Data Driven Soft Robotics

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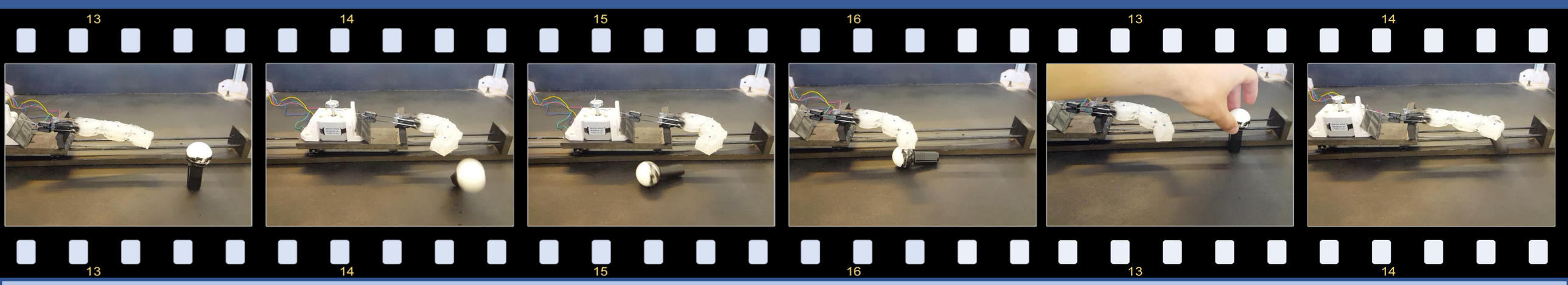

Motivation: Soft robots are attractive because they are safe to use, can handle fragile objects and can be cheap to manufacture

What is the theory behind it?

1) SHAPE VECTOR EXTRACTION FROM POINT CLOUD

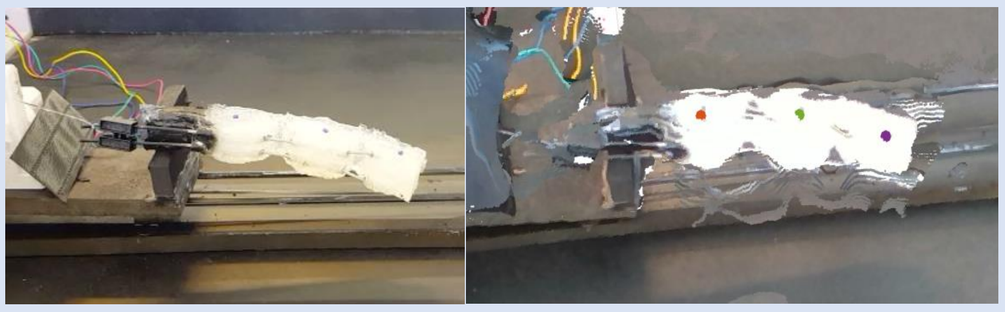

Figure 1: sample robot shapes for different control parameters

2) LEARN SHAPE FUNCTION

Shape function $\vec{s}(\vec{\alpha}) \approx \vec{s}_0 + J^T \Delta\vec{\alpha}$

Control parameters $\vec{\alpha}_k = [\alpha_0^k, \alpha_1^k, \ldots, \alpha_P^k]^T$

Shape vector $\vec{s}_k = [x_0^k, y_0^k, z_0^k, x_1^k, y_1^k, z_1^k, ..., x_N^k, y_N^k, z_N^k]^T$

Displacement vector $\vec{u}_i = \vec{s}_i - \vec{s}_0$

$A = [\vec{a}_1\vec{a}_2 \cdots \vec{a}_{K-1}\vec{a}_K] \quad U = [\vec{u}_1\vec{u}_2 \cdots \vec{u}_{-1}\vec{u}_K]$

Jacobian $J = UA^T(AA^T)^{-1}$

- split configuration space into disjoint regions
- embarrassingly parallel
- 5-fold cross-validation for optimal approximation order vs number of local models

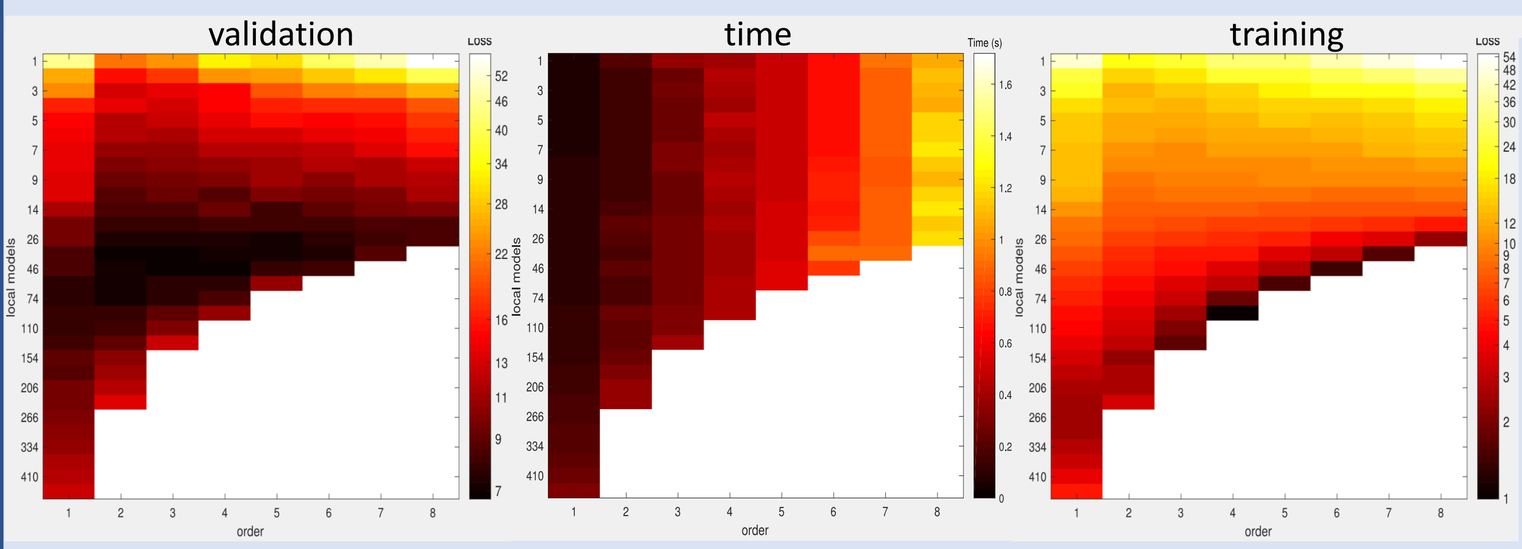

Figure 2: many low ordered, local models show promising results in terms of time complexity and validation loss

3) INVERSE KINEMATICS

solve inverse kinematics to find optimal control parameters for desired shape $\vec{s}_{goal}$

$$\vec{\alpha}_{goal} = \arg\min_{\vec{\alpha}} \frac{1}{2}\|\vec{s}(\vec{\alpha}) - \vec{s}_{goal}\|$$

How do we execute it?

THE LEARNINGCUBE

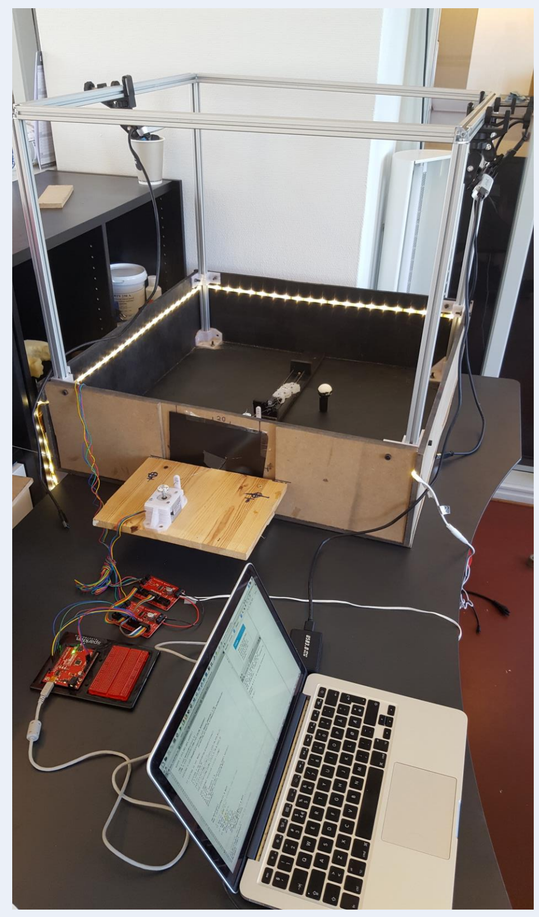

Figure 3: overview of hardware setup

THE ROBOTS

Figure 4: The robots used

pySoRo

- software for communicating with motors and cameras
- camera calibration and noise analysis
- postprocessing of data
- various methods for learning the configuration function
- real time interaction of robot with environment, using learned function
- documented
- publicly available on GitHub![*]
- github.com/erleben/pySoRo

INFO

- price for complete setup: < 10 000 DKK
- contact us if you are interested

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Scan QR-code to see the robots in action on YouTube!

[*]Scan QR-code to check out pySoRo on GitHub!

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