MIT EECS - Lincoln Labs Undergraduate Research and Innovation Scholar

# Computational Design for Printable Hydraulic Robots

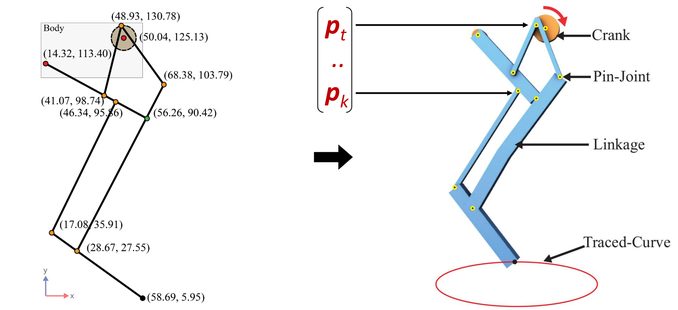
Landon Carter
Robert MacCurdy, Daniela Rus

## Problem

We want to close the loop on automated robot design and construction, to reduce human toil of designing robots.

- Current research is only on link sizing for animation.
- Our lab has previously developed a 3D-printable bellows actuation system.
- Combining these will allow for automated end-to-end robot fabrication.

## Previous Work



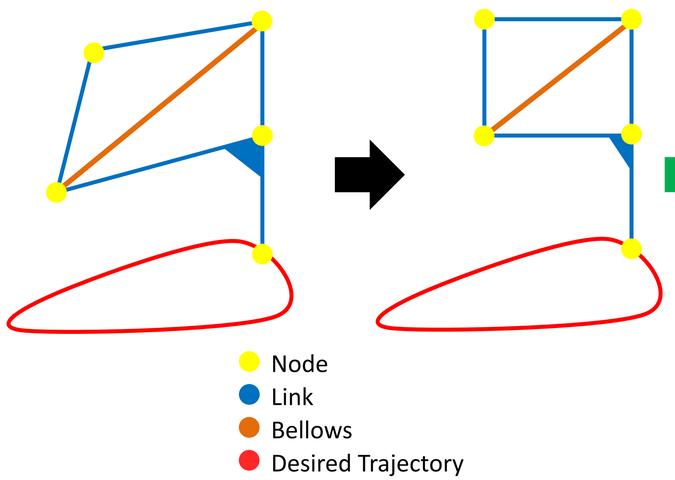




Bharaj et al, 2015

- Kinematics-based evaluation
- GMM-based optimization
- Rotational input
- **No route to physical realization**

## Approach




Basic Geometry Input

Geometry Optimization

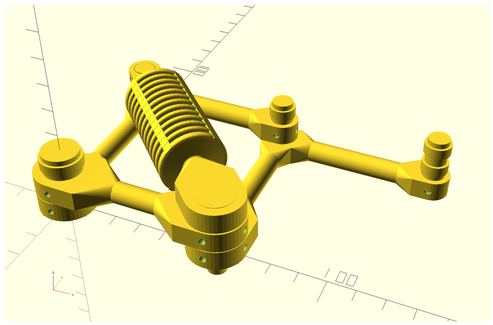
```
{
  "nodes": [
    [0, 0],
    [60, 0],
    [60, 60],
    ...
  ],
  "links": [
    [0, 1],
    [1, 2],
    [2, 3],
    ...
  ],
  "bellows": [4]
}
```

3D file input

```
union() {
  translate(v=[0, 0, 0]) {
    rotate(a=180, v=[0.0, 0.0, 48.0]) {
      cylinder(h=24.0, r=7);
    }
  },
  translate(v=[0.0, 0.0, 2.0]) {
    rotate(a=180, v=[0.0, 0.0, 8.0]) {
      cylinder(h=4.0, r=8);
    }
  },
  translate(v=[0.0, 0.0, 10.0]) {
    rotate(a=180, v=[0.0, 0.0, 8.0]) {
      cylinder(h=4.0, 4=8);
    }
  }, ...
```

3D file generation

## Results



## Future Work

- Geometry verification – currently, files are checked manually for compliance
- Testing of printed components
- Full robot generation, rather than just a set of legs
  - Fluid channel routing
  - Electronics integration
  - Attachment point optimization
- Cycle testing for longevity
- Strength input
  - FEA integration

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