灵巧手抓取

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内容

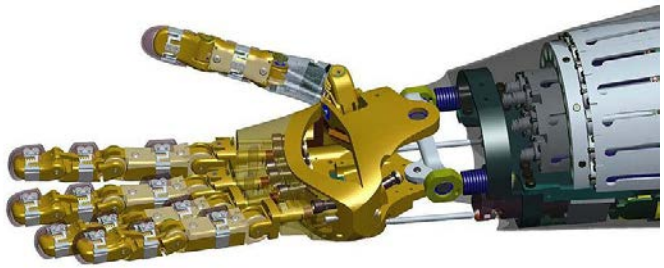
- 机械手发展
- 抓取是什么?
- 抓取规划
  - 精巧抓取规划(Fine grasp)
  - 强力抓取规划(Power grasp)
- 工作介绍
- 相关工具

机械手

Schunk JGP

Barrett Hand

DLR Hand II

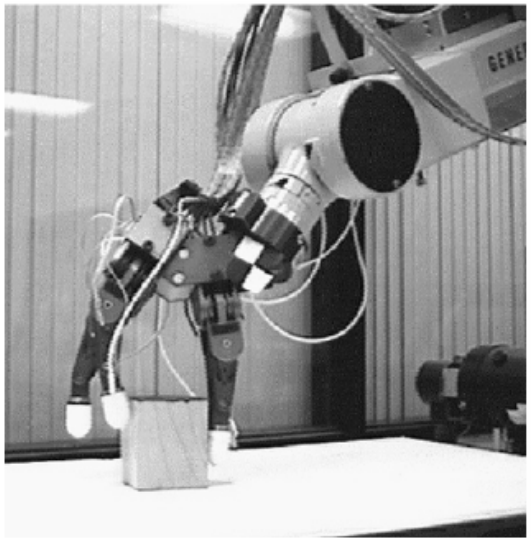


Robonaut Hand

平行夹具 ⟶ 多指手

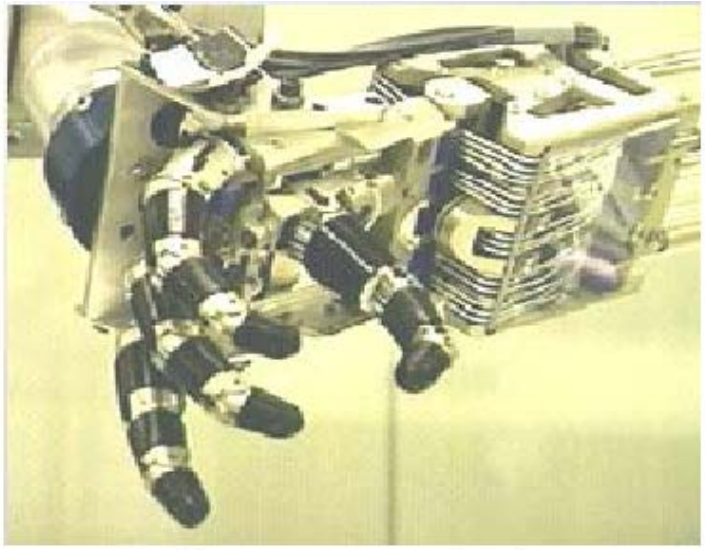
机械手发展

- Stanford/JPL 1982
  - 3指，9-DOF
  - 首次完整引入了位置、触觉、力等传感器系统



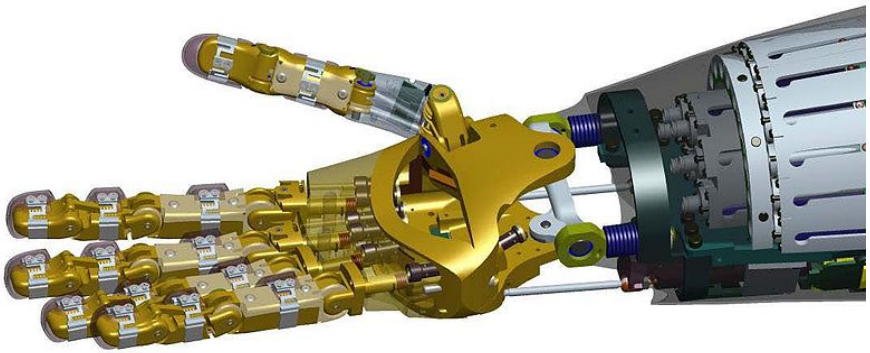
机械手发展

- Utah/MIT Hand - 1985
  - 4指，每个手指包含4个关节和4个自由度
  - 第一只具有灵巧性操作的机械手



机械手发展

- Robonaut – NASA 1999
  - 5个手指, 14-DOF
  - 第一个与人手外形最接近的五手指灵巧手



机械手发展

- Shadow Hand
  - 5 指，24-DOF

什么是抓取？

- 给定一个物体和手：
  - 如何去抓？
    - 抓取规划(Grasp Planning)
  - 如何控制
    - 抓取控制(Grasp Control)
  - 如何操作
    - 灵巧操作(Dexterous Manipulation)

抓取规划

- 解决问题:
  - 需要多少个手指？
  - 物体上的接触点如何分布？
  - 机器人如何接近物体？
  - 能否满足给定任务？

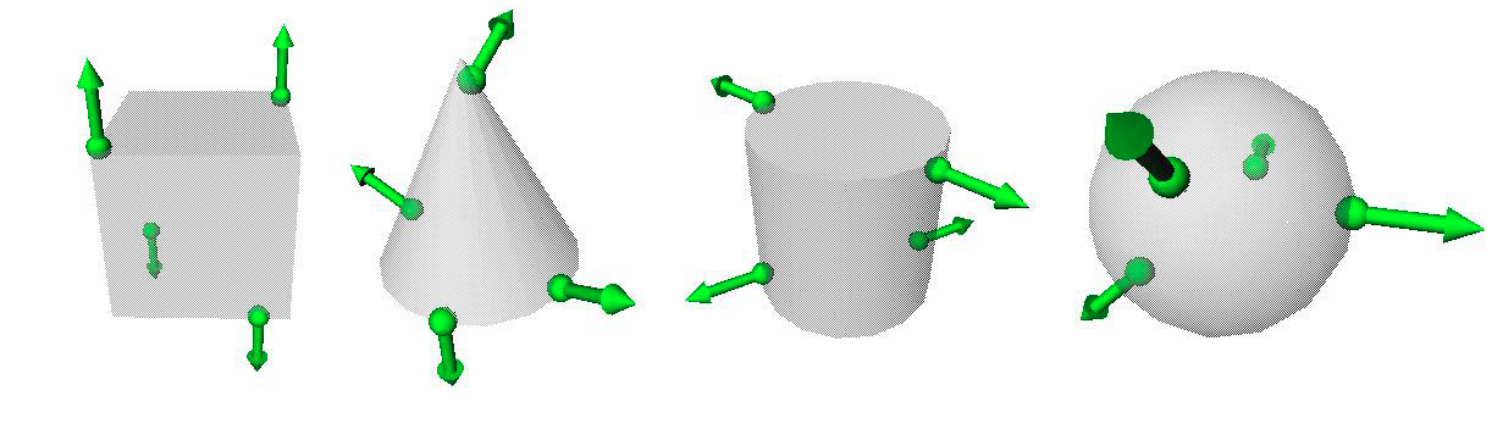
抓取分类

- 精巧抓取(Fine grasps)
  - 精巧操作
  - 一个手指只有一个接触点

- 强力抓取(Power grasps)
  - 包裹住物体
  - 一个手指上有多个接触点

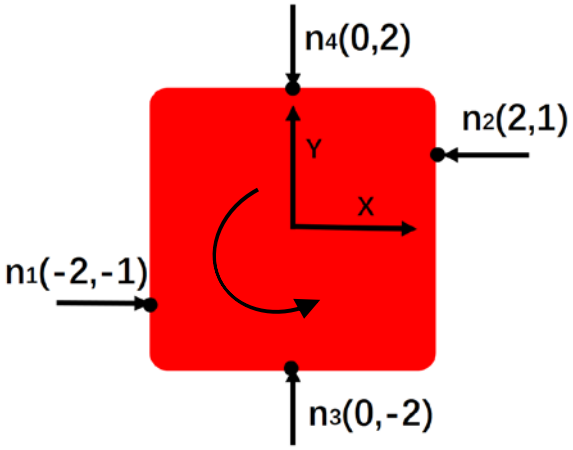
精巧抓取(Fine grasps)规划

- 传统的2阶段方法
  - 给定模型，计算一个满足力闭包的抓取
  - 计算手的构型



力闭包

- 能否使得被抓物体在抓取状态下抵抗任何外力
  - 不稳定例子



$$\hat{n}_1 = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad \hat{n}_2 = \begin{bmatrix} -1 \\ 0 \end{bmatrix} \quad \hat{n}_3 = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \quad \hat{n}_4 = \begin{bmatrix} 0 \\ -1 \end{bmatrix}$$

$$\vec{r}_1 = \begin{bmatrix} -2 \\ -1 \end{bmatrix} \quad \vec{r}_2 = \begin{bmatrix} 1 \\ 2 \end{bmatrix} \quad \vec{r}_3 = \begin{bmatrix} 0 \\ -2 \end{bmatrix} \quad \vec{r}_4 = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$$

$$M_i = \vec{r}_i \; X \; \hat{n}_i$$

$$M_1 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad M_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad M_3 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \quad M_4 = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

力闭包

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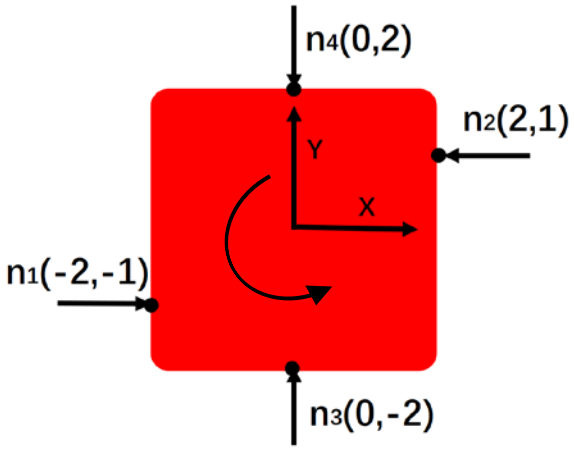
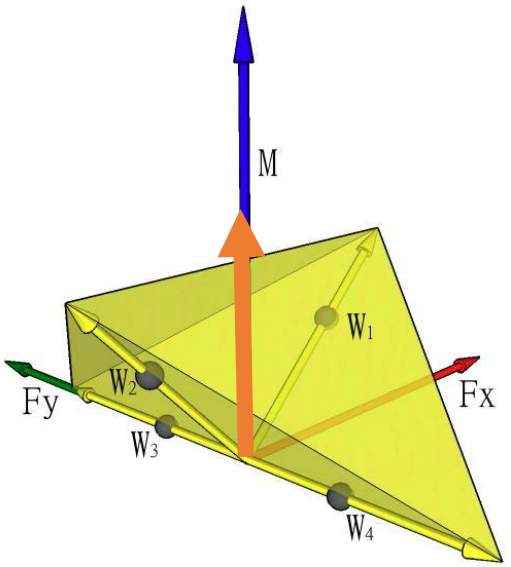


$$[n_x \quad n_y \quad M]^T$$

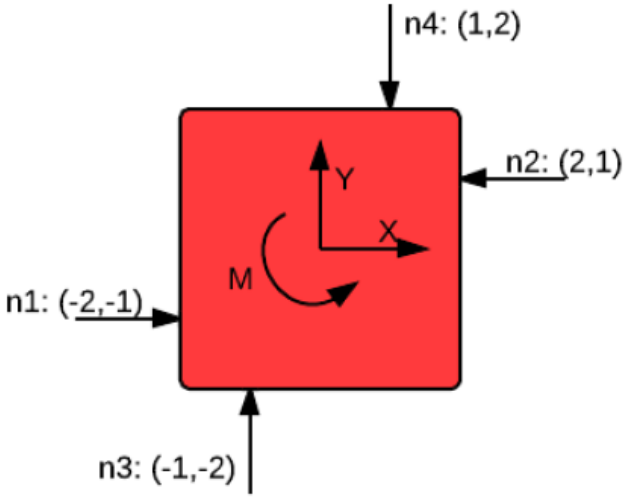


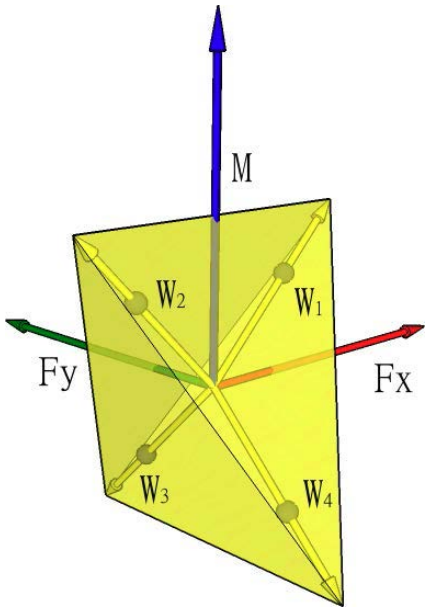
旋量空间

$$W_1 = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} \quad W_2 = \begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix} \quad W_3 = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad W_4 = \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix}$$

力闭包

- 能否使得被抓物体在抓取状态下抵抗任何外力
  - 稳定抓取





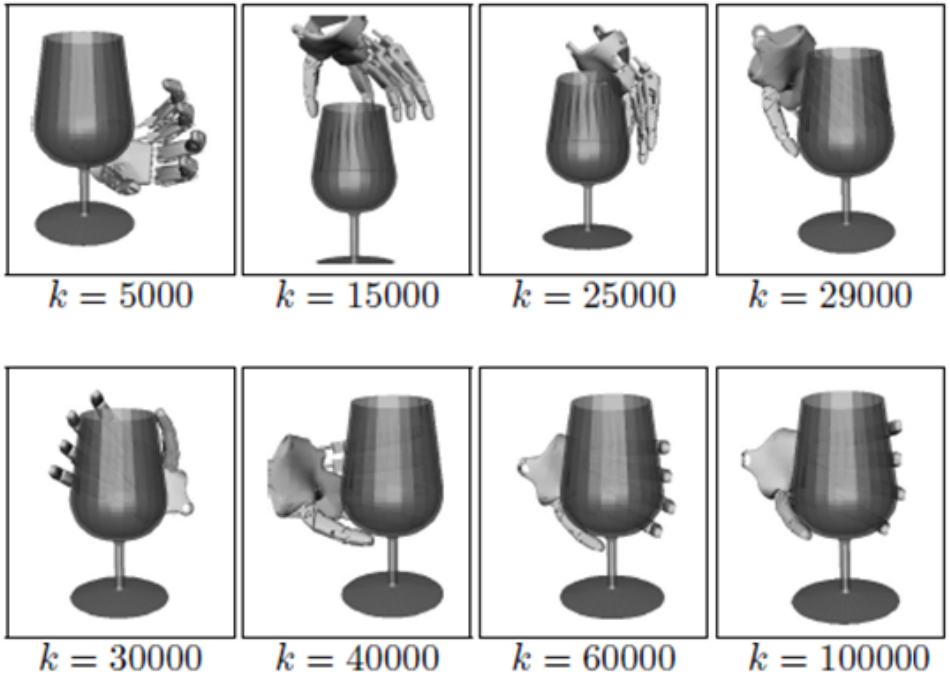
旋量空间

强力抓取(Power grasps)规划

- 一个手指上不只一个接触点

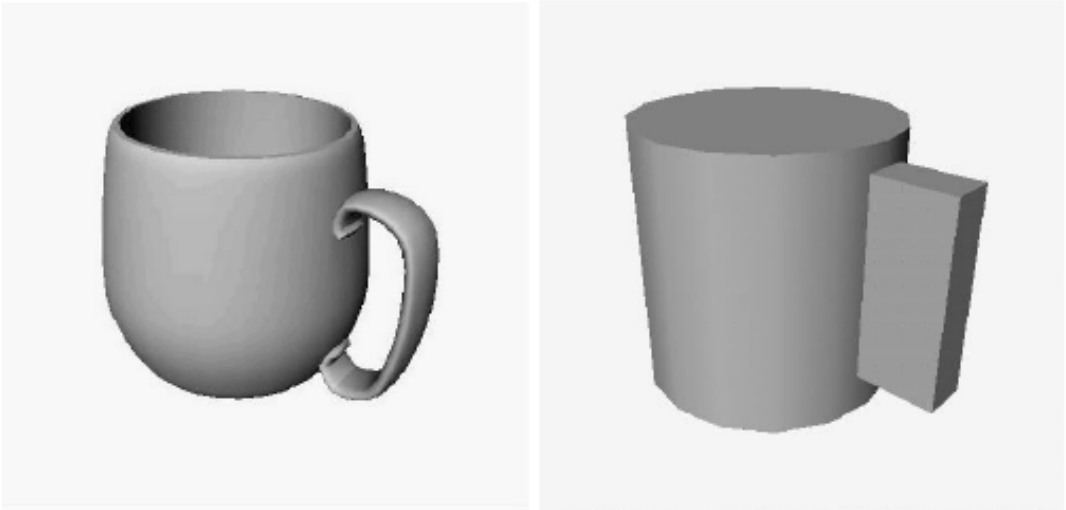
强力抓取(Power grasps)规划

- 一个手指上不只一个接触点
- 策略
  - 基于物体的优化



强力抓取(Power grasps)规划

- 一个手指上不只一个接触点
- 策略
  - 基于物体的优化
  - 采用简单形状进行近似表示

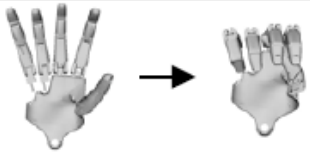
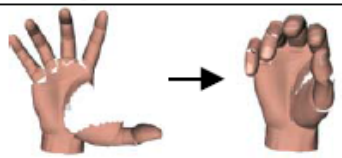
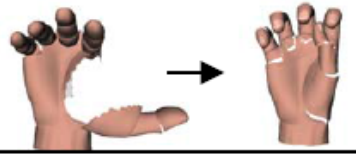


强力抓取(Power grasps)规划

- 一个手指上不只一个接触点
- 策略
  - 基于物体的优化
  - 采用简单形状进行近似表示
  - 基于数据驱动的方法

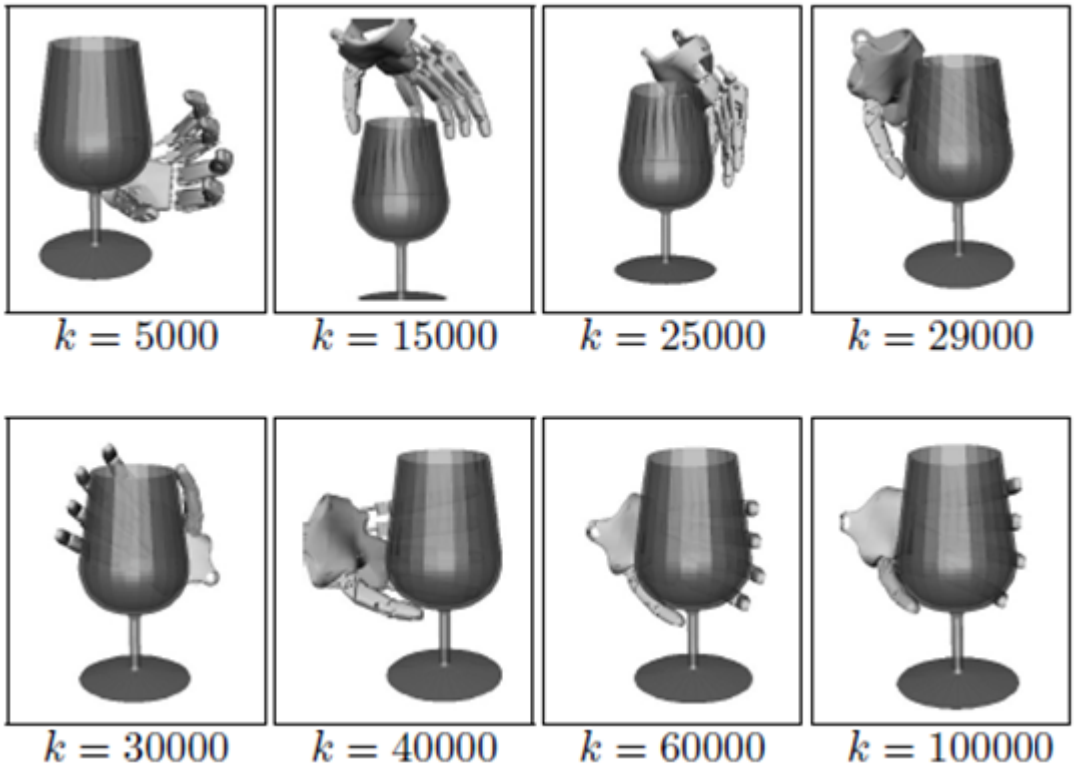
Eigengrasps

- Dimensionality reduction for hand-independent dexterous robotic grasping
  - Matei Ciocarlie, Corey Goldfeder and Peter Allen, IROS2007

Model	DOFs	Eigengrasp 1			Eigengrasp 2		
		Description	min	max	Description	min	max
Barrett	4	Spread angle opening			Finger flexion		
DLR	12	Prox. joints flexion Finger abduction			Dist. joints flexion Thumb flexion		
Robonaut	14	Thumb flexion MCP flexion Index abduction			Thumb flexion MCP extension PIP flexion		
Human	20	Thumb rotation Thumb flexion MCP flexion Index abduction			Thumb flexion MCP extension PIP flexion		

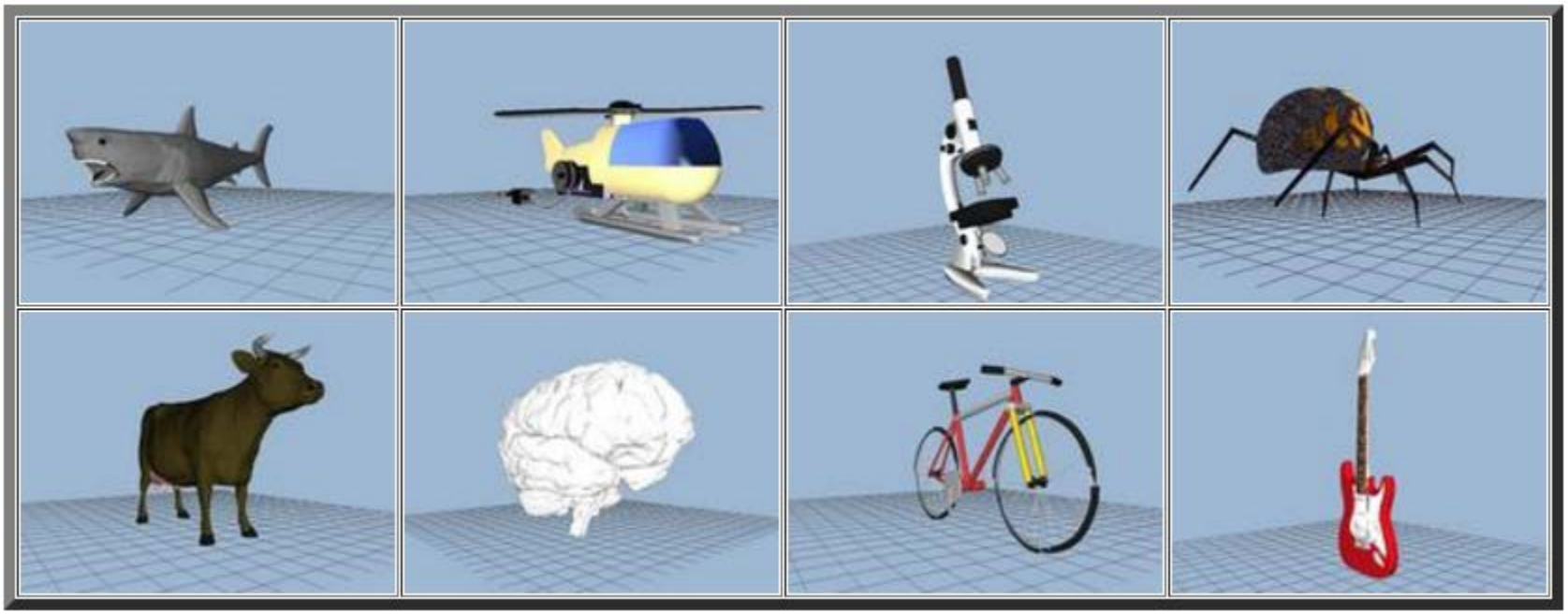
Eigengrasps

- 抓取规划
  - 模拟退火



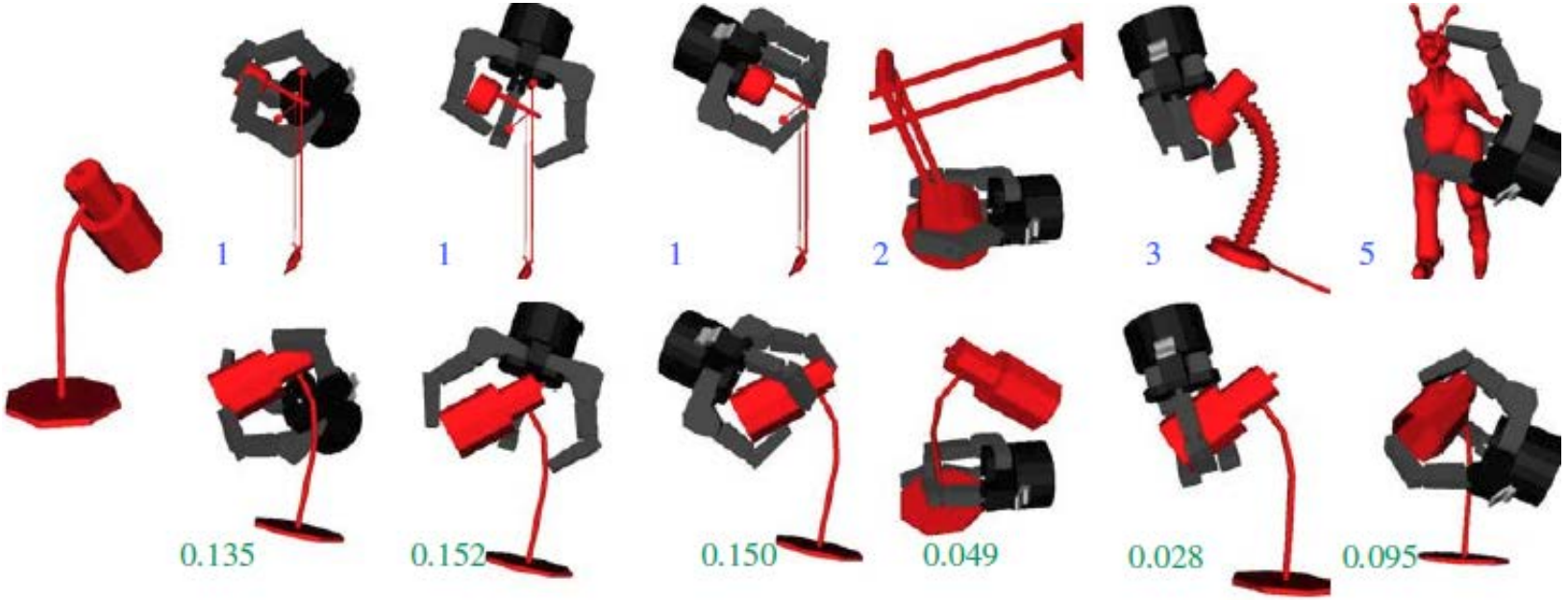
The Columbia Grasp Database

- 1814个模型，4个缩放比例
- 1个月时间



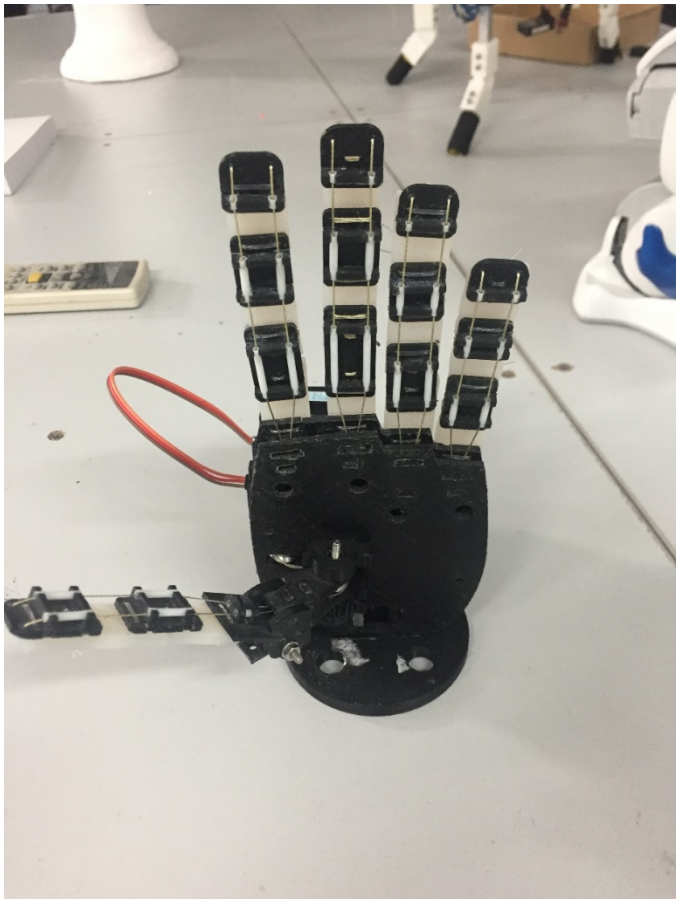
The Columbia Grasp Database

- 1814个模型，4个缩放比例
- 1个月时间
- 应用



我们的工作

- 低成本机械手

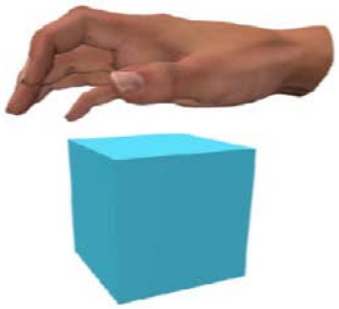


我们的工作

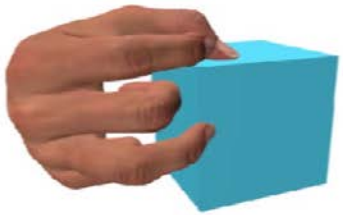
- 穿透深度(PD)计算

我们的工作

- 抓取规划算法

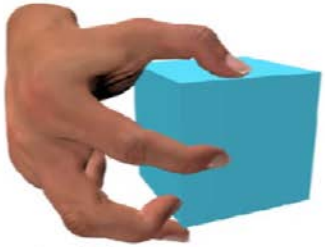


collision-free



contact, unstable grasp

collision

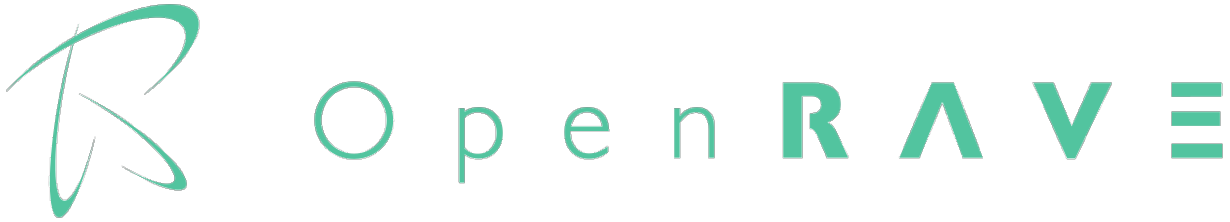


stable grasp

相关工具

- GraspIt!

- Open Robotics Automation Virtual Environment (OpenRAVE)



谢谢