Self-Transforming Robotic Planetary Explorers

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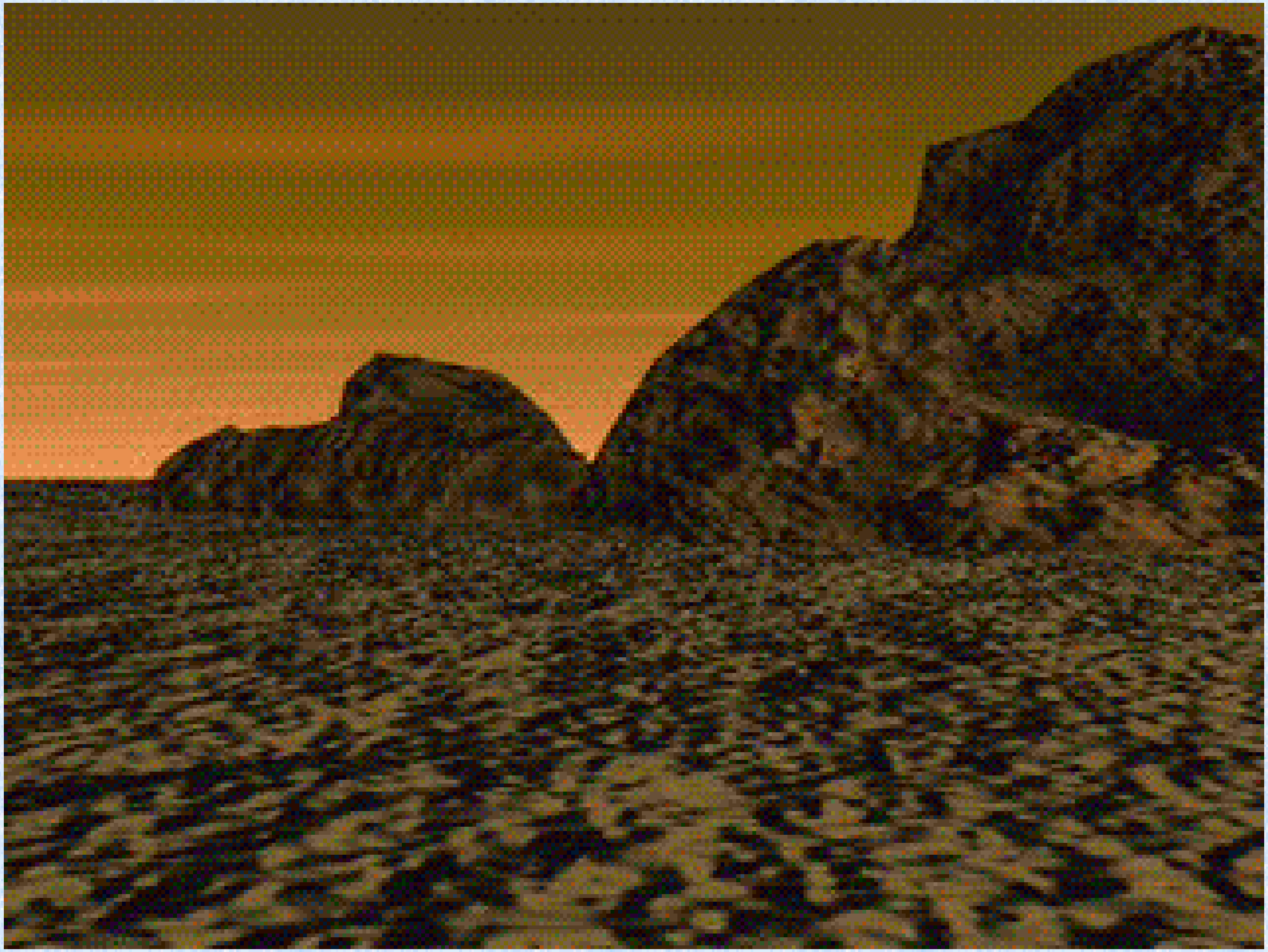
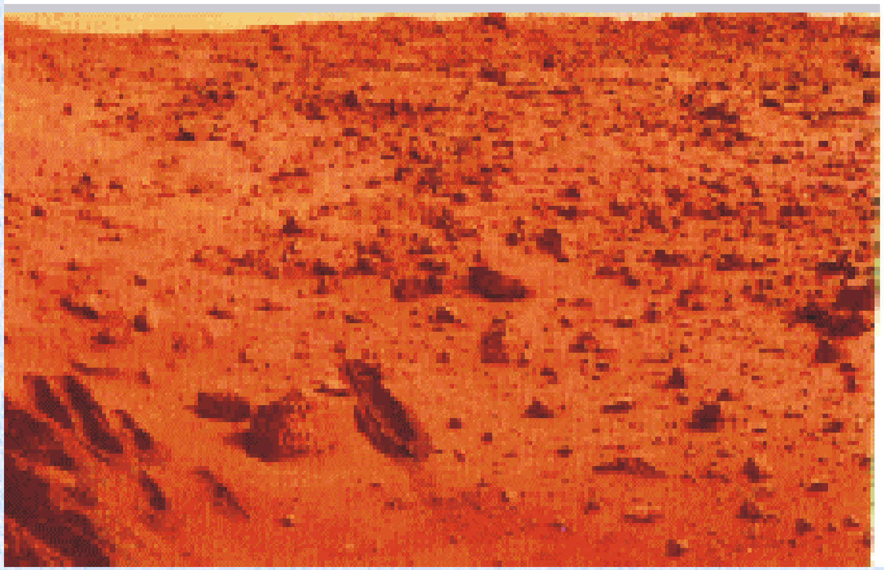
The Ultimate Space Exploring Robot

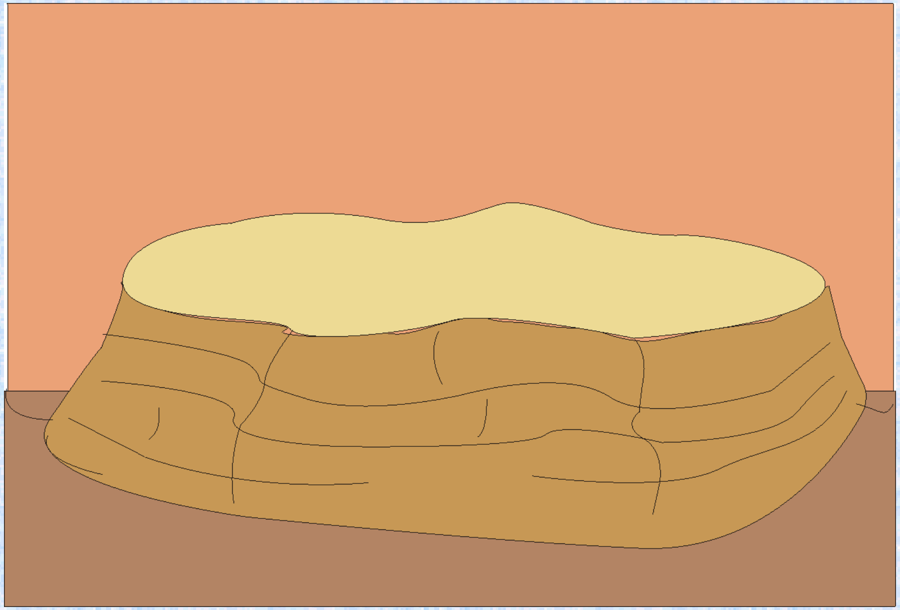
Surface of Generalized Planet





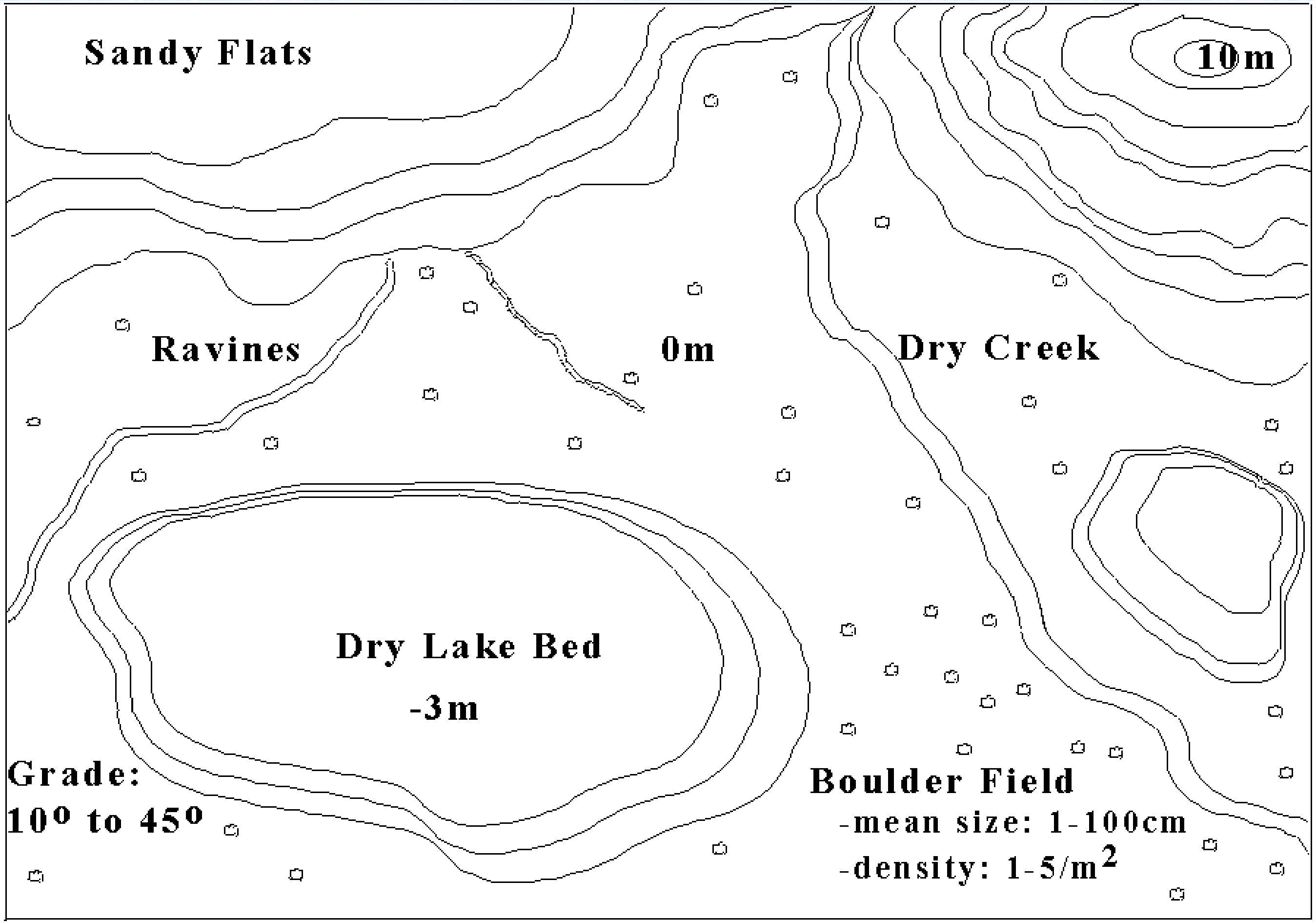
Traversing Varying Terrain Obstacles

Climbing Steep Cliff Faces

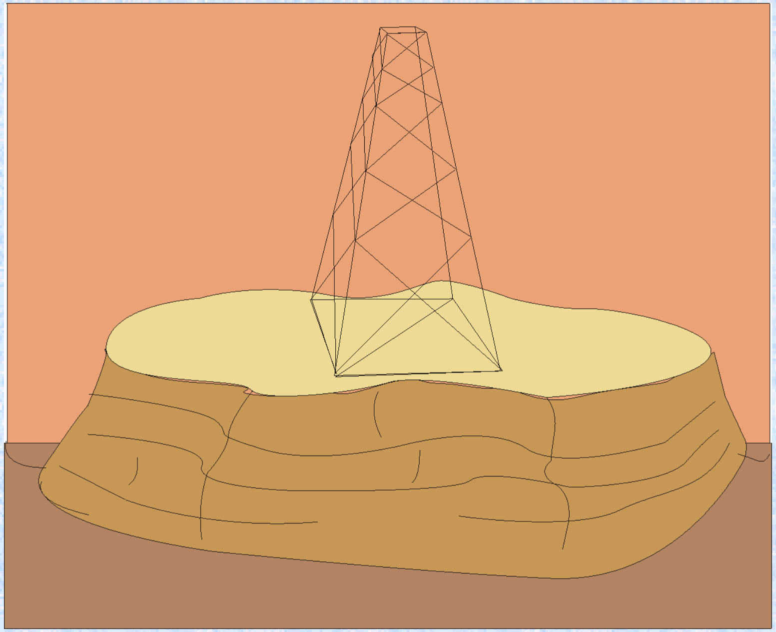


Future Planetary Exploration Mission

Mars 2010 and Beyond

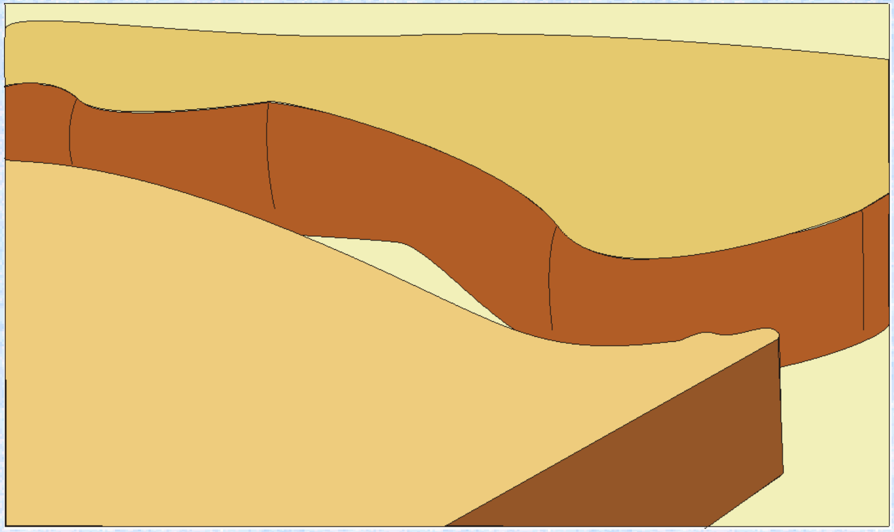


Martian terrain Map



Assembling Structures

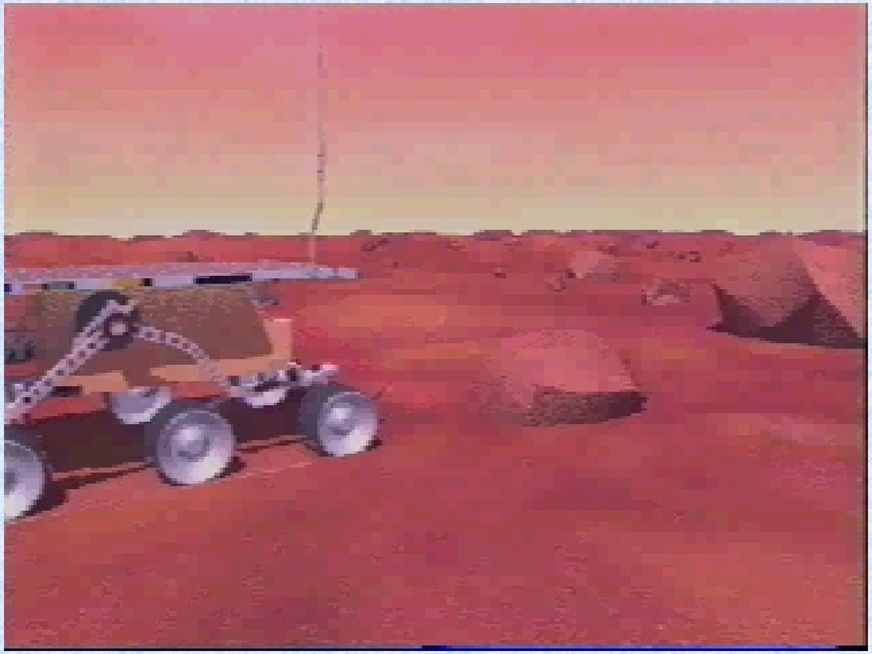
Fuel Extraction as a Precursor to HEDS



Crossing Wide Ravines and Canyons

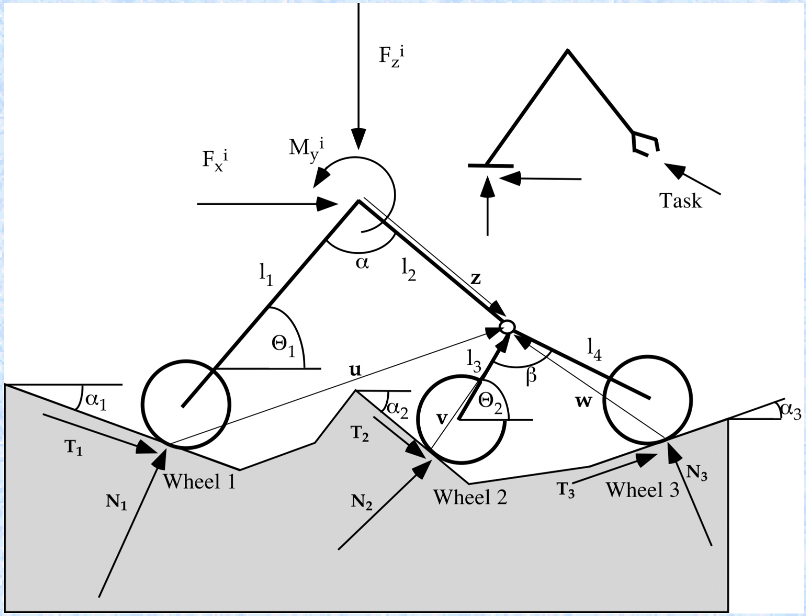
Current Rover Limitations (2000 c.e.)

- Obstacles of 2x wheel diameter
- Gap crossing of 1/2x wheel diameter
- “Cliff” climbing of 2x wheel diameter
- No assembly capabilities



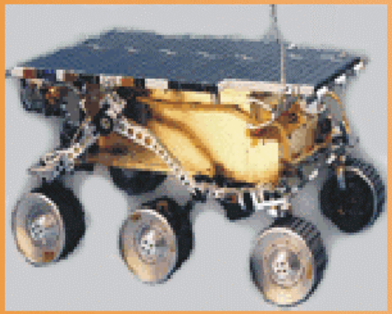
Rough Terrain Control

- In rough terrain, maximize traction
- The rover has two degrees of redundancy
  - We can "choose" wheel torques to optimize a metric, such as:
    - Traction
    - Power Consumption. . .
- We must also consider physical constraints
  - Actuator saturation
  - Tire/ground normal forces must be positive



Progression of Self-Transforming Planetary Explorers

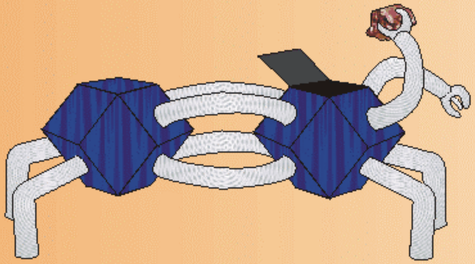
2000



ROVERS

Discrete Components

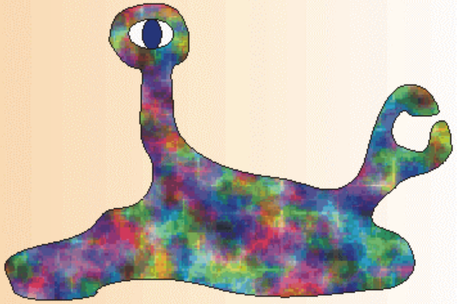
2010



STX

Hybrid System

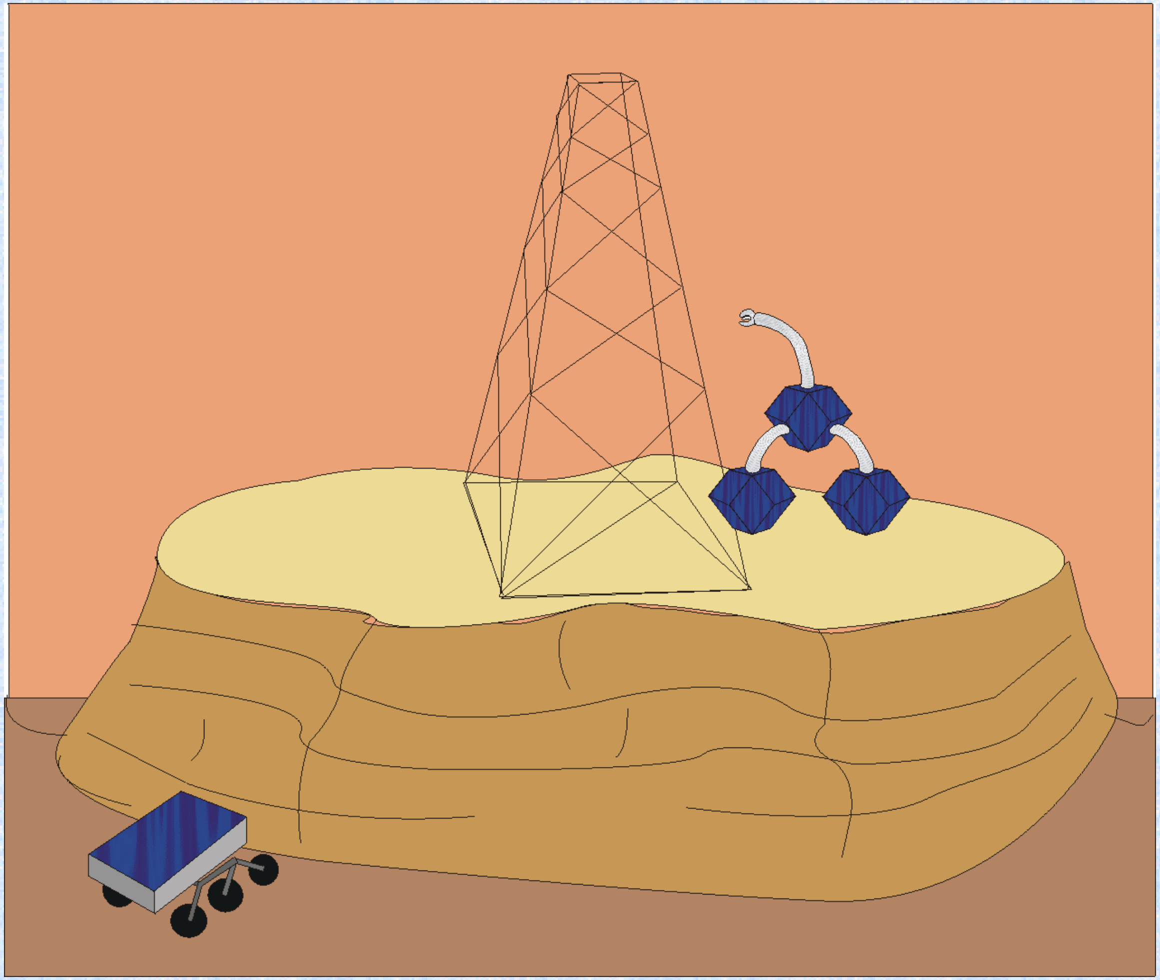
2040



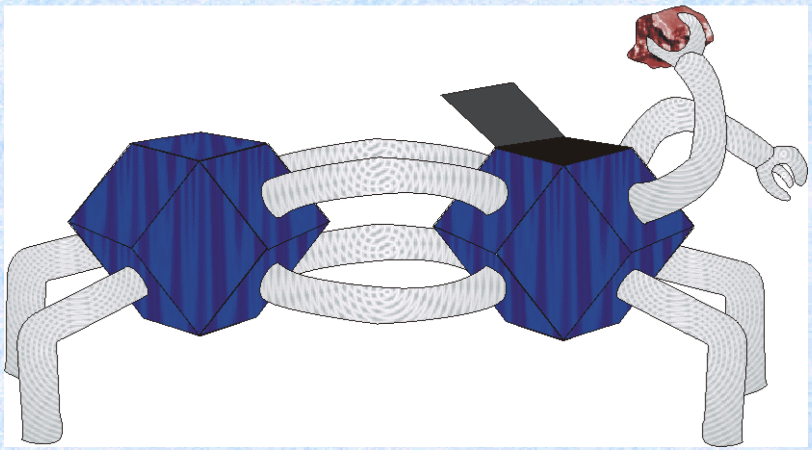
CTX

Continuous System

Rover vs. STX



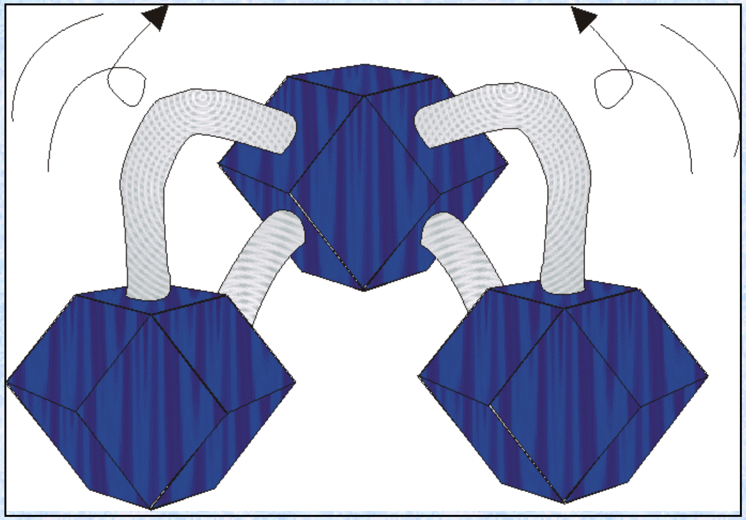
Self-Transforming Exploring Robot Concept (2010)

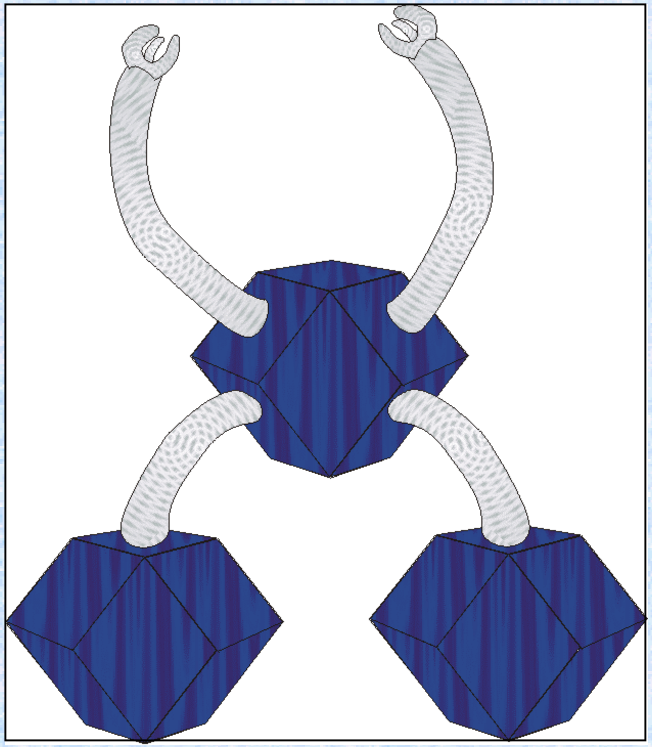


The STX c.2010

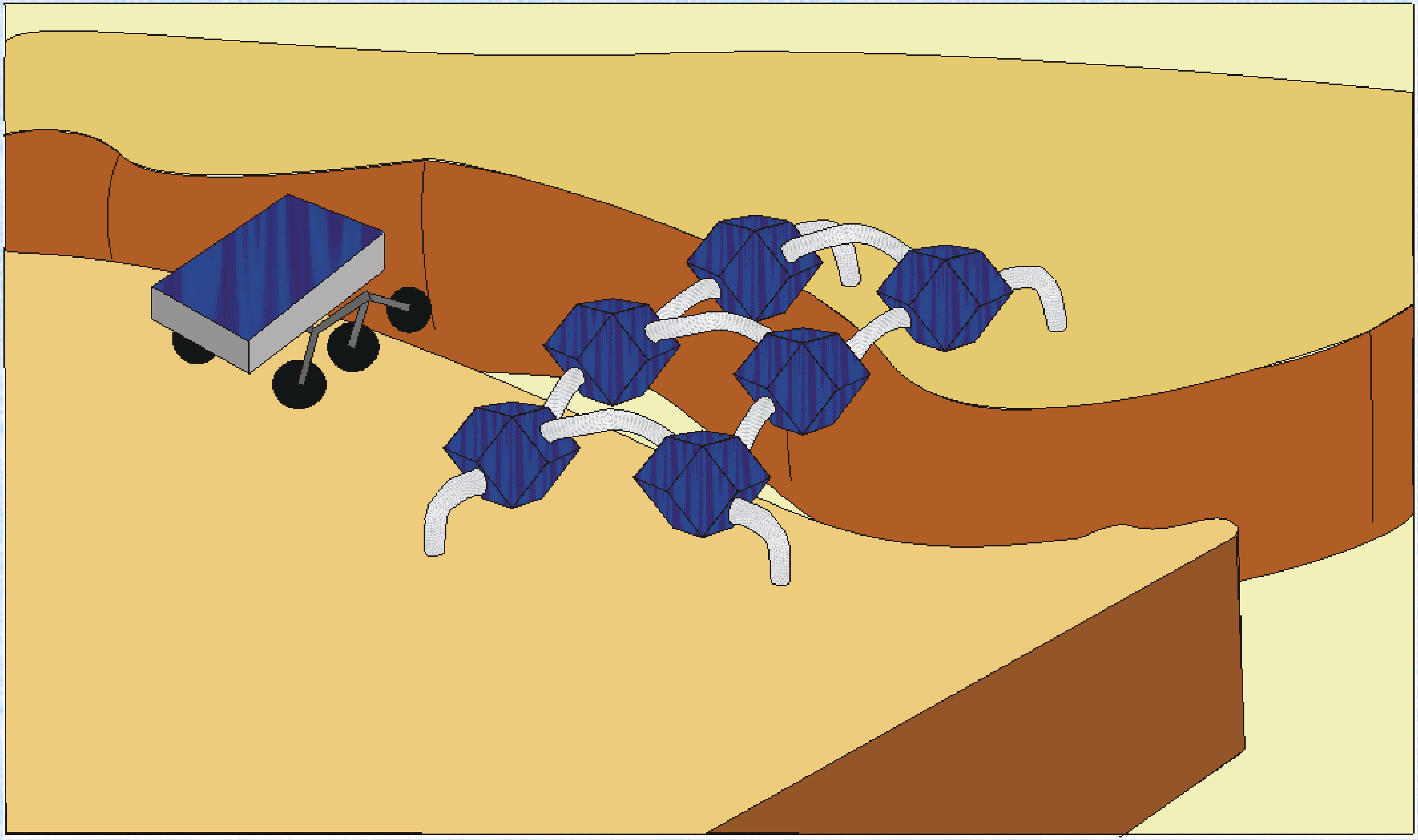
- Network of Node Elements
- Connected by Smart Deformable Members

Self Transformation

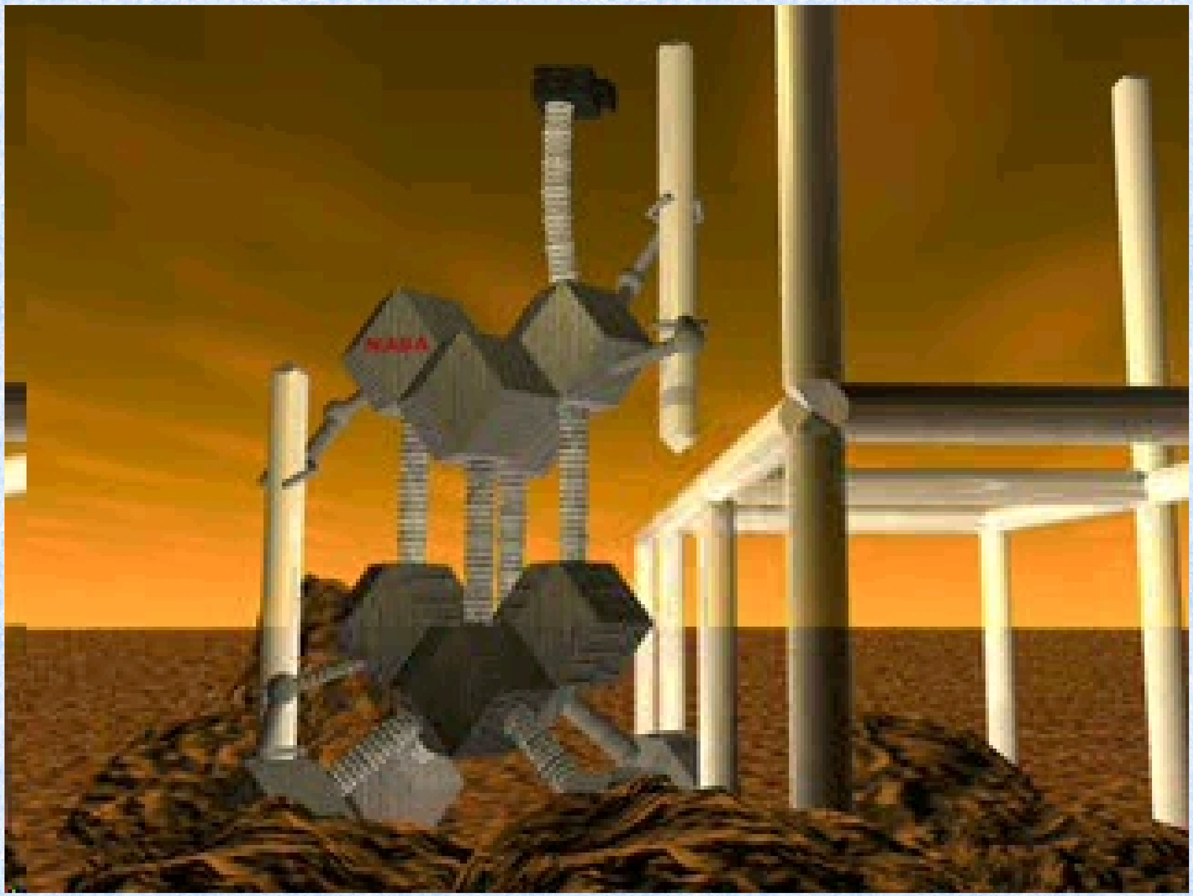




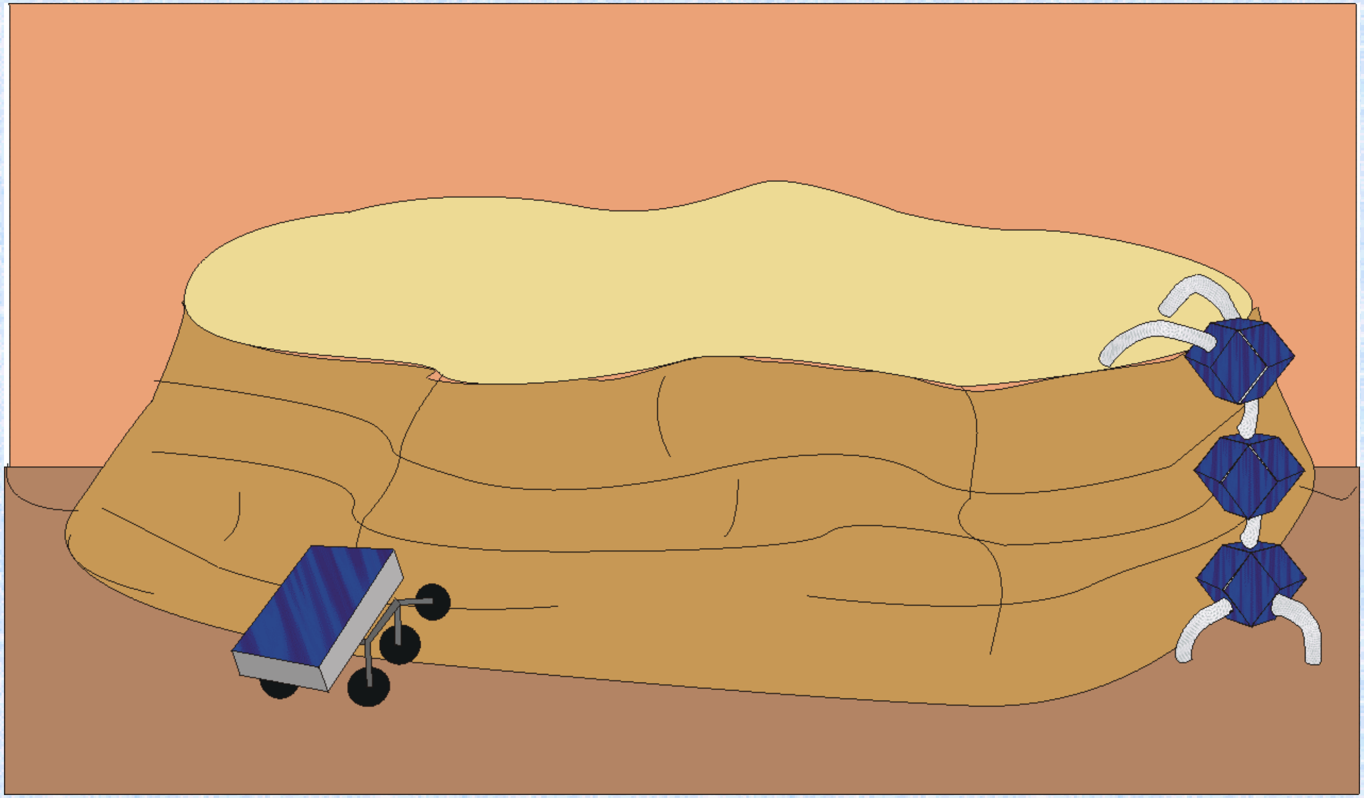
Rover vs. STX



Visualization of STX Embodiment

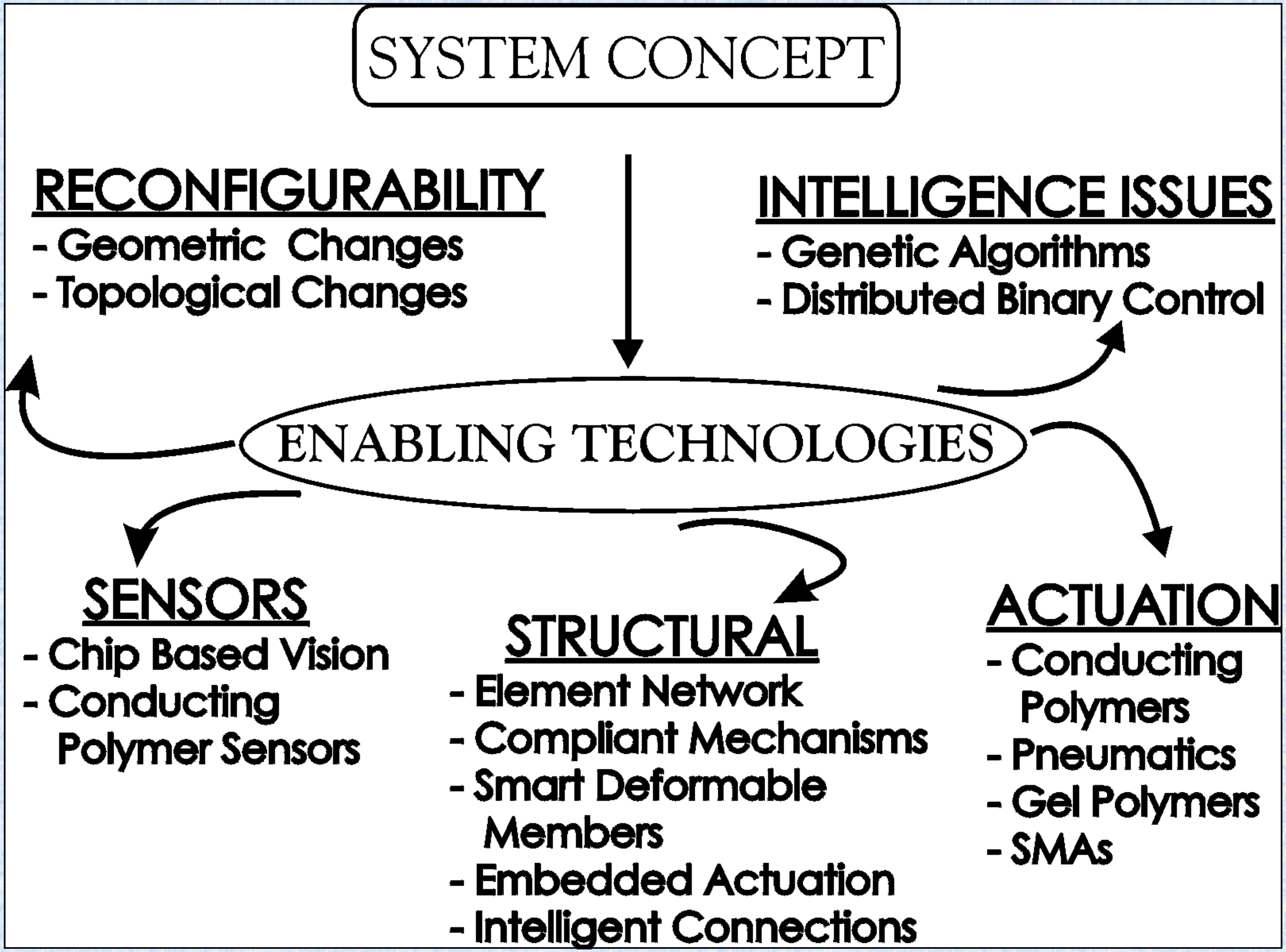


Rovers vs. STX



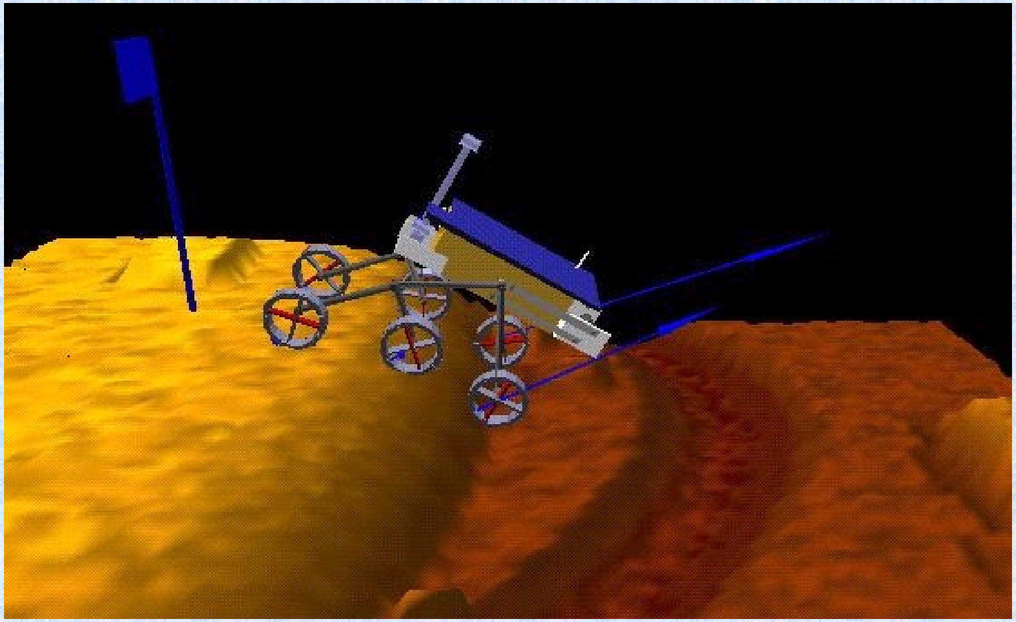
Visualization of STX

Research Roadmap



Smart Reconfigurability

- Genetic Algorithms
  - Path Planning
  - Reconfiguring Topology and Geometry

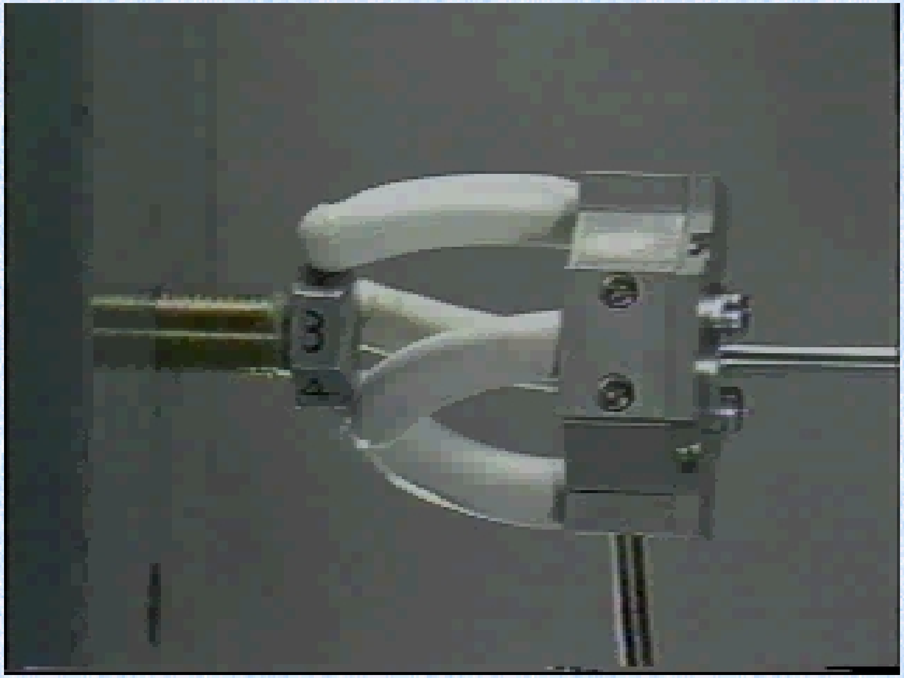


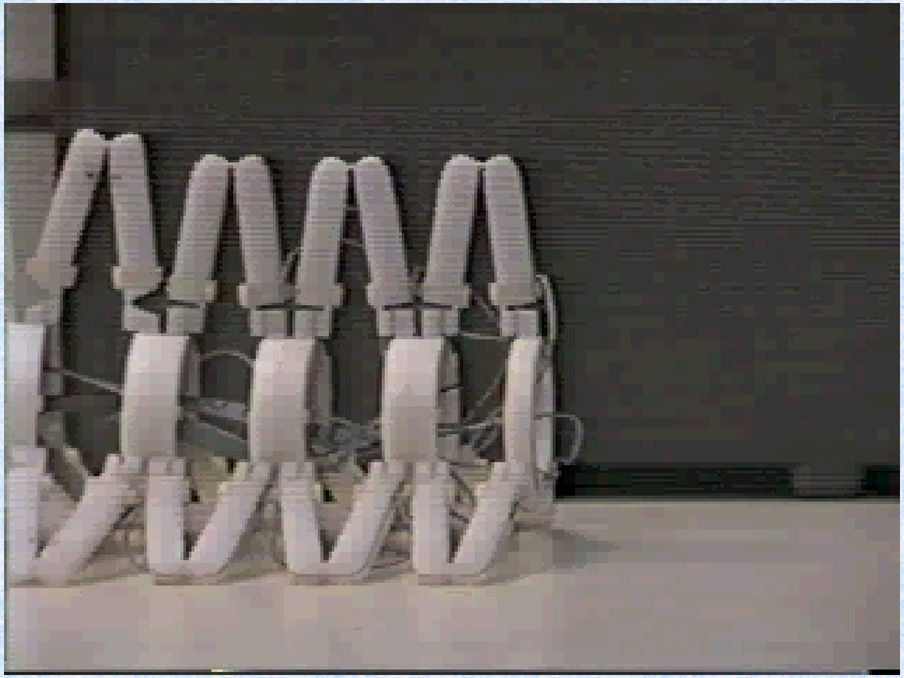
Smart Deformable Members

- Generalized Robotic Appendage
- Large Motions
- Reduced Number of Moving Parts
- Lightweight

- Basis for future CTX Systems

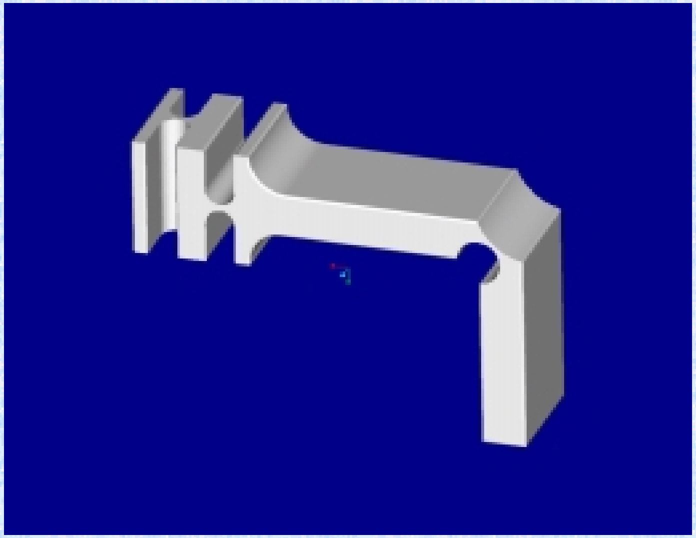
SDM Physical Structure





Compliant Mechanisms

- No Moving Parts
- Lightweight
- Large Deformations

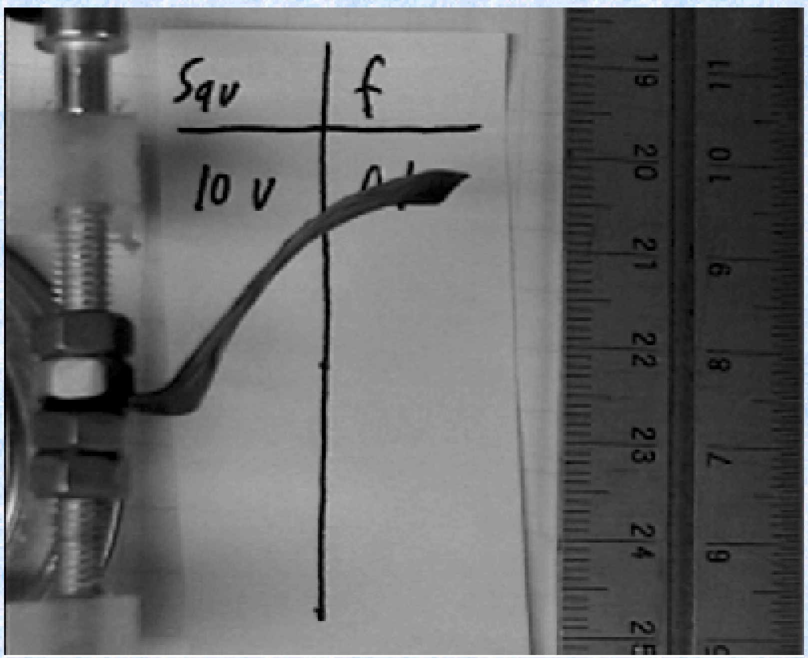


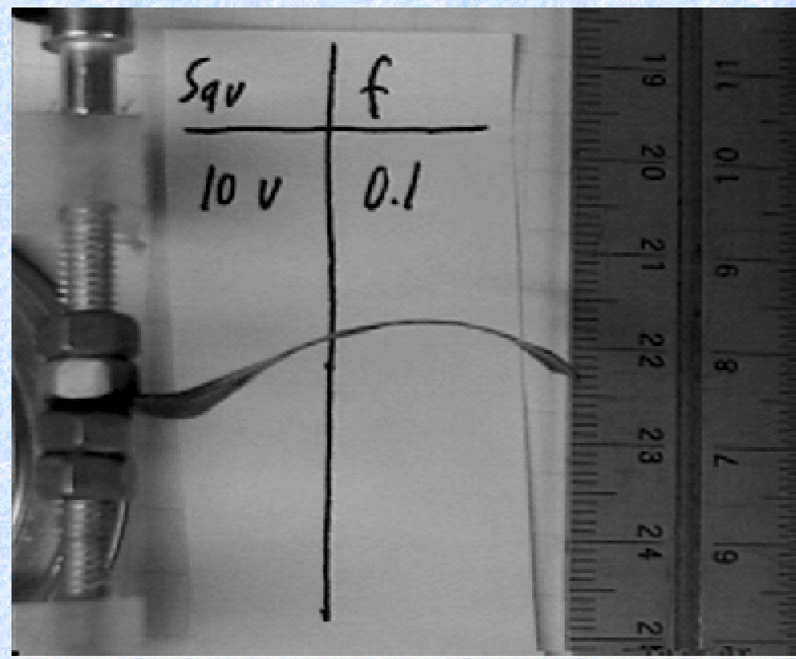
Conducting Polymer Actuation

Embedded Muscles

Conducting Polymers

- Actuation
- Sensing
- Signal Transmission



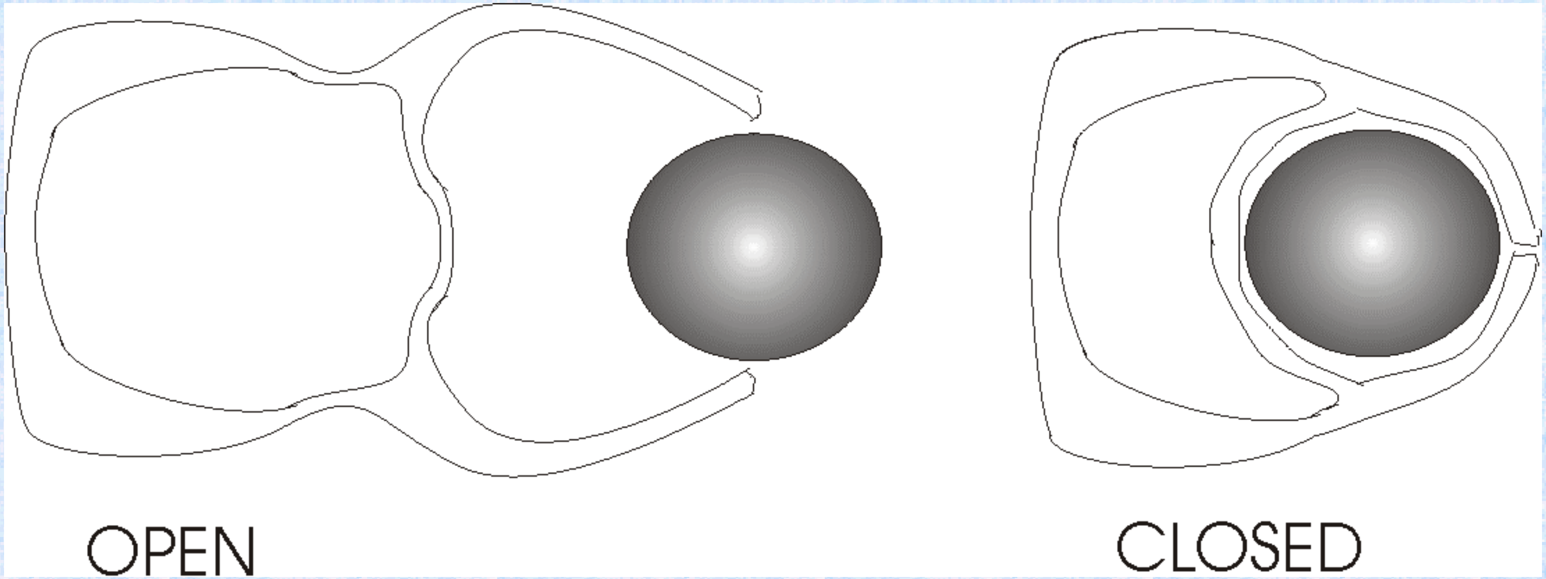


I. Hunter

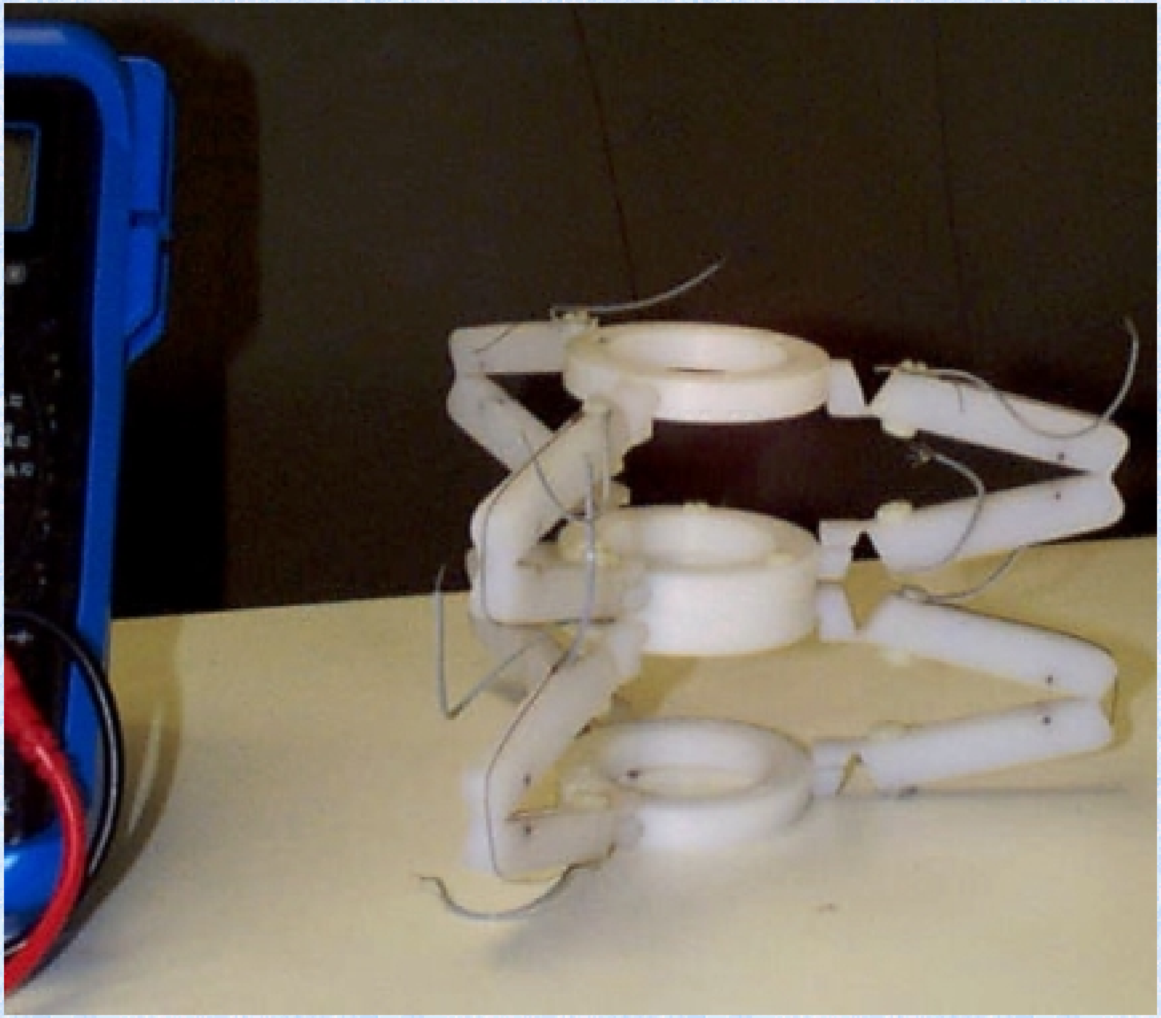
SDM Connectors

- Parallel Physical, Power and Information Connections
- Embedded Conductor Polymers - with “Active Hand Shake” to establish Connectivity

Bi-Stable SDM Latch Connection



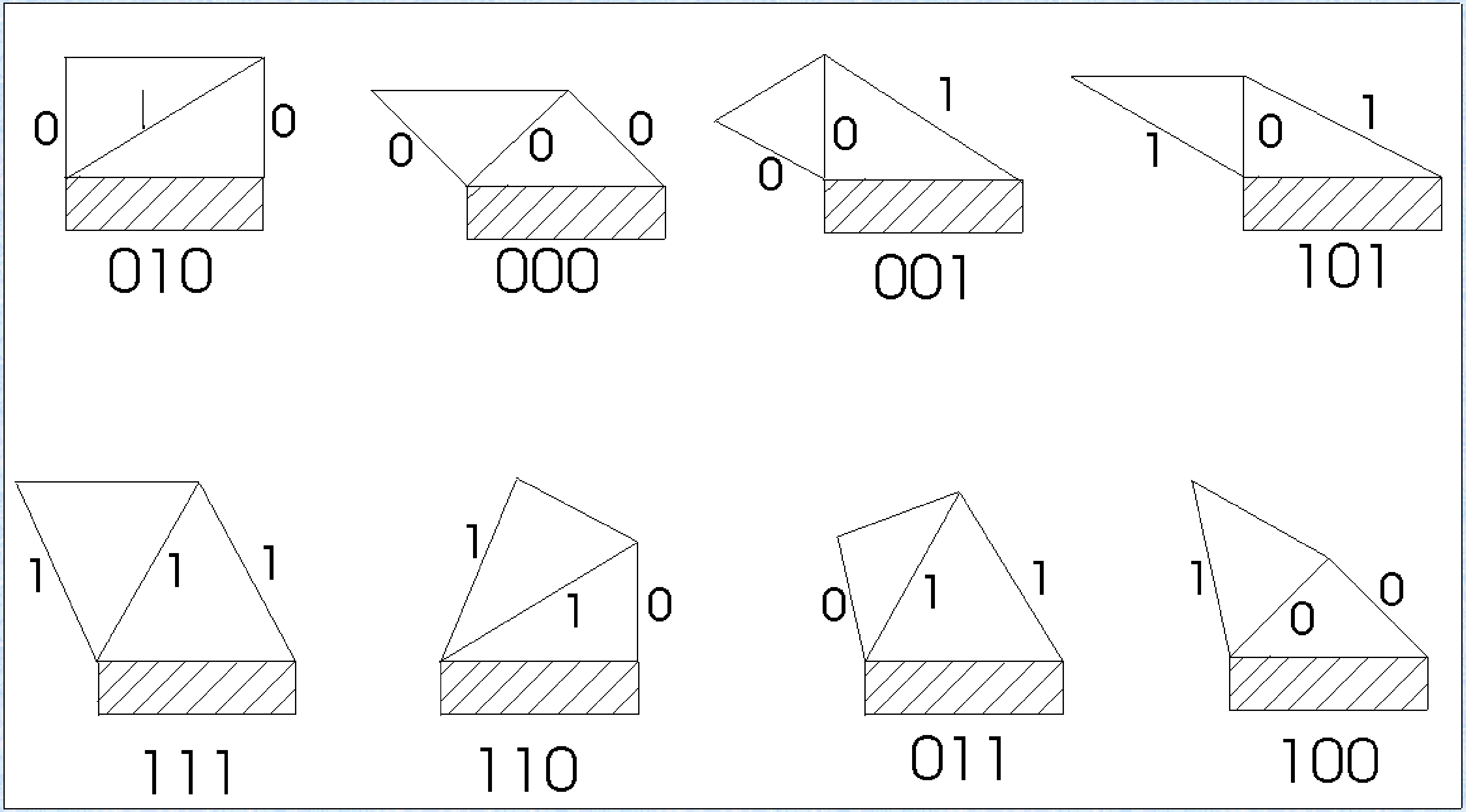
Physical System



Discrete Actuation

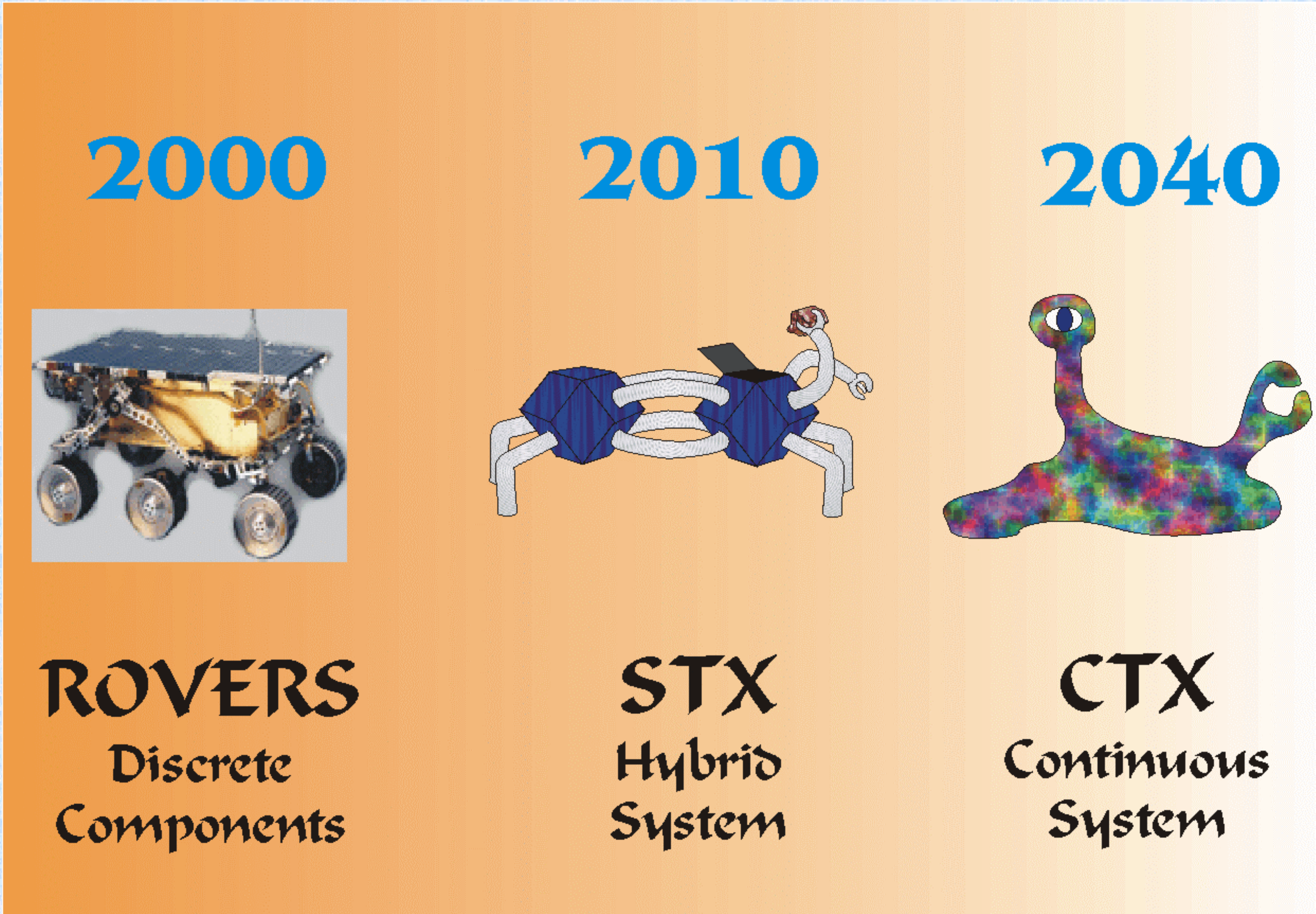
- Network of Binary Embedded Actuators
- Simplified Control Architecture
- Digital Computer Analogy

Configurations of a 3 Bit Platform Manipulator



G. Chirikjian

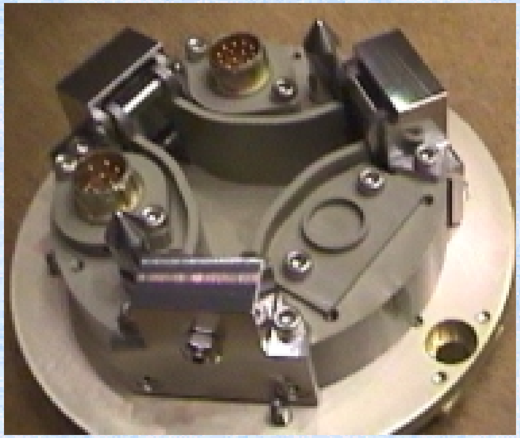
Planetary Robotic Explorer Timeline

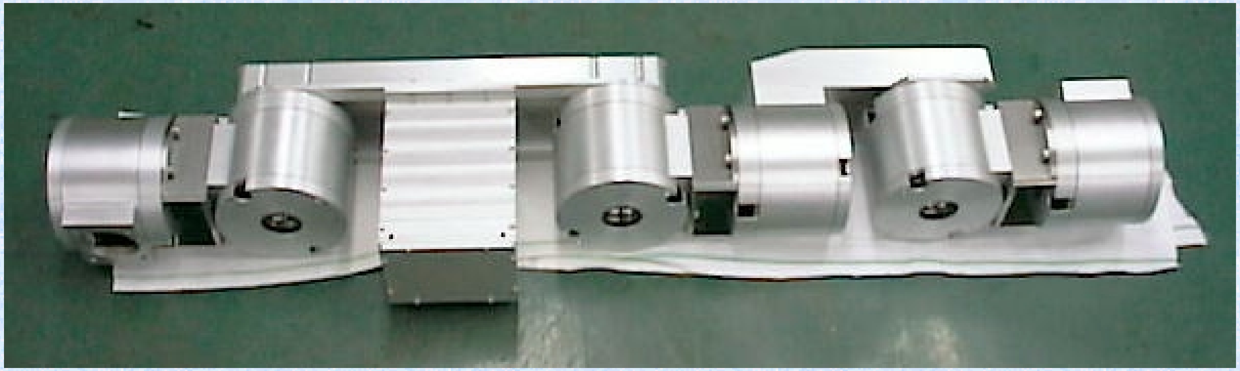


STX

- Robustness
- Redundancy
- Increased Functionality
- Lightweight

State-of-the-Art Physical/Mechanical Connectors





NASDA (Y. Ohkami)

New Paradigm for Robotic Exploration

NIAC NASA Institute for Advanced Concepts

MIT