Abort and Retry
... or Fast Fumbling

ICRA 2011 - Workshop Mobile Manipulation

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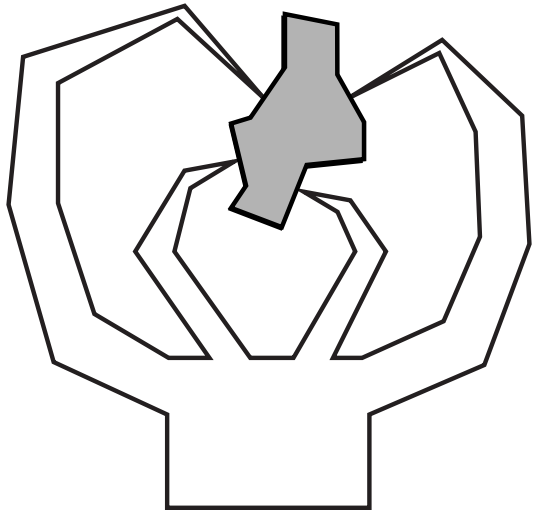
Grasping Approach

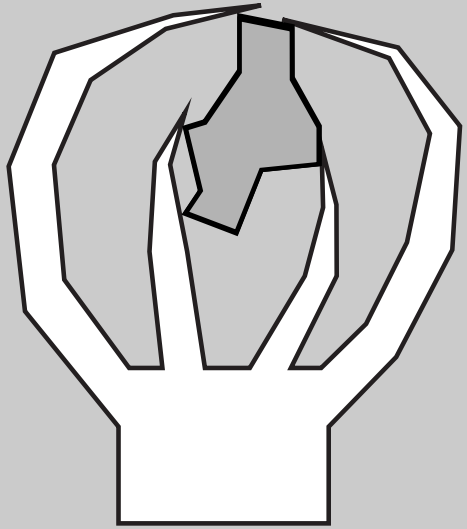
"Put the fingers on the right place"



Assume

Complex Hands

"Let the fingers fall where they may"



Expect

Simple Hands

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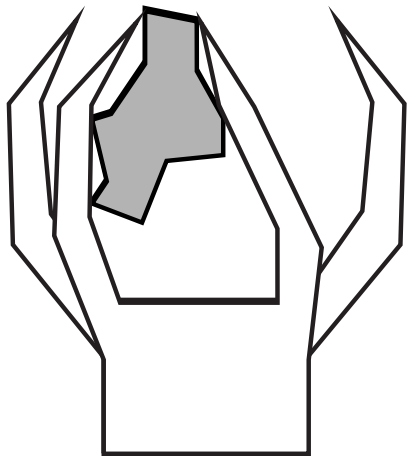
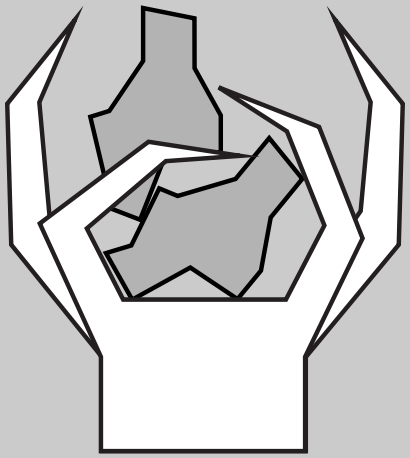
Let the fingers ...

"Hand conforms to object"



Passive Adaptation

"Object conforms to hand"



Passive Sensing

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Bin-Picking

- High clutter.
- High pose uncertainty.
- Goal: Singulation.
- Simple Hand
  - ✓ Singe actuator.
  - ✓ Thin, hard compliantly coupled fingers.
  - ✓ Low friction.

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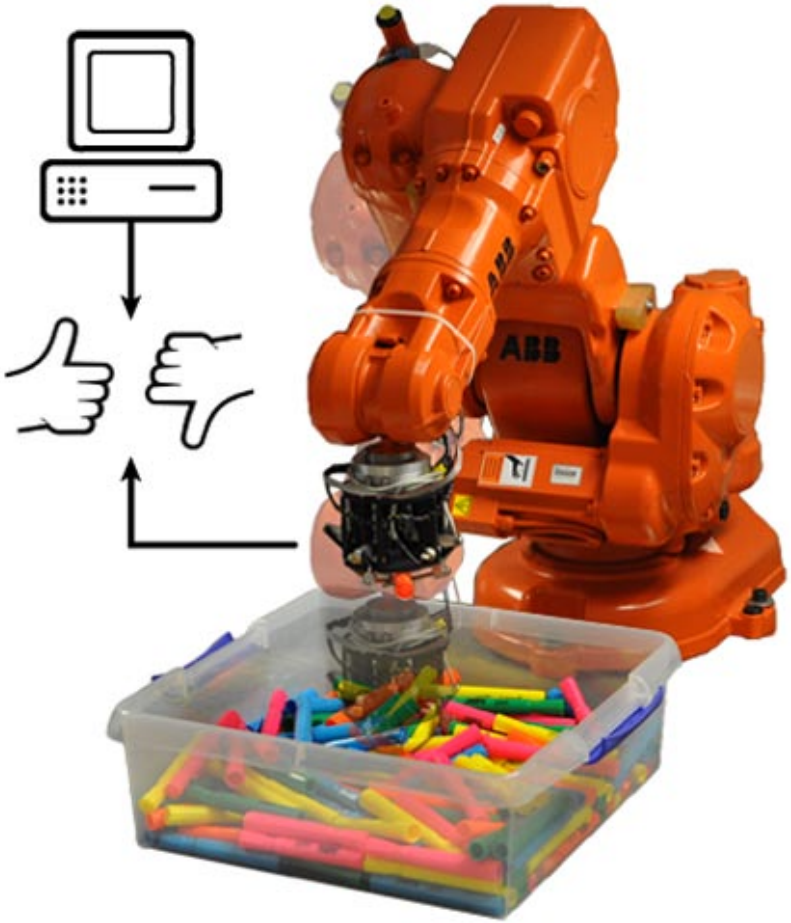
Bin-Picking



- Blind grasp.
- Grasp signature.
- Success/Failure.

- Success ratio 42%

$\downarrow$

$\tau = 2.17$

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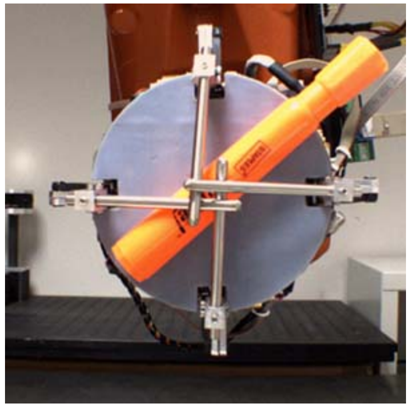
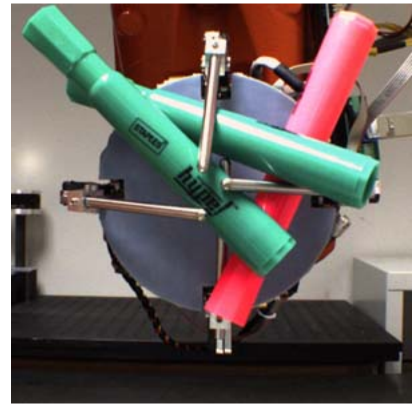
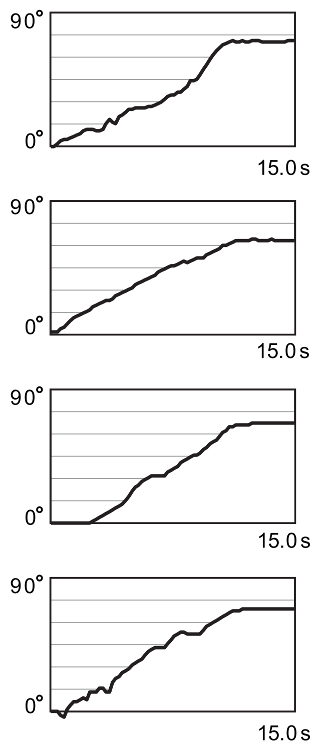
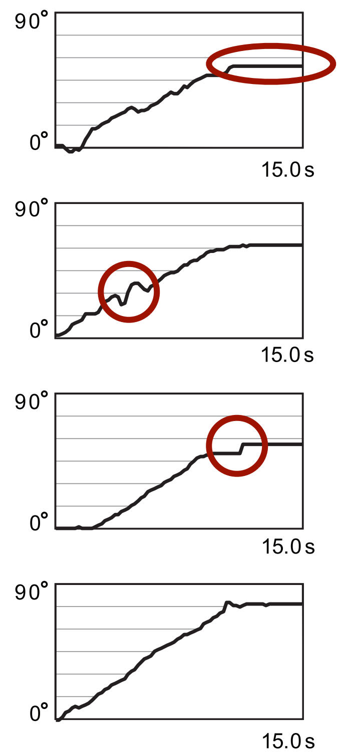
We can do better









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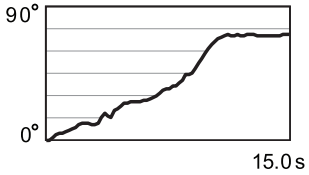
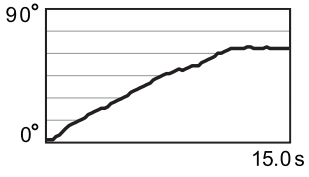
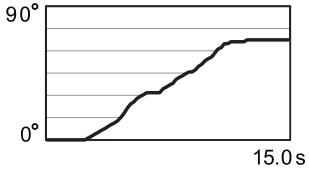
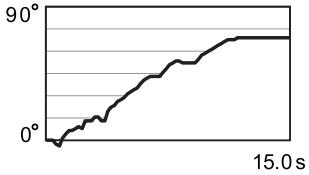
Probability of Success





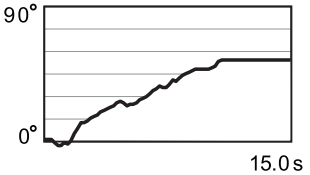


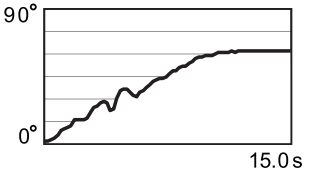


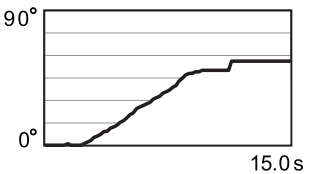
- Data driven model of instantaneous probability of success.

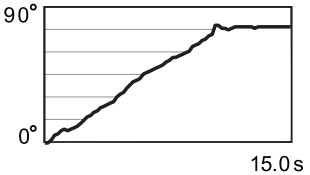
$$\mathcal{M} : s([0,t]) \longrightarrow p(t)$$

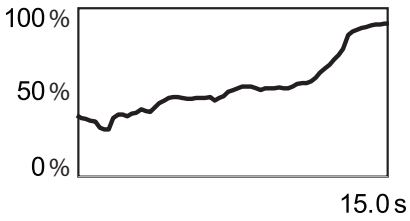
- Relevance Vector Machine.
- Principal Component Analysis.

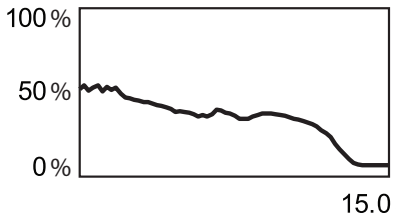












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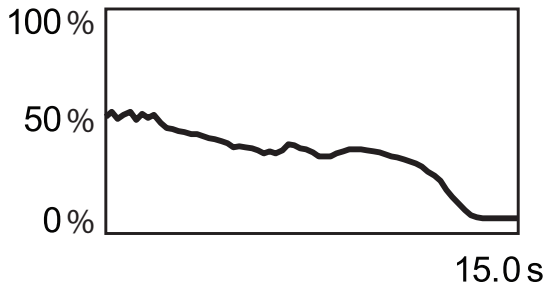
Abort and Retry



- Threshold the probability of success?
  - ✓ Discretize the system: $S_1, S_2 \ldots S_n$
  - ✓ Instantaneous probabilities: $p_1, p_2 \ldots p_n$
  - ✓ Abort thresholds: $\pi_1, \pi_2 \ldots \pi_n$
  - ✓ Transition probabilities

$$P_i = P\left[S_i \rightarrow S_{i+1}\right]$$

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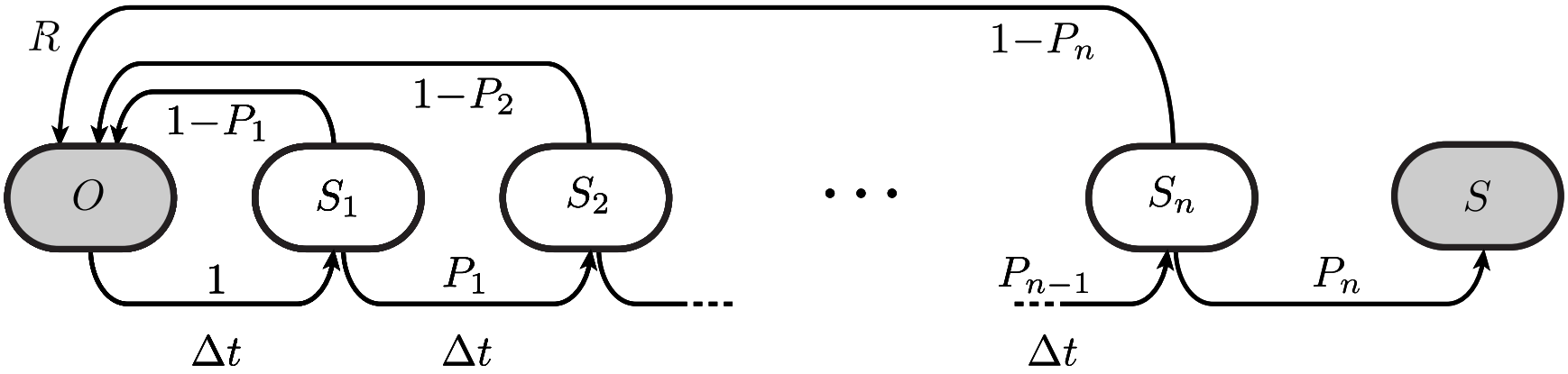
Abort and Retry Model

- Markov Chain



- Transition cost Δt
- Abort cost R

Time Successful Grasp

$$\tau = \Delta t \left[\frac{1 + \sum_{i=1}^{n-1} \left(\prod_{j=1}^{i} P_j \right)}{\prod_{i=1}^{n} P_i} \right] + R \left[\frac{1 - \prod_{i=1}^{n} P_i}{\prod_{i=1}^{n} P_i} \right]$$

- Estimate first P_i to estimate τ
  - ✓ Given N grasp executions.
  - ✓ Choose thresholds.
  - ✓ Estimate $P_i = \dfrac{\text{Grasps reach } S_{i+1}}{\text{Grasps reach } S_i}$
  - ✓ Compute τ
- Off the shelf direct search optimizer.

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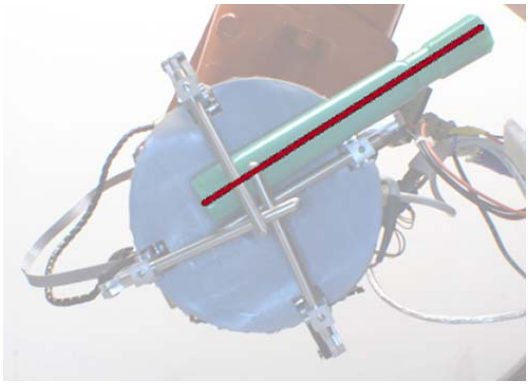
Implementation

- ROS
- State machine that implements the Markov Chain.
  - ✓ Robot controller.
  - ✓ Grasp controller.
  - ✓ Vision interface.
  - ✓ Learning interface.



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Results

n	τ	Improvement
1	2.17	-
2	2.12	4.3%
4	1.98	16.5%
8	1.91	22.0%
16	1.58	50.4%

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Take Home Message

- Simple Hands are less capable than Complex Hands but more capable than we think.
- Use proprioception to observe the grasp process.

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