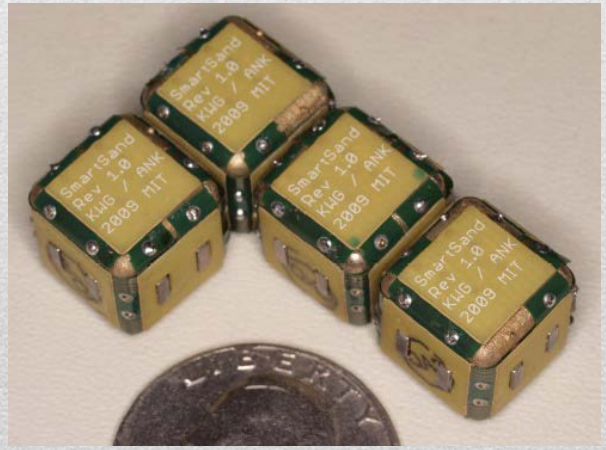
- Design and build a self-reconfigurable modular robot
  - Moves Independently
  - Able to connect to other modules
  - Able to move as a complete system
  - Able to reconfigure system shape

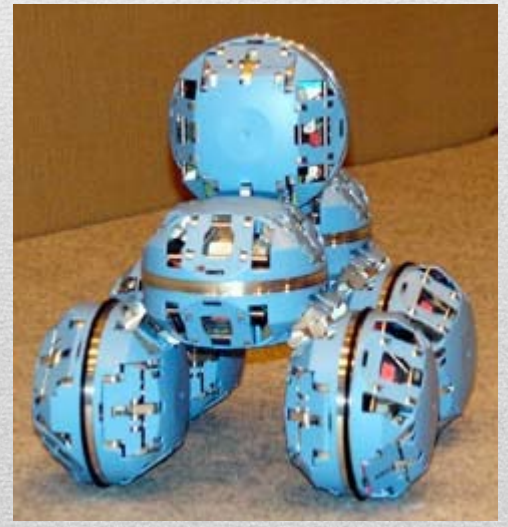


Prior Art

- M-Tran (AIST)
- Superbot (USC)
- Imobot (UCDavis)
- Atron (USD)
- Miche (MIT)
- Pebbles (MIT)
- CK Bot (UPenn)



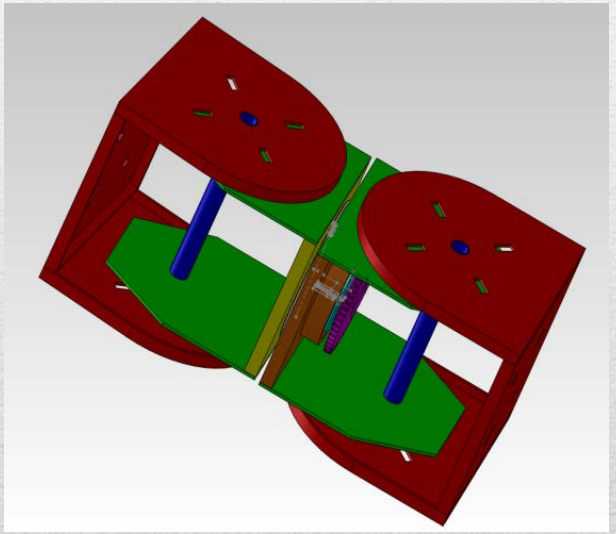




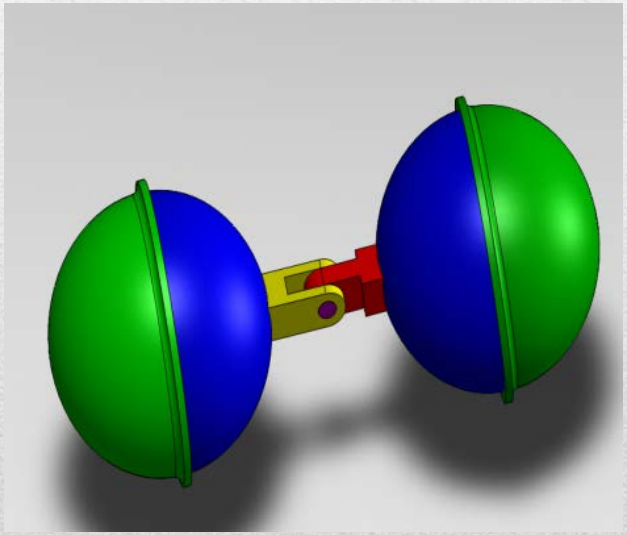
(CW from top): http://www.isi.edu/robots/superbot/SuperbotModule.JPG; http://ployer.com/archives/atron2.jpg; http://www.hizook.com/files/users/3/Programmable_Matter_Robot_Pebbles_Electropermane

Housing Design

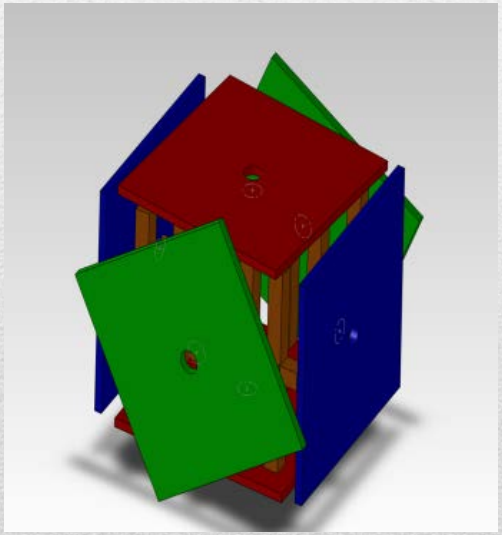
- Initial design concepts



Super-Tran



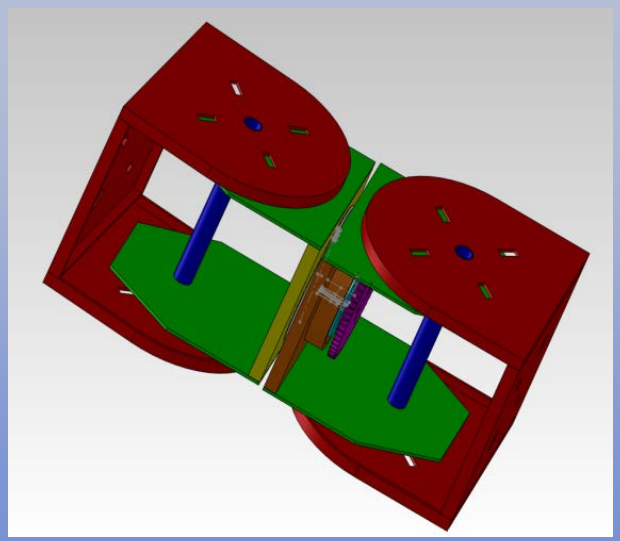
AM-Tran



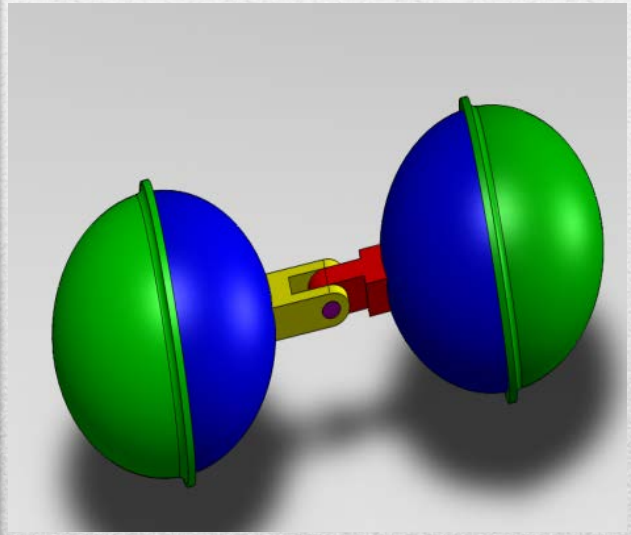
Spaceframe

Housing Design

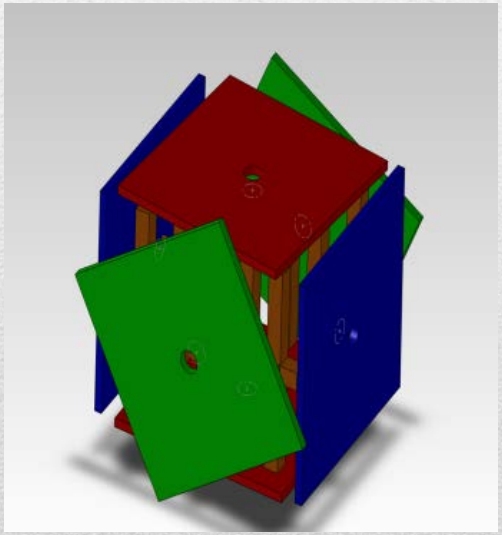
- Through a set of design metrics chose one design



Super-Tran



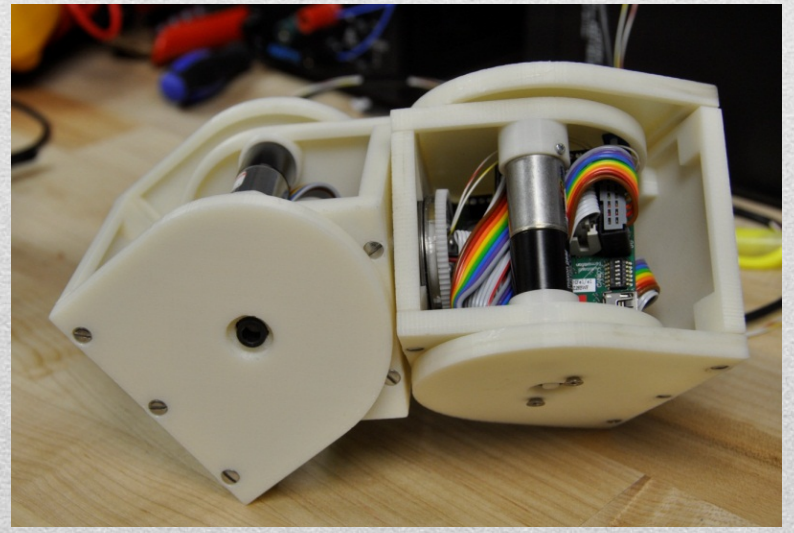
AM-Tran



Spaceframe

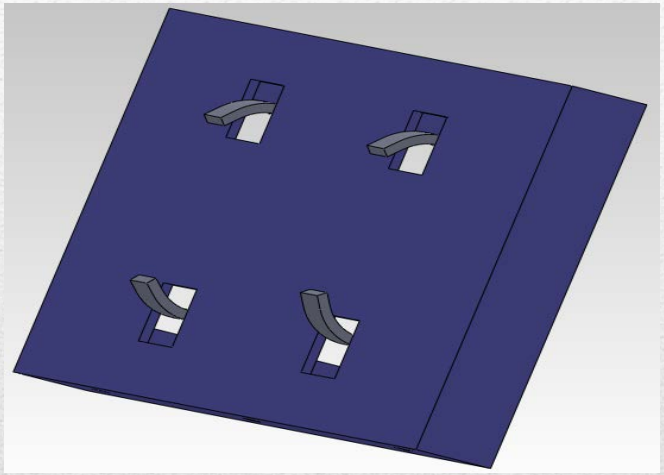
Prototypes

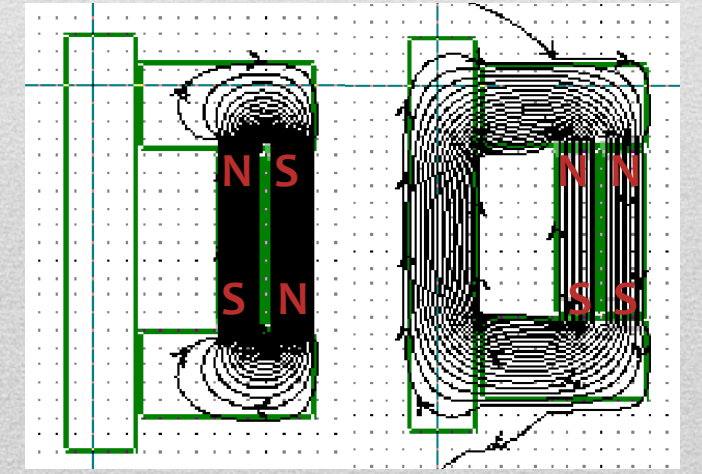
- Laser-cut Module
  - Physical representation
  - Motion & basic gaits
- 3D printed Module
  - Full functionality & component integration
  - Limited space awareness



Connection Mechanism

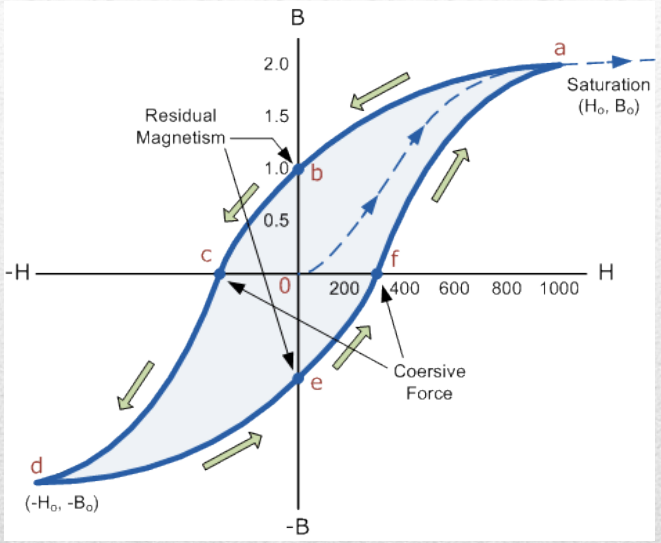
- Mechanical Connector
- Switchable Magnet Connector
  - Two permanent magnets in parallel
  - Swap poles of one magnet
    - Mechanically
    - Electrically
  - Negates the external magnetic field

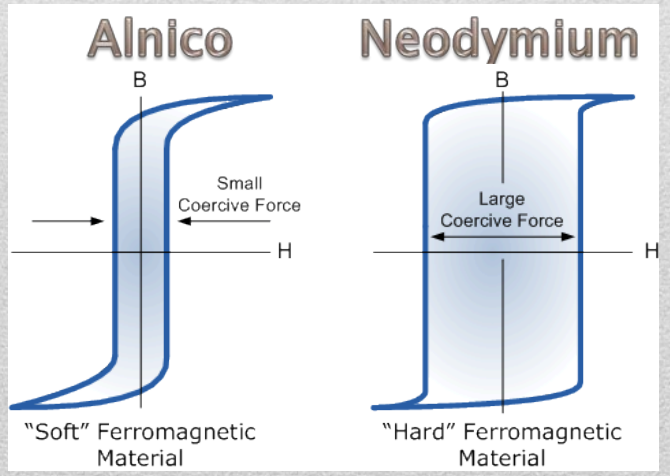




Electrically Switchable Magnet

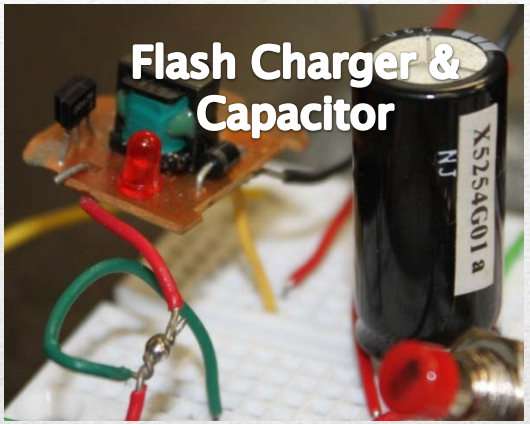
- Generate a magnetic field large enough to swap poles of the "softer" magnet
  - Wire coiled around the magnet
  - High current pulse induces a large magnetic field

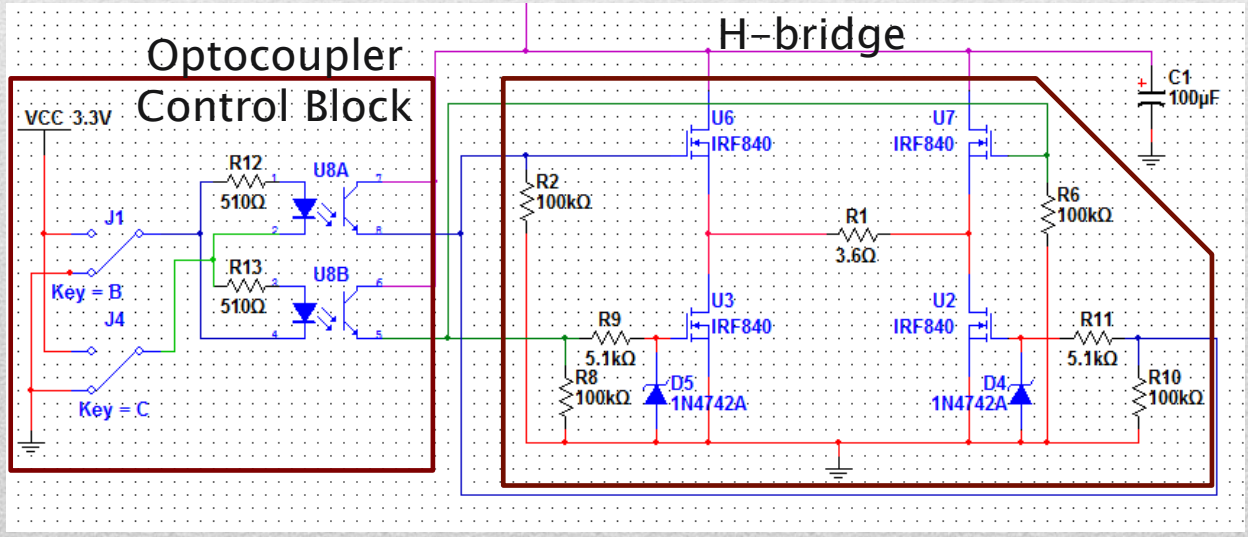




ESM: Circuit and Prototype

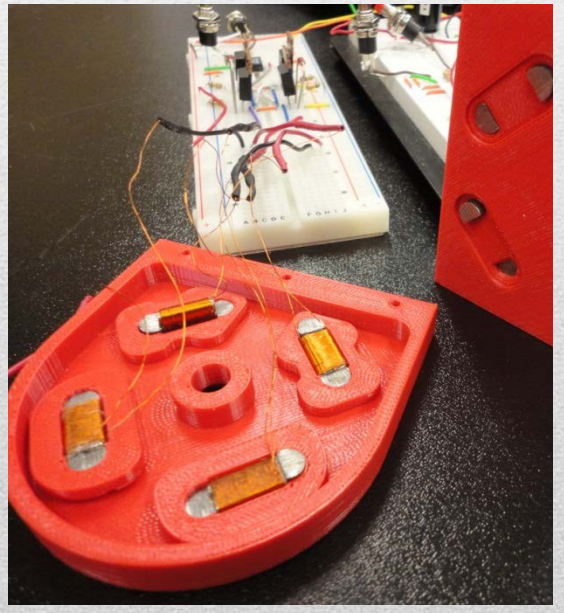
- Transformer circuit to charge a capacitor
- H-bridge configuration to control current direction
- Optocoupler to isolate control components

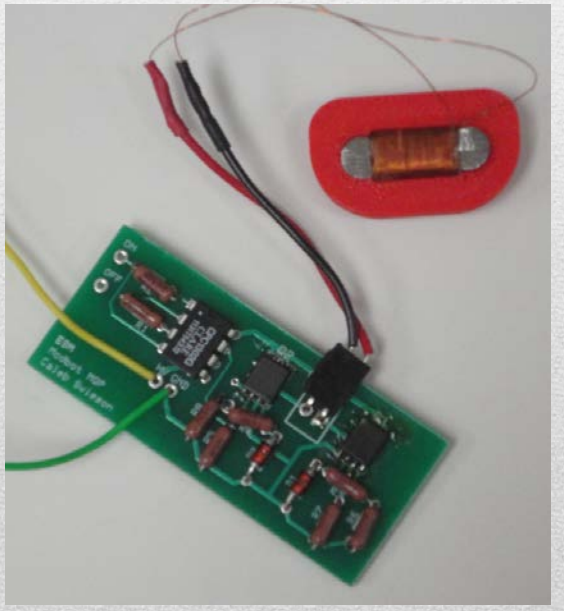




ESM: Final Product

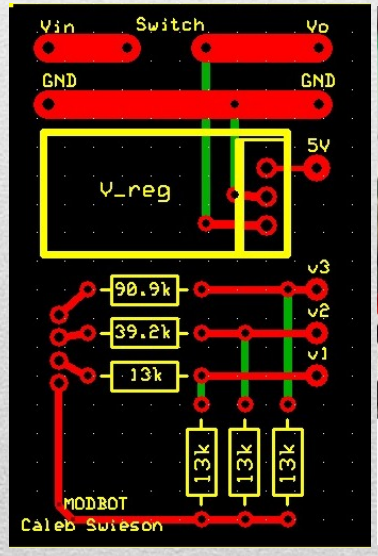
- 3D printed connection mechanism faces
- PCB board printed for switching circuit

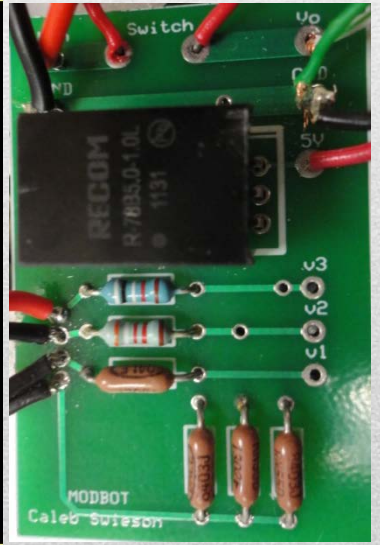


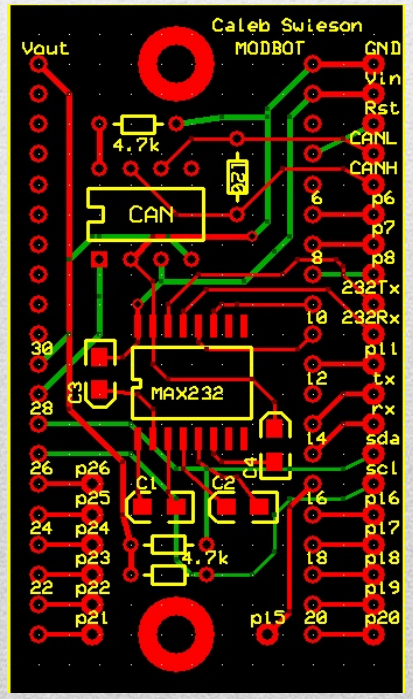


Electronics

- Power & power management
- Microcontroller communication & breakout board
- Sensors

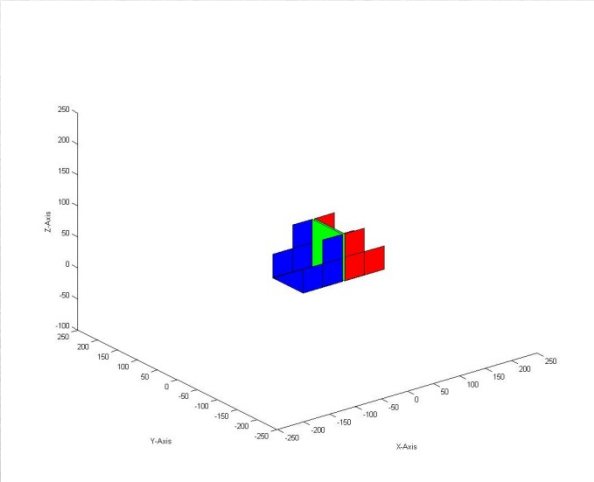


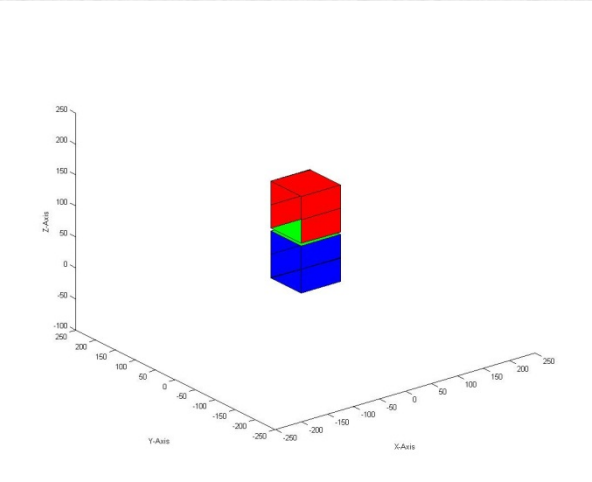


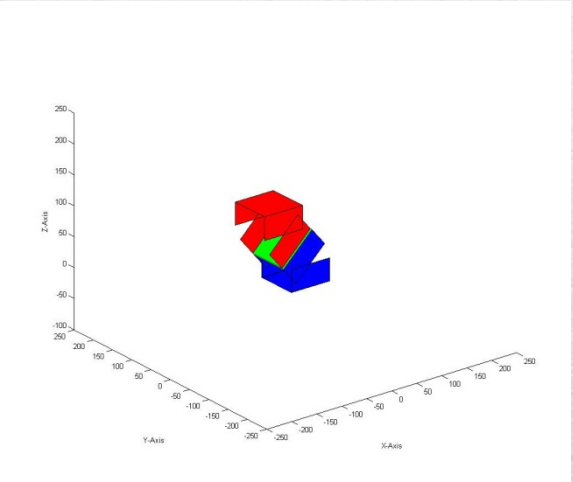


Simulation

- Single module gaits simulated using Matlab



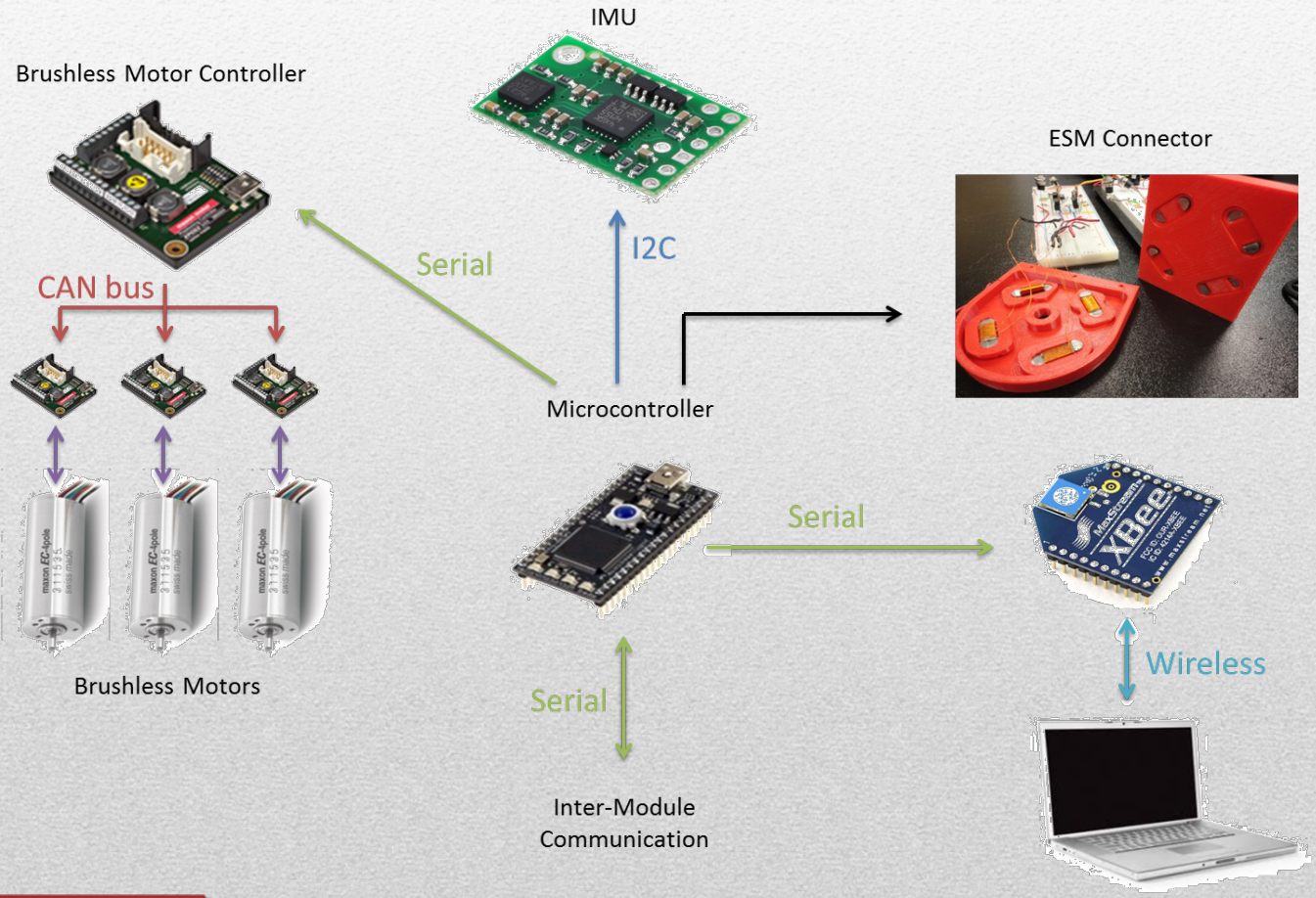




Program Structure

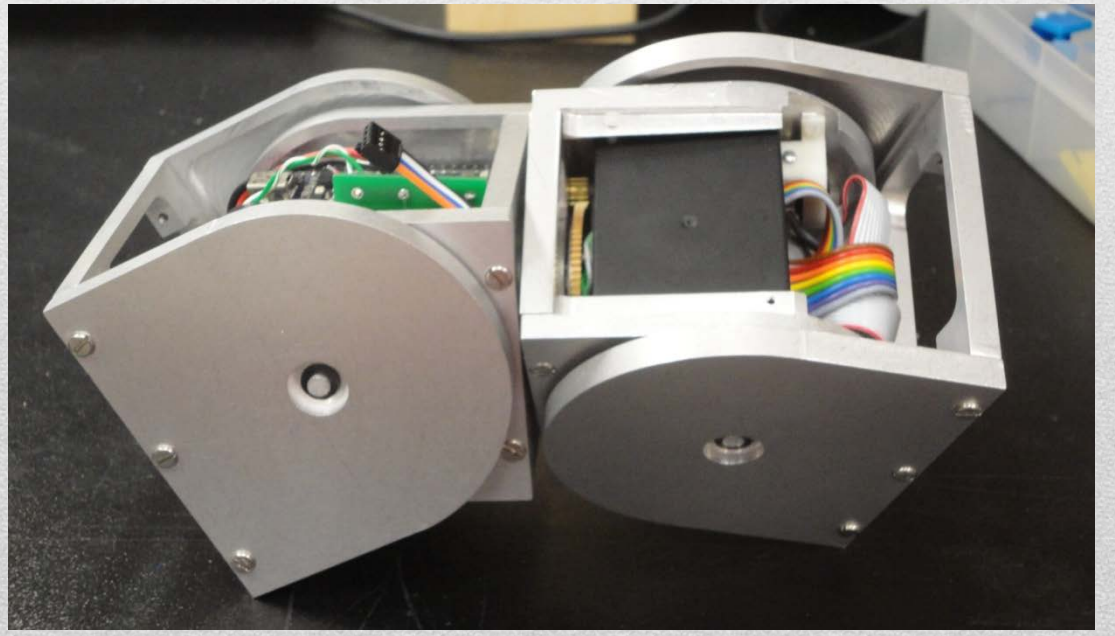
- Object oriented Software design
  - C++
  - Allows for the creation and destruction of instances of objects
  - Easy to add new motors or entire modules
  - Intuitive access to motor controller properties
  - Easier system configuration (control of separate module properties as part of an entire system)

Control Diagram



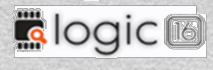
Project Accomplishments

- Realized module
- Integrated electronics
- Individual module movement
- Viable connection mechanism

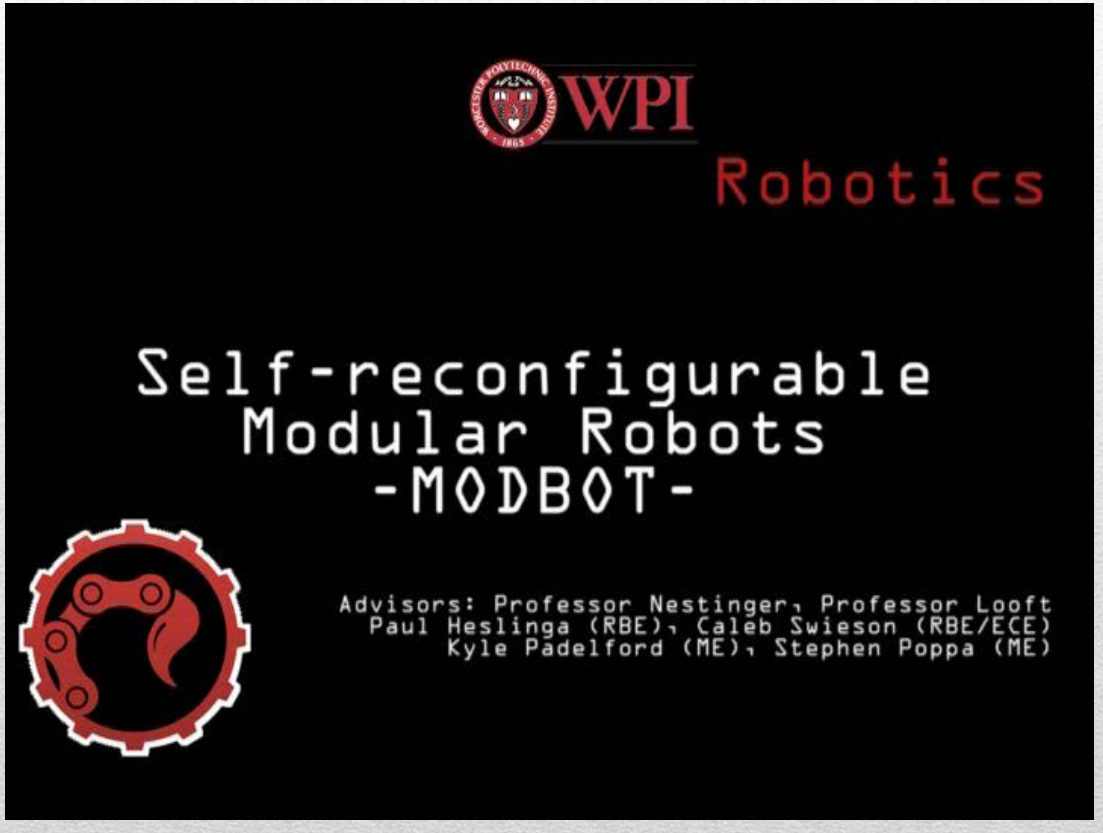


Acknowledgements

- Professor Nestinger
- Professor Looft
- Dave Ephraim
- Torbjorn Bergstrom
- Adam Sears
- James Loiselle
- Maxon Motor Company
- Saleae Logic
- NXP Mbed
- SDP/SI



Video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Questions?