High-level perception and control for autonomous reconfigurable modular robots

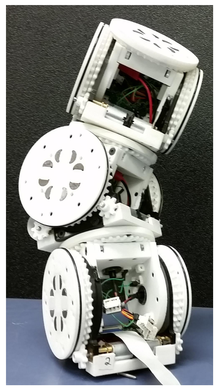
PIs: Hadas Kress-Gazit (Cornell), Mark Campbell (Cornell), Mark Yim (UPenn)
Students: Jonathan Daudelin, Gangyuan Jing, Daniel Lee, Chao Liu, Tarik Tosun

Objective

Develop the theory, hardware and computational infrastructure that will enable **automatically transforming user-defined, high-level tasks into correct, low-level perception informed control and configurations for modular robots**

Approach

- Library of controllers for perception and motion
- Hardware constrained perception
- Component composition to create complex components
- Temporal composition to create high-level behaviors
- Synthesis for provably correct behavior

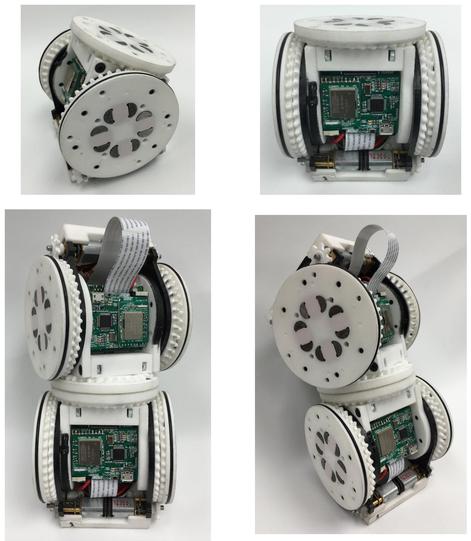


Hardware (SMORES V2 modules)

The design of this module is capable of rearranging its modules in all three classes of reconfiguration: lattice style, chain style and module reconfiguration.

Highlights:

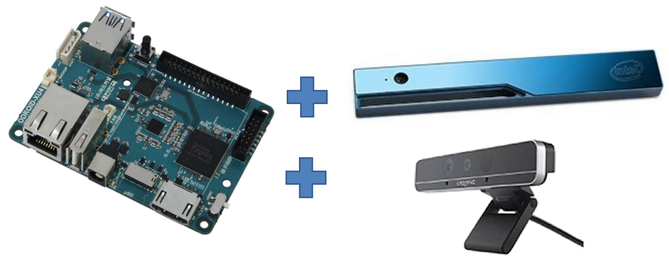
- 3D-Printed mechanical parts
- 4 degree of freedom per module
- Modules can drive like a car
- 802.11 Wi-Fi communication
- 30 modules to be manufactured
- Electro-Permanent magnets used for latching
- Serial communication through magnets for cluster self-discovery



Hardware (sensor/brain module, passive pieces)

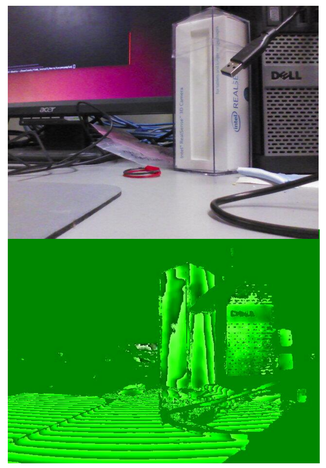
Sensor/Brain Module

- Intel REALSENSE sensors
- ODROID CPU w/Linux
- Enable the modules to sense the environment
- Double SMORES V2 form factor – attachable to SMORES modules



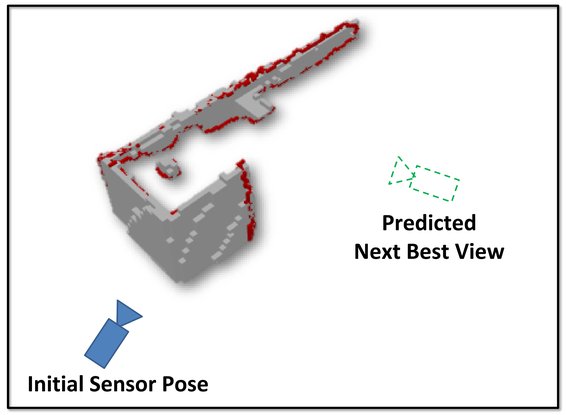
Passive Pieces

- Specialized modules for focused tasks (minimal)
- Examples:
  Lightweight arm extenders
  Grippers
  Strengtheners

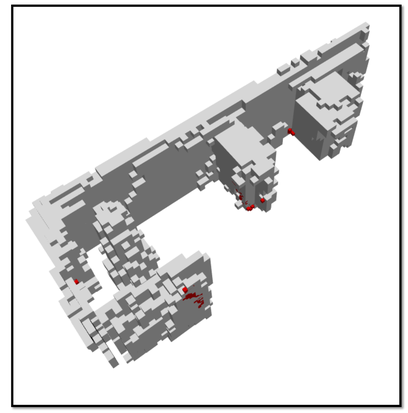


Hardware constrained perception

Probabilistic, Data-Driven Next Best View Planning



Initial partial representation of unknown object



Representation of unknown object after measurement from Next Best View

- Subject to hardware constraints, intelligently plan motion/reconfiguration to obtain information about the environment (such as shape estimation of an unknown 3D object).
- Use this information to inform planning for completion of high-level tasks.