Grasp Control: Theory and Practice

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Grasping using feedback control

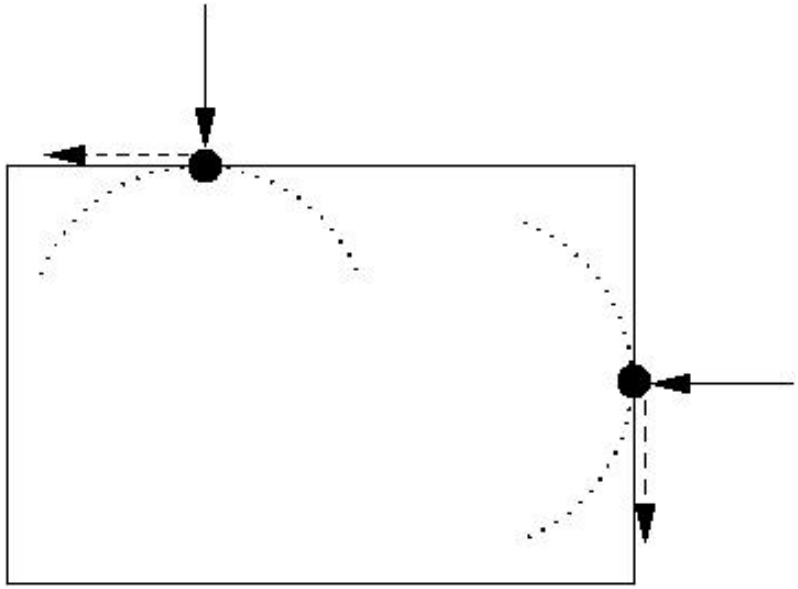
Approach to grasping:

1. Use gross task and object information to select an approximate grasp.
2. After approximately positioning the contacts, use force feedback to guide the contacts to their final configuration.

This talk:

1. Report new theoretical convergence guarantees for grasp control.
2. Report experimental results.

Force residual controller

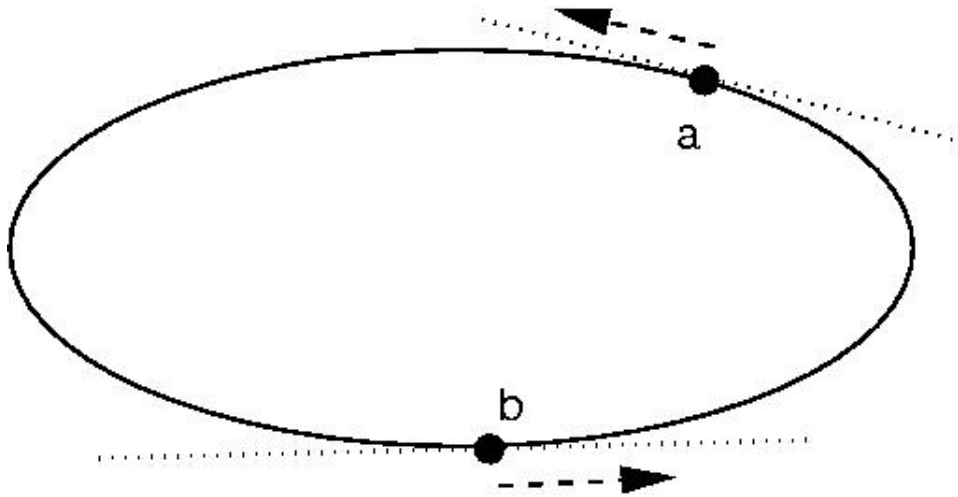


Displace contacts toward force equilibrium configurations.

Error function: $\varepsilon_{fr} = \frac{1}{2}\mathbf{f}^T\mathbf{f}$ $\qquad \mathbf{f} = \sum_{j=1}^{k} \hat{\mathbf{n}}_j$

This is also Lapunov function ... convergence proof is easy.

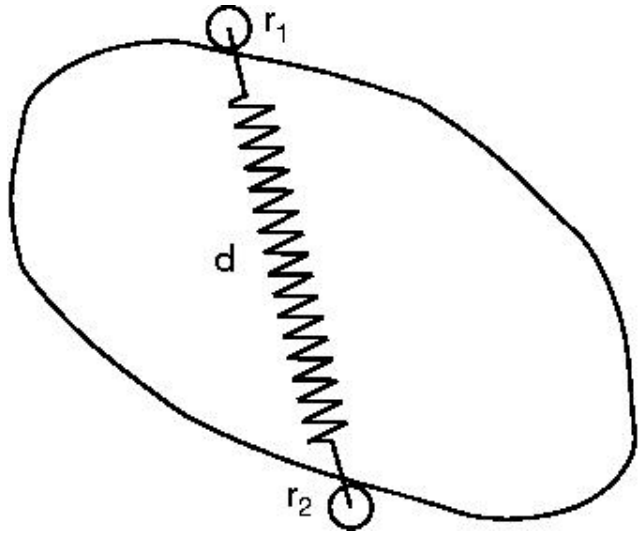
Moment residual controller



Displace contacts toward moment equilibrium configurations.

Error function: $\varepsilon_{fr} = \frac{1}{2}\mathbf{m}^T\mathbf{m}$ $\mathbf{m} = \sum_{j=1}^{k} \mathbf{r}_j \times \hat{\mathbf{n}}_j$

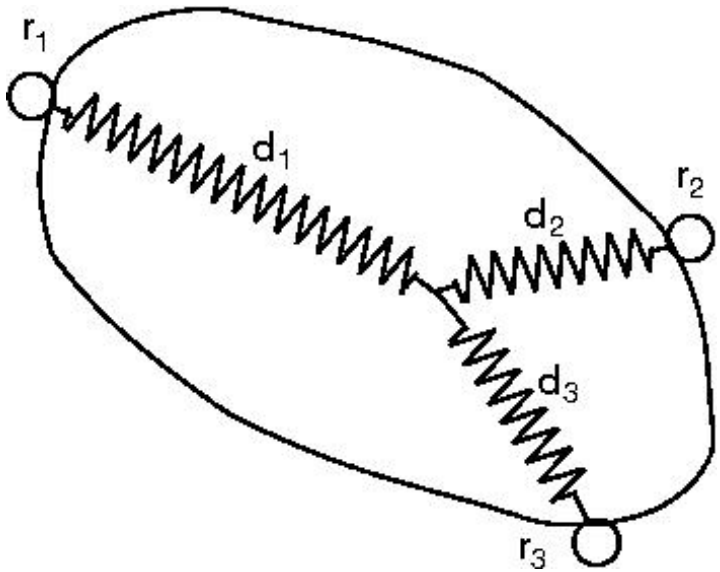
Lyapunov convergence proof sketch (two contacts)



Lyapunov function: $V(d) = \frac{1}{2}\mathbf{d}^T\mathbf{d}$

$$\dot{V}(d) \leq 0$$

Lyapunov convergence proof sketch (three contacts)

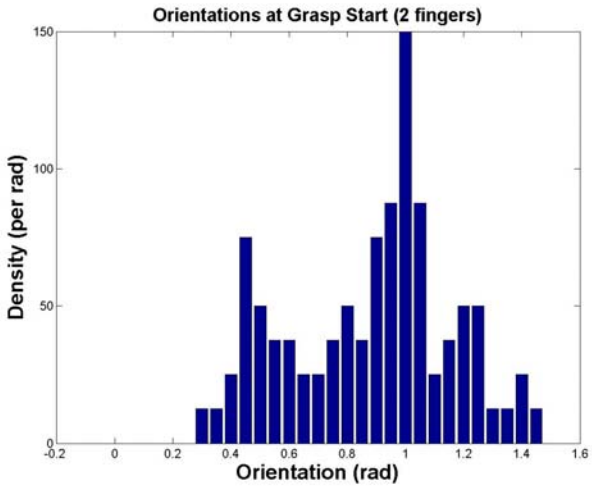


Lyapunov function:

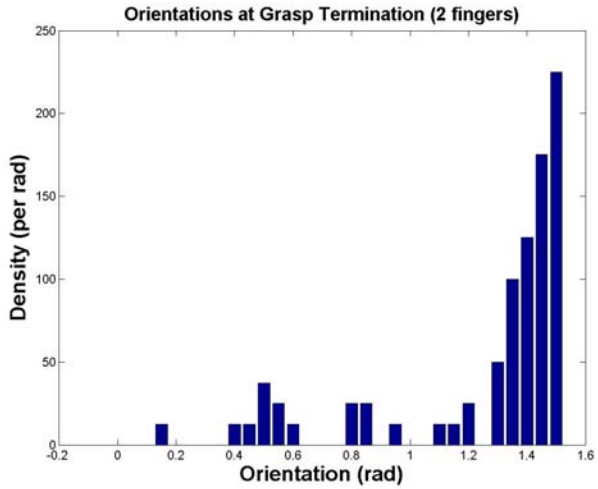
$$V(d) = \frac{1}{2}\mathbf{d}_1{}^T\mathbf{d}_1 + \frac{1}{2}\mathbf{d}_2{}^T\mathbf{d}_2 + \frac{1}{2}\mathbf{d}_3{}^T\mathbf{d}_3$$

$$\dot{V}(d) \leq 0$$

Experimental Results



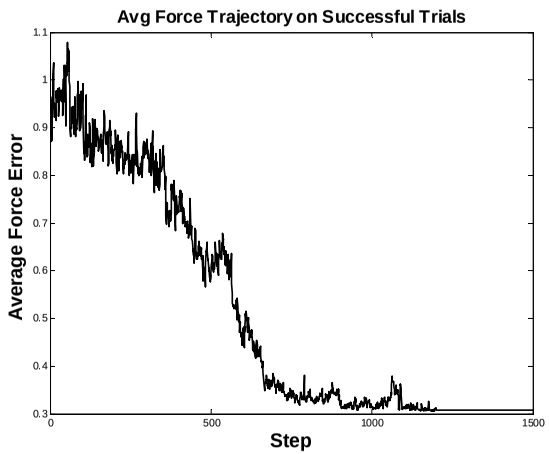
Controller



before

after

Error trajectories



force residual

moment residual

Robonaut Application