Abort and Retry in Grasping

IROS 2011 - San Francisco

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Alberto Rodriguez, Matthew T. Mason, Siddhartha S. Srinivasa, Matthew Bernstein and Alex Zirbel
Abort and Retry
... or Fast Fumbling

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What do we need

- We need to detect or predict failure.
- We need a rule to decide when to abort.
- (We need a task)
Bin-Picking

- Goal: Singulation.
- High clutter.
- High pose uncertainty.
- Blind grasping.

✓ OK to fail.
Bin-Picking

• Grasp signature.
• Success/Failure.
• Success ratio 42%

\[ \tau = 2.17 \]
We can do better
Probability of Success

- Model of instantaneous probability of success.

\[ M : s([0, t]) \rightarrow p(t) \]

- (Relevance Vector Machine with PCA.)
Abort and Retry

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

• Stochastic optimization problem. Brute Force?
  ✓ Transition probabilities

\[ P_i = P [S_i \rightarrow S_{i+1}] \]
Abort and Retry Model

- Transition cost $\Delta t$
- Abort cost $R$
- Time-homogeneous Markov Chain
Time Successful Grasp

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

- Estimate first \( P_i \) to estimate \( \tau \)
  - Given \( N \) grasp executions.
  - Choose thresholds.
  - Estimate \( P_i = \frac{\text{Grasps reach } S_{i+1}}{\text{Grasps reach } S_i} \)
  - Compute \( \tau \)

- Standard optimization problem
  - Integrated out stochasticity.
Results

• Set of 200 grasps.

<table>
<thead>
<tr>
<th>n</th>
<th>$\tau$</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.17</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2.12</td>
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<tr>
<td>4</td>
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<tr>
<td>8</td>
<td>1.91</td>
<td>22.0%</td>
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</tbody>
</table>

• Main limitation:
  Number of grasp before signature degradation.
Take Home Message

• Failure prediction is possible and useful.

• Contribution: Mathematical model for fast fumbling.

Questions?