Robot Programming for Assembly Task

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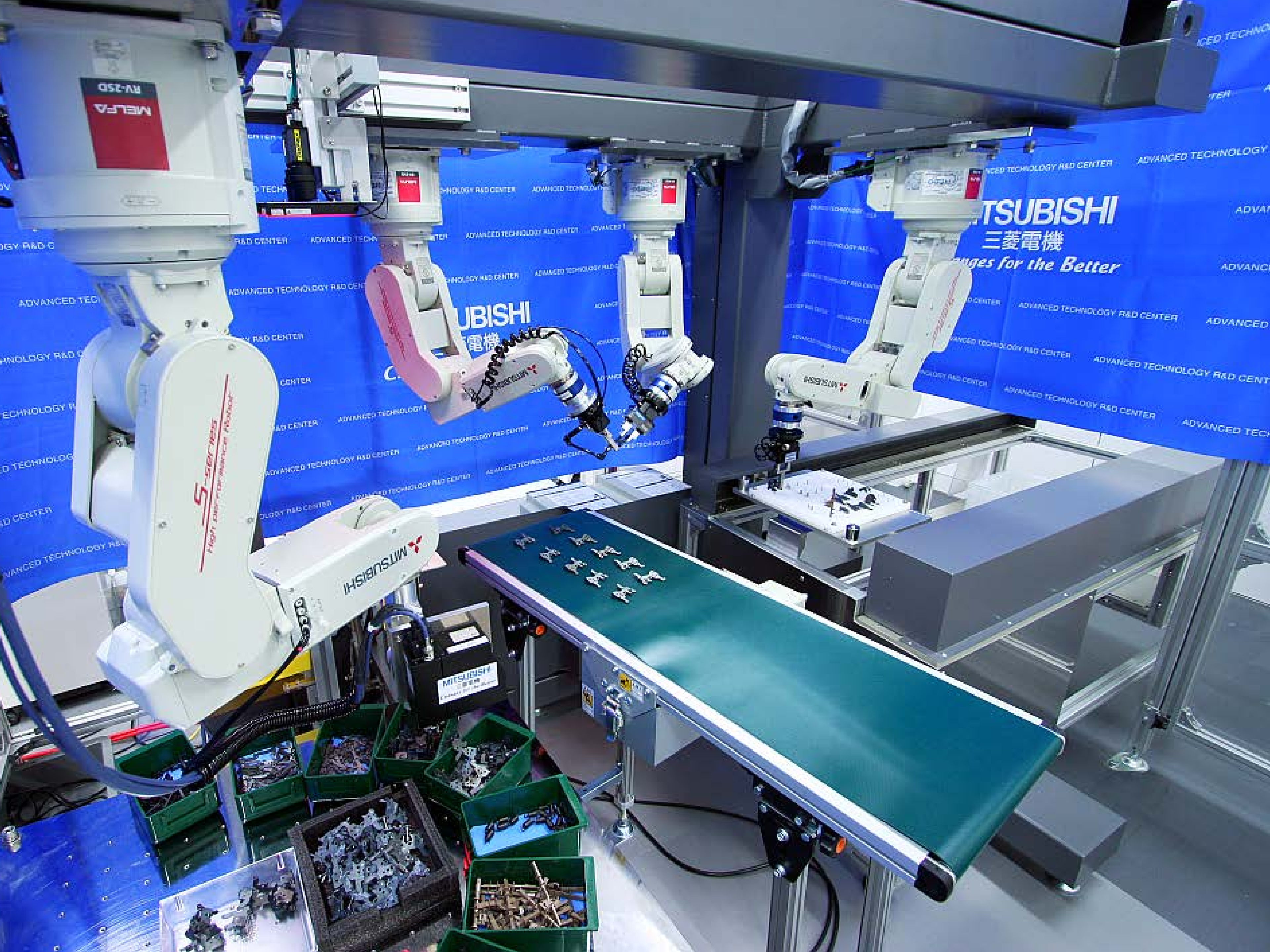
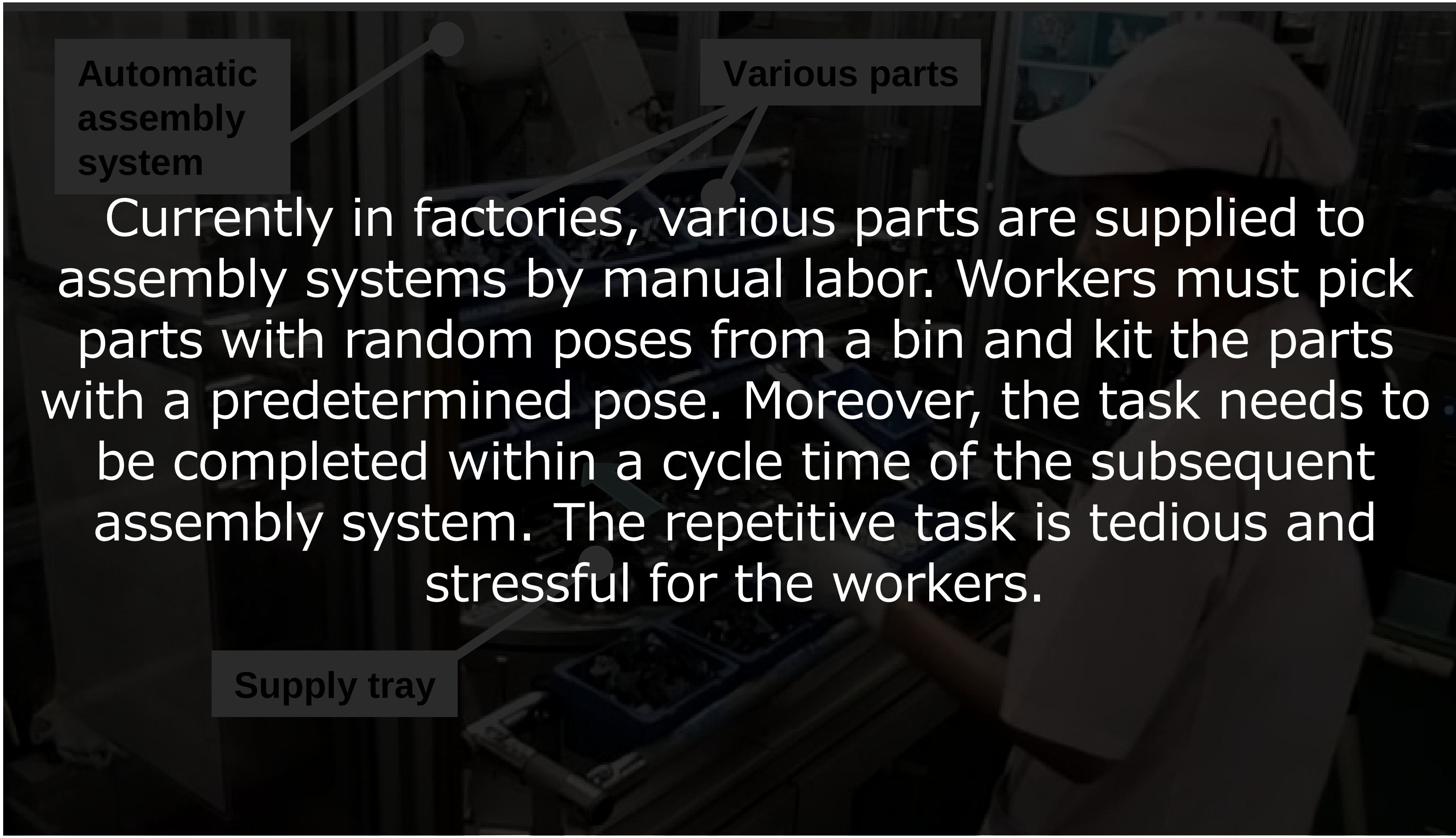
Motion Planning for Industrial Robots
ICRA 2014, June 05

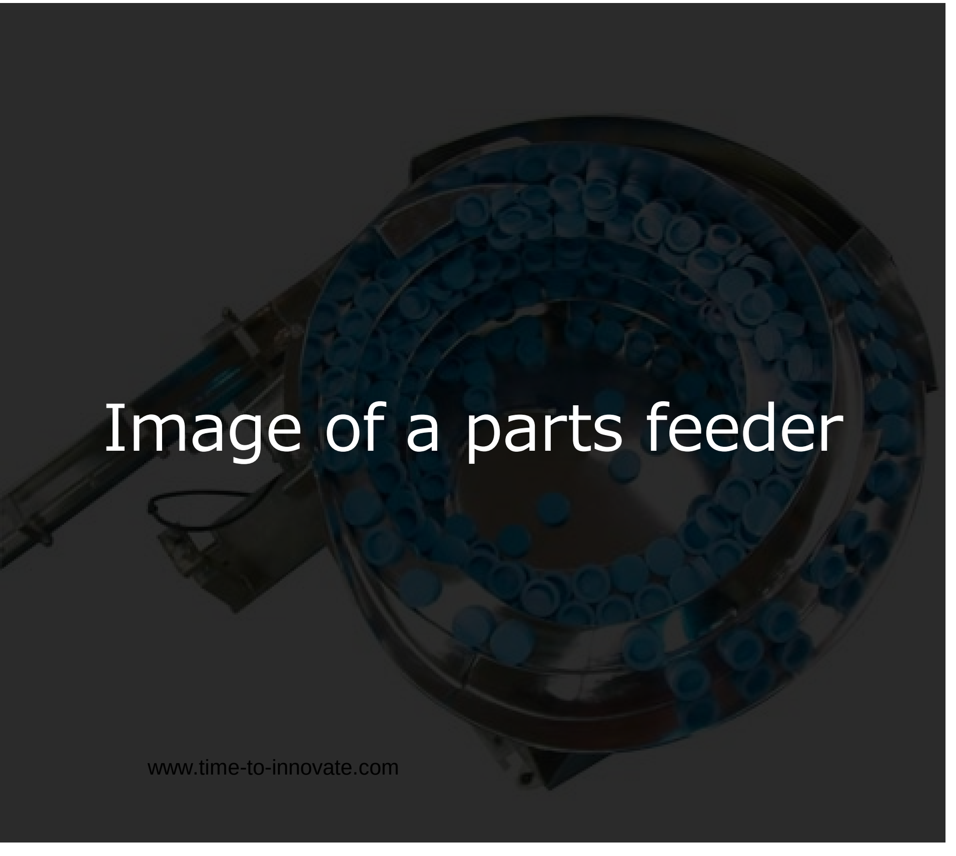

MITSUBISHI
三菱電機
ADVANCED TECHNOLOGY R&D CENTER
S-series
High performance Robot
MITSUBISHI

Motivation



Currently in factories, various parts are supplied to assembly systems by manual labor. Workers must pick parts with random poses from a bin and kit the parts with a predetermined pose. Moreover, the task needs to be completed within a cycle time of the subsequent assembly system. The repetitive task is tedious and stressful for the workers.

Conventional method 1



Parts feeders

- Require custom designs for each object

⇒ **Long lead time**

- Require the same number of parts feeder as many as the number of types of object shapes

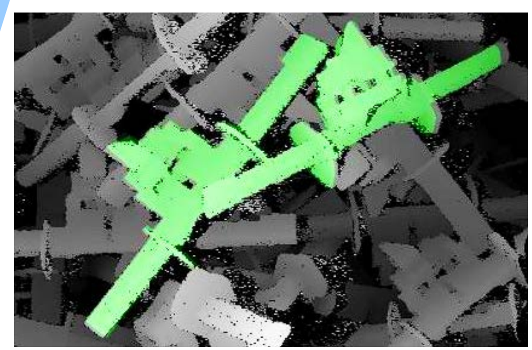
⇒ **Large space and high cost**

Conventional method 2

Robot system (3D sensor and robot arm)

3D sensor

Depth map

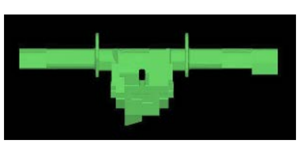


pose estimation

Gripper pose

Grasping

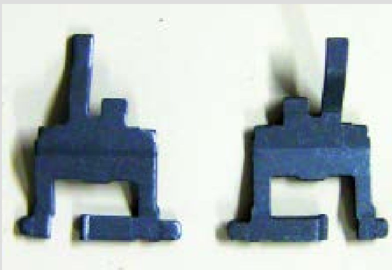
Matching

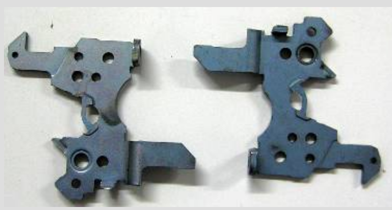


Object model

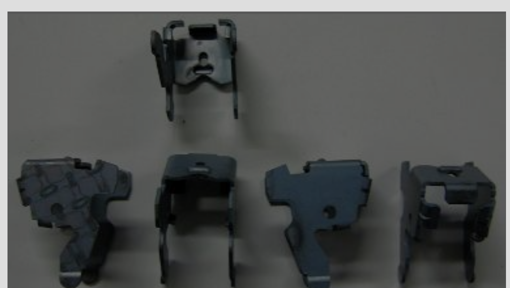
Applicable objects

Plane





Box



Spring

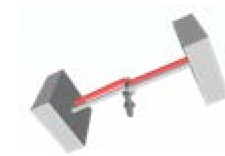
Cylinder

Others

Problem

Need object pose estimation?

Need regrasping?
How to regrasp?



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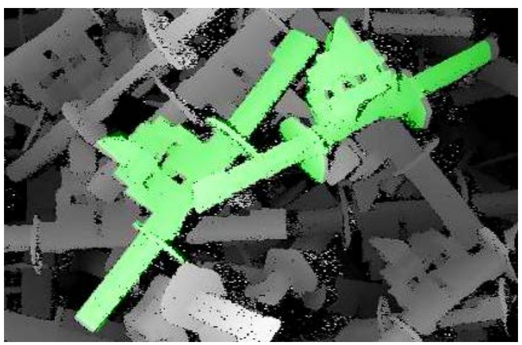
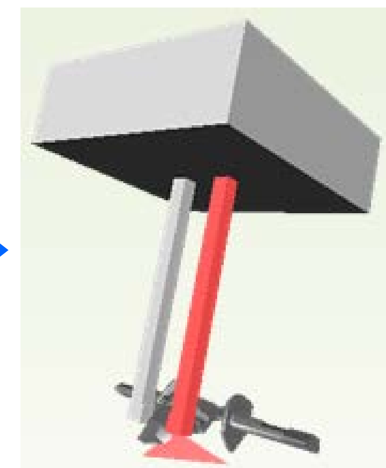


Finding

Grasping

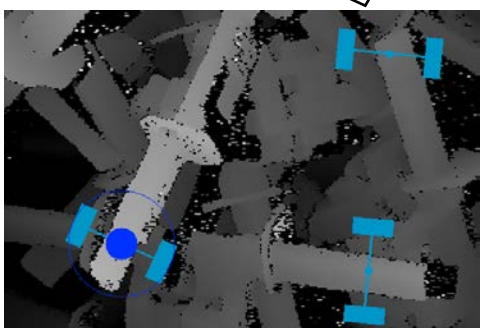


Kitting

Our solution

Fast graspability evaluation for object isolation

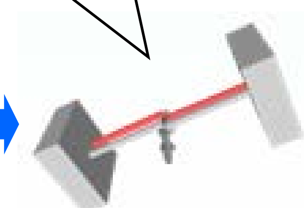
Regrasp motion planning



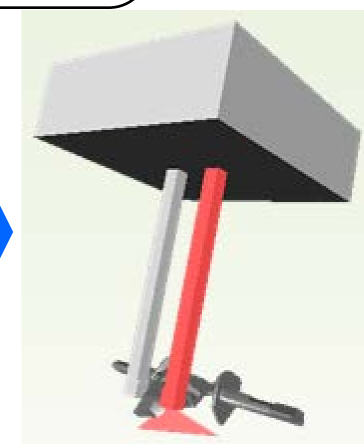
Finding

Grasping

Placing
on
a planer table



Regrasping

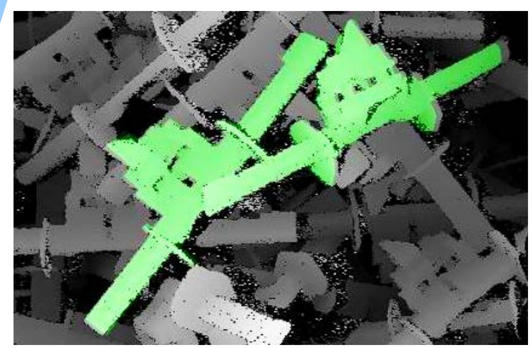


Kitting

Fast graspability evaluation

3D vision sensor

Depth map

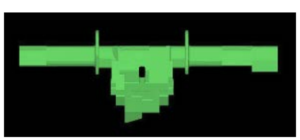


pose estimation

Gripper pose

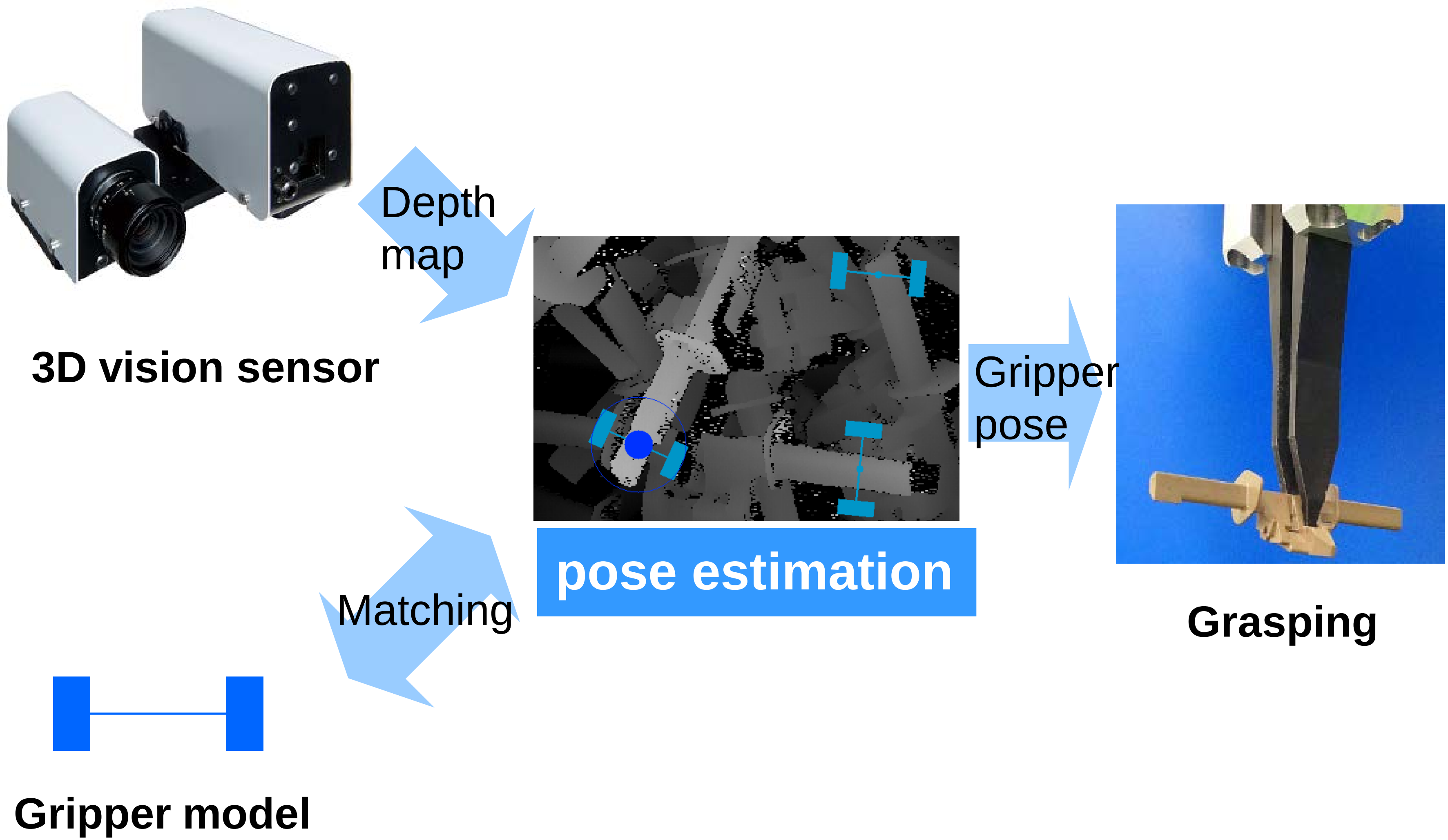
Grasping

Matching



Object model

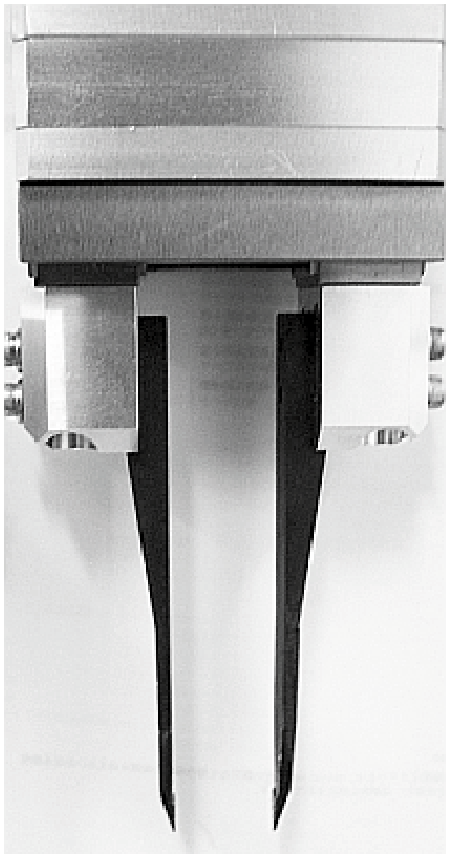
Fast graspability evaluation

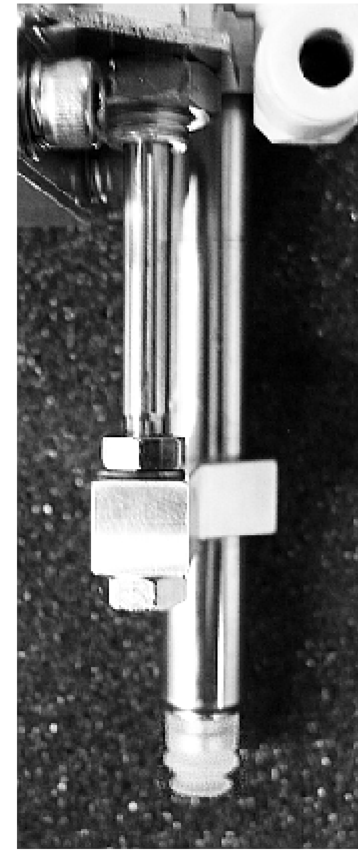


Y.Domae, H.Okuda, et.al. “Fast Graspability Evaluation on a Single Depth Maps for Bin-picking with General Grippers”, ICRA2014

Algorithm

For each grippers,
we define
its contact and collision region
using two masks





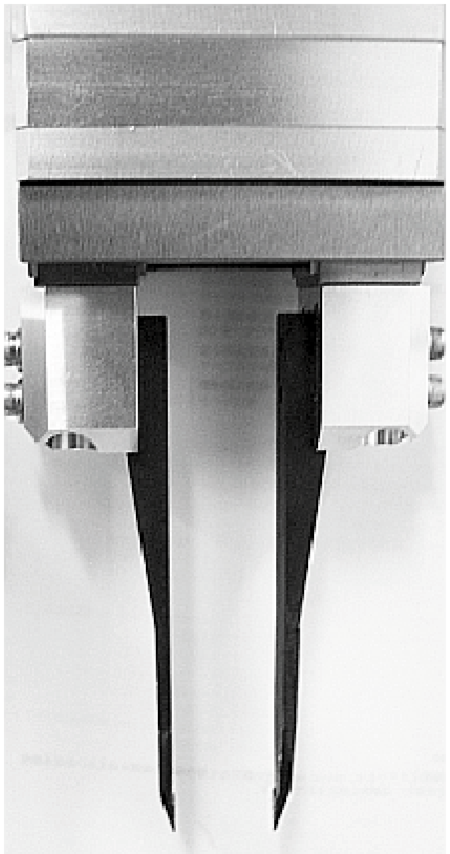
2-finger

Vacuum

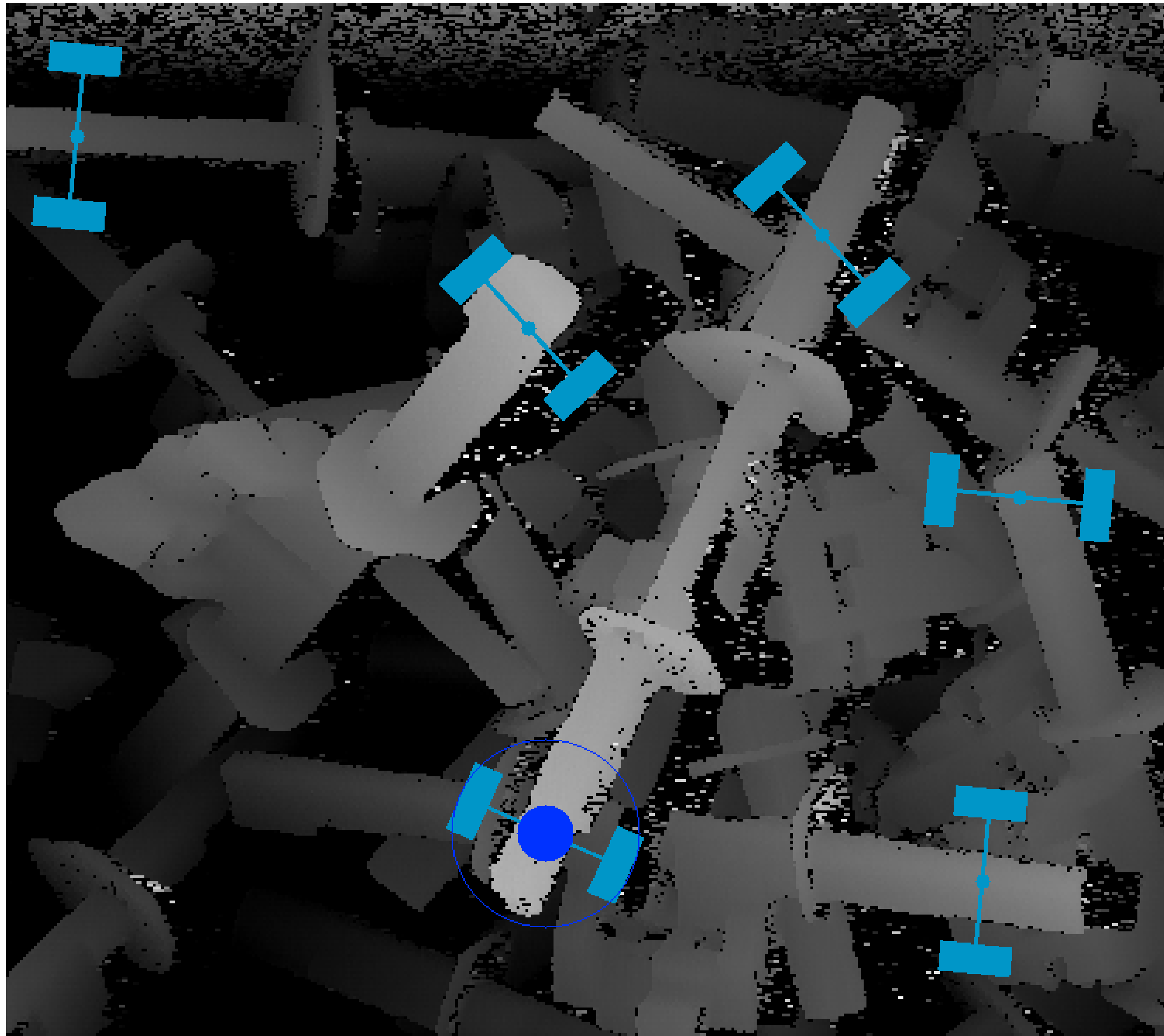
Y.Domae, H.Okuda, et.al. “Fast Graspability Evaluation on a Single Depth Maps for Bin-picking with General Grippers”, ICRA2014

Algorithm

We compute the graspability map by filtering a depth map with the masks

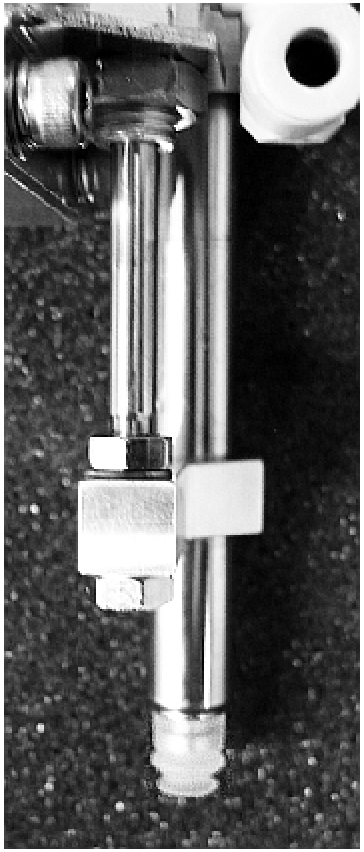


2-finger

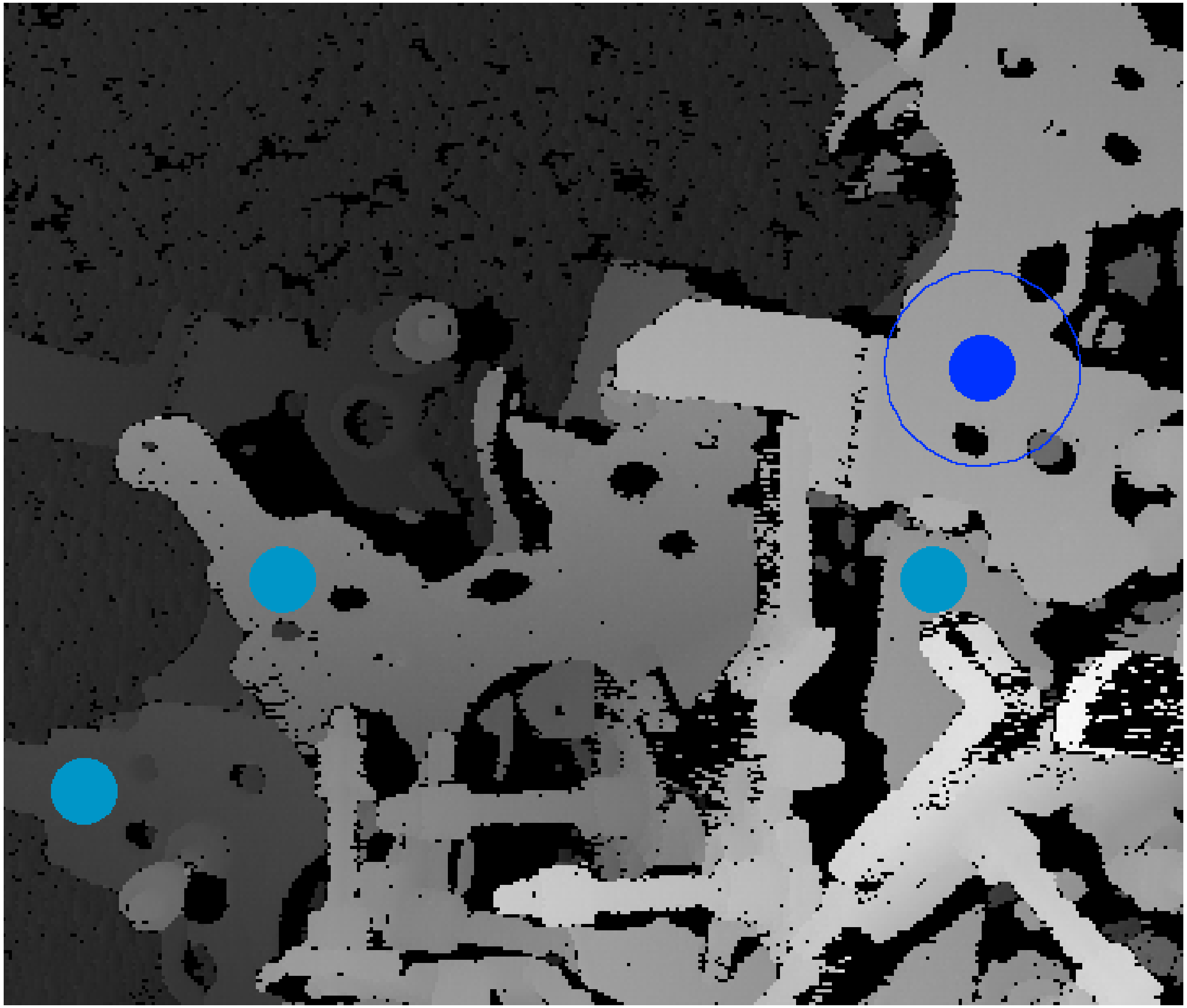


Algorithm

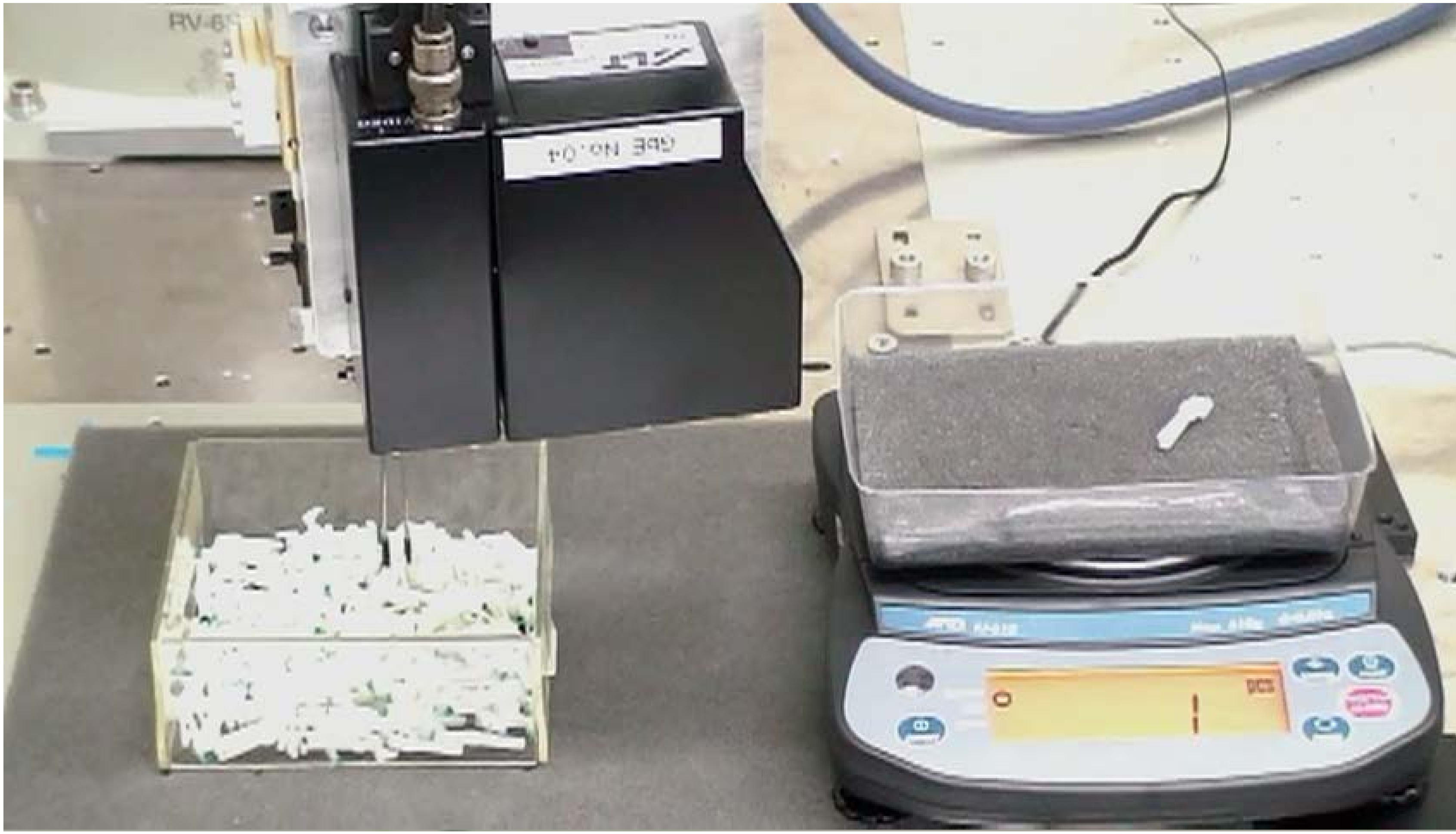
We compute the graspability map by filtering a depth map with the masks



Vacuum



Demo

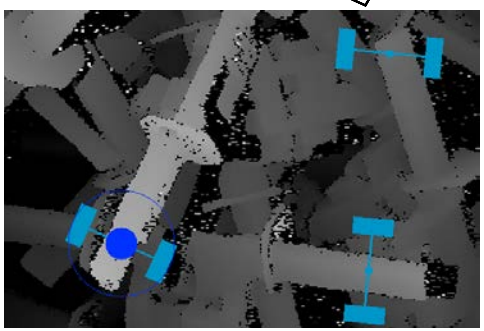


Y.Domae, H.Okuda, et.al. “Fast Graspability Evaluation on a Single Depth Maps for Bin-picking with General Grippers”, ICRA2014

Our solution

Pick-and-place
for object isolation

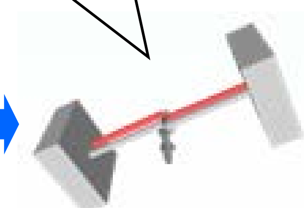
Regrasp motion planning



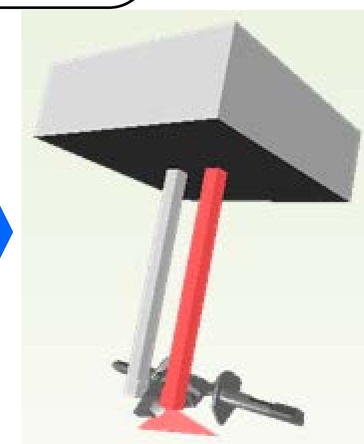
Finding

Grasping

Placing
on
a planer table

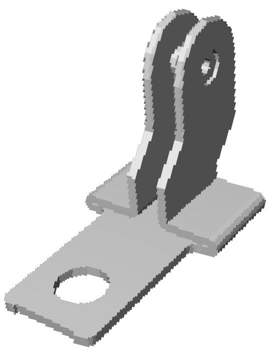


Regrasping



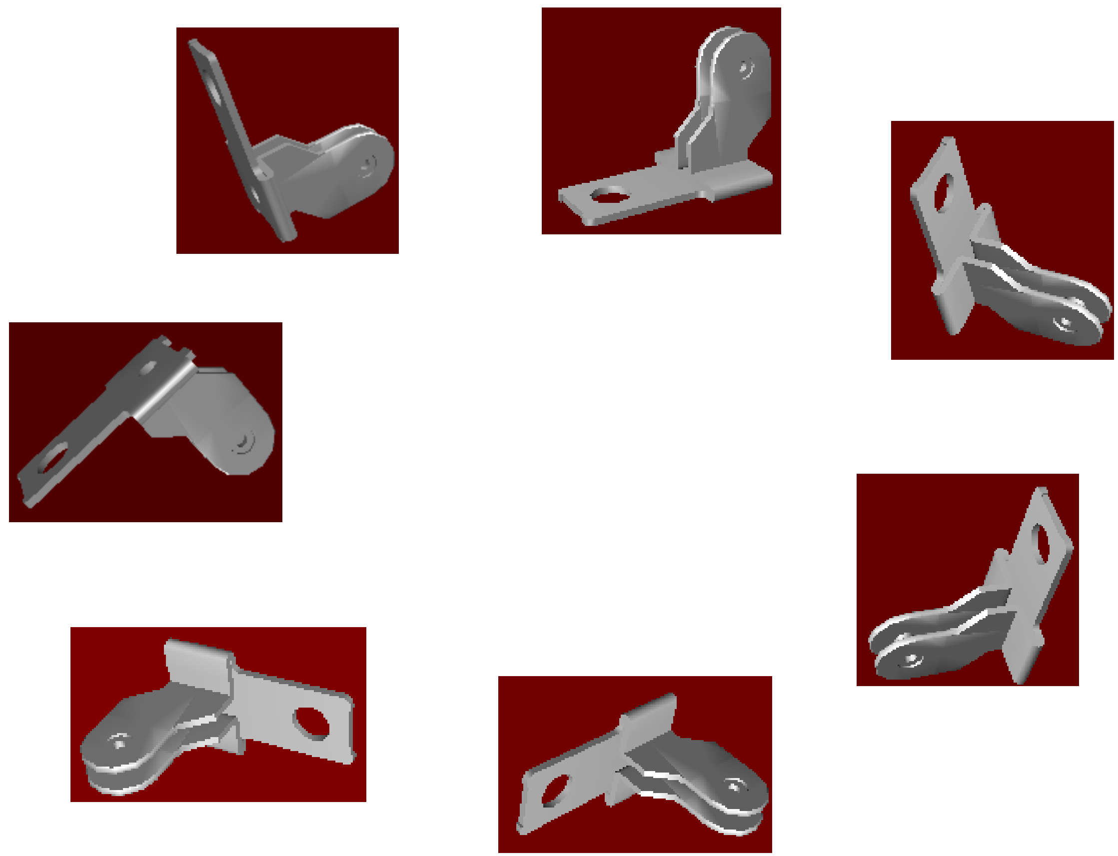
Kitting

Regrasp motion planning



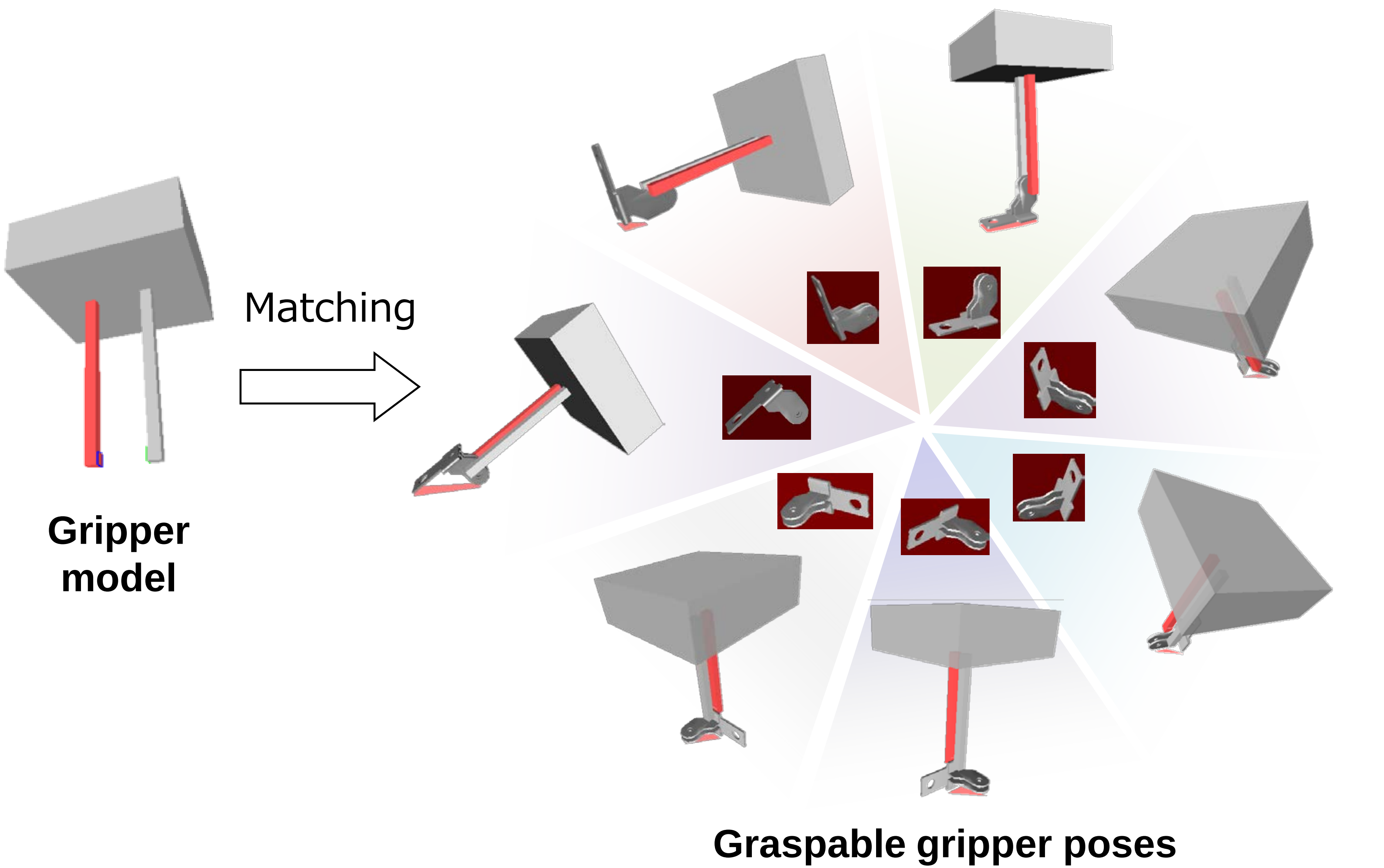
Object model

Physical simulation

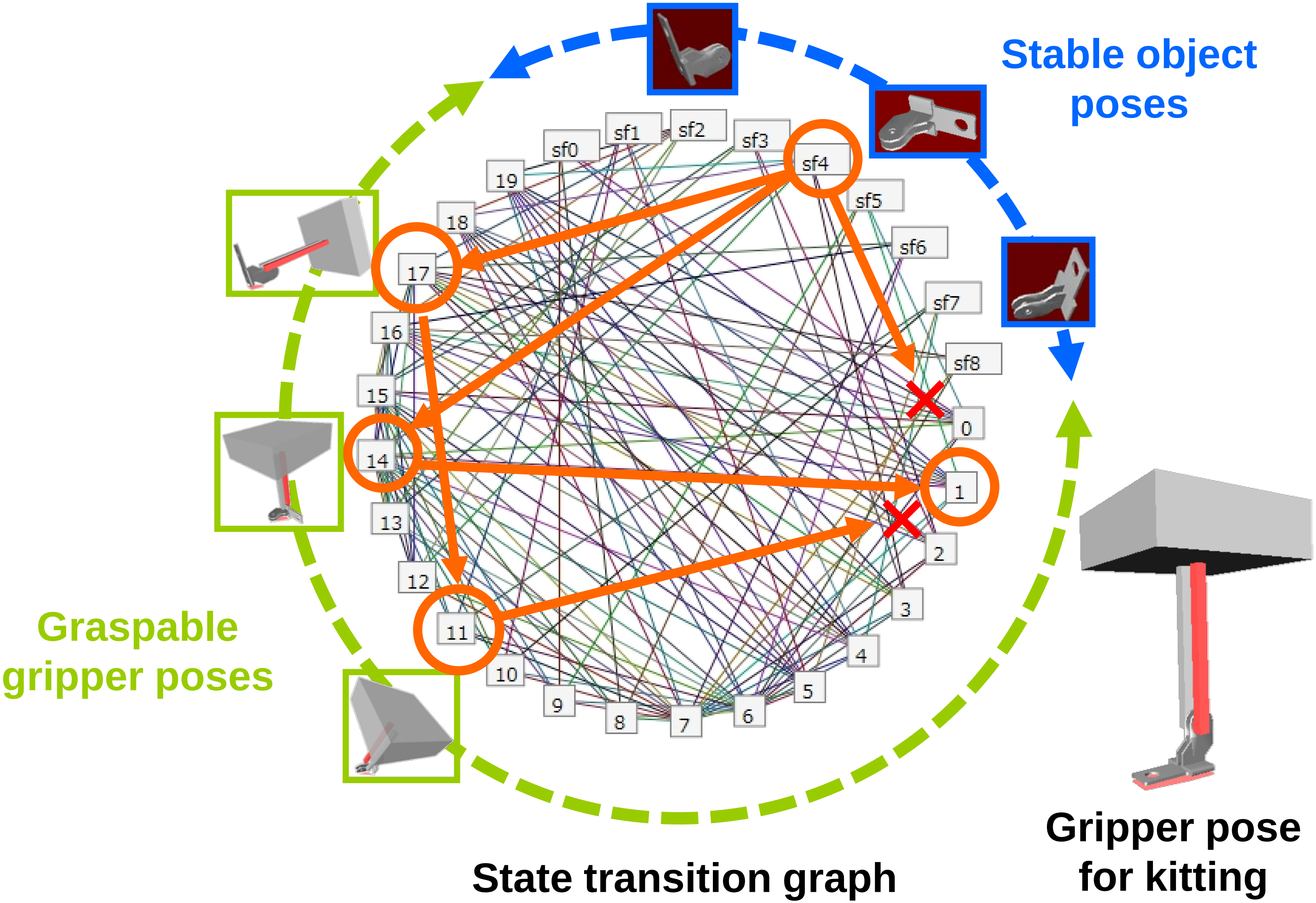


Stable poses on a planer table

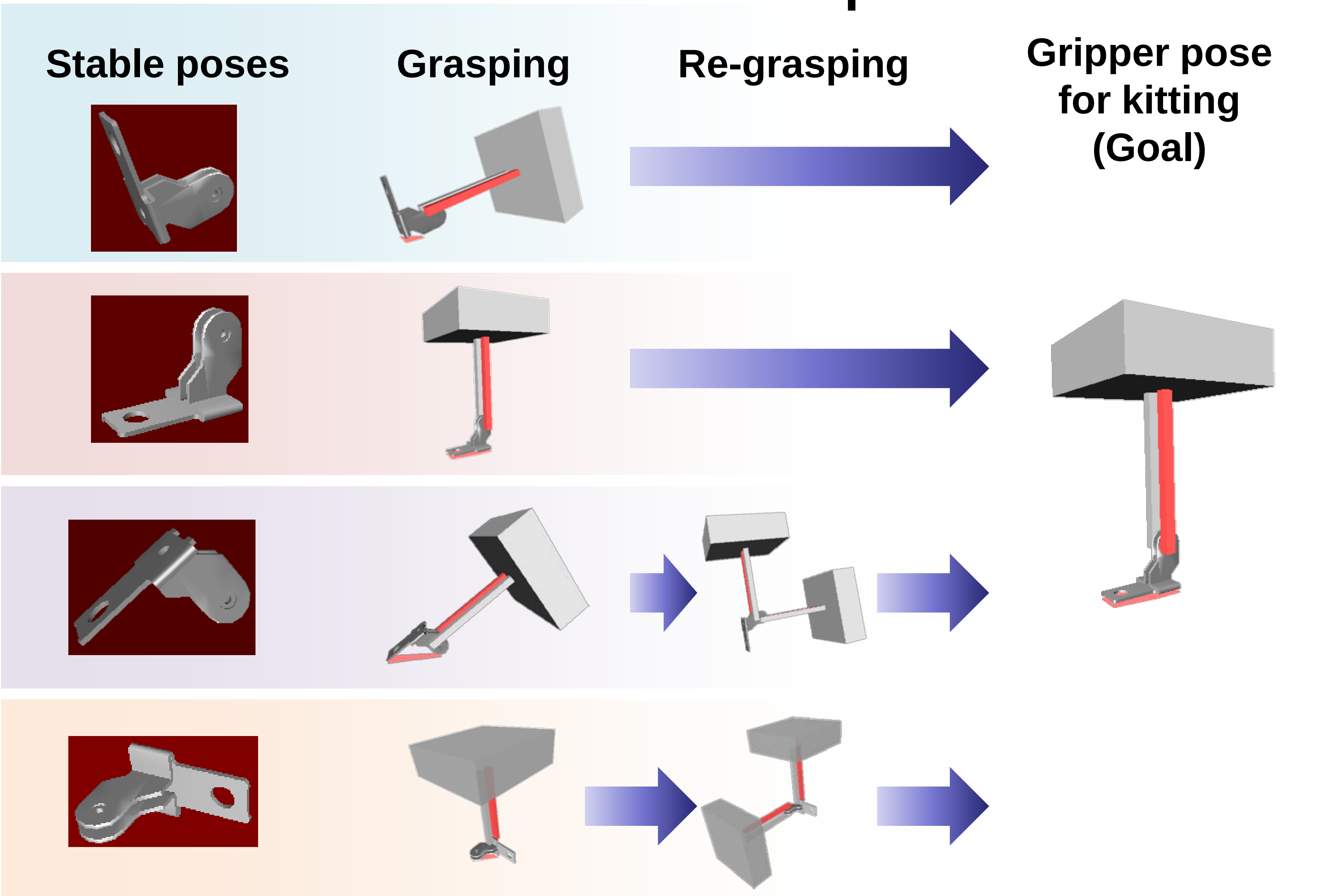
Regrasp motion planning



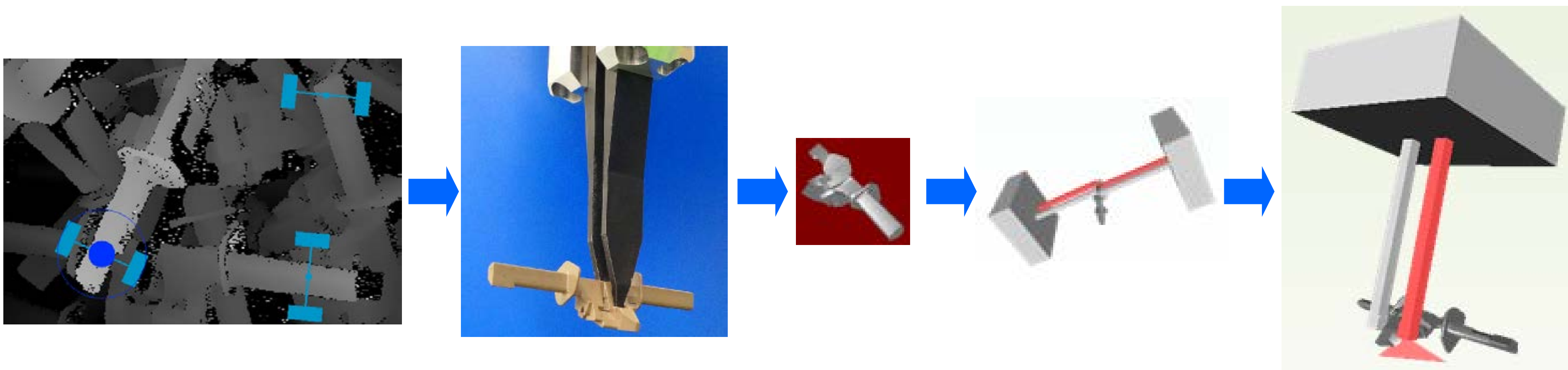
Regrasp motion planning



Result examples



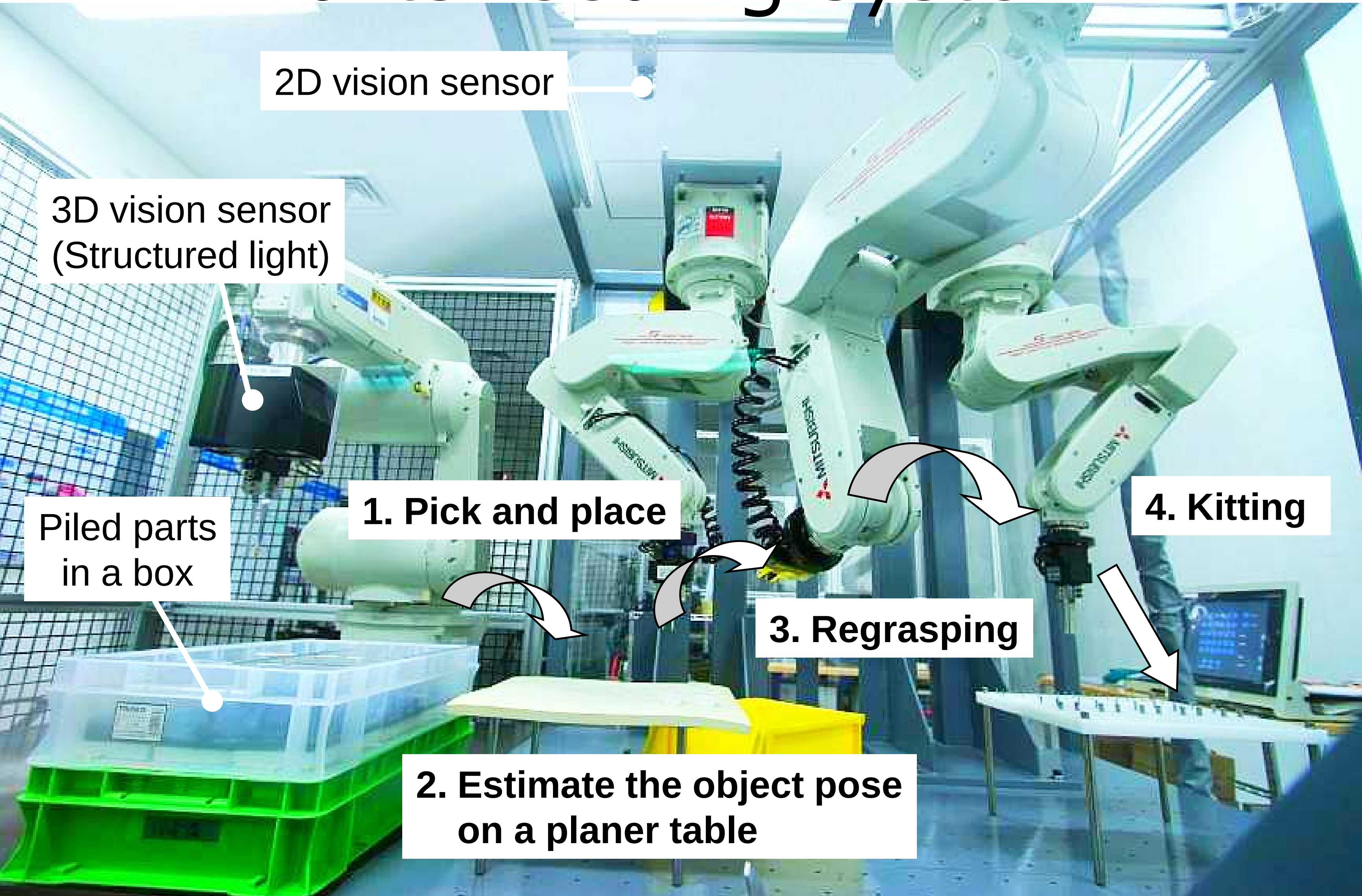
Our solution



Finding **Grasping** **Placing** **Regrasping** **Kitting**

on
a planer table

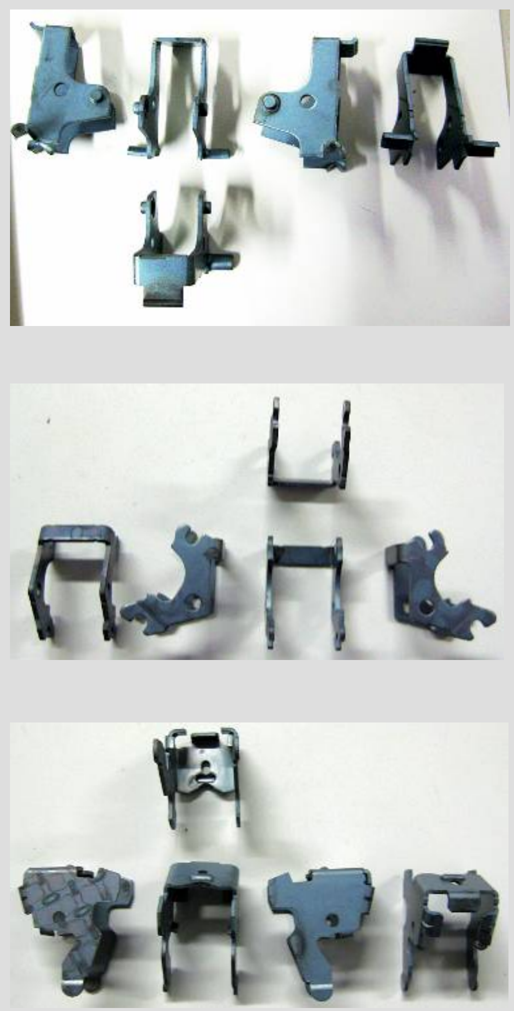
Parts feeding system



Applicable objects

Plane

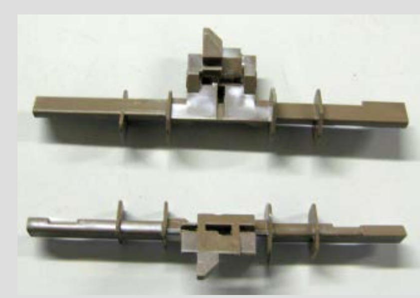
Box



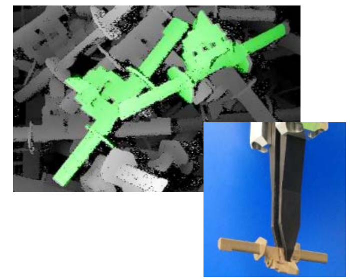
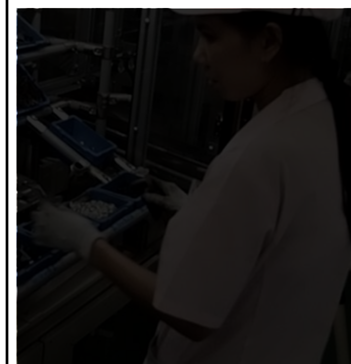
Spring

Cylinder

Others



Comparisons

	Our method 	Parts feeders 	Traditional robot system 	Manual labor 
Arbitrary part shapes	OK	NG	NG	OK
Cycle time	3～5 seconds	1～2.5 seconds	3.5～10 seconds	1～3 seconds
Lead time for product change	2～3 days for robot programming	1 month for H/W renewal	2 weeks for S/W renewal	1 hour for starting 2 weeks for mastership

Conclusion

- We developed the parts feeding system for industrial small parts including two algorithms.

  - Fast graspability evaluation
  - Regrasp motion planning

- We evaluated the system performance

  - Applicable to general object shape
  - Cycle time : 3～5 seconds
  - Lead time : 2～3 days

- We released the 3D sensor incluing the algorithms in Japan in 2013

Discussion

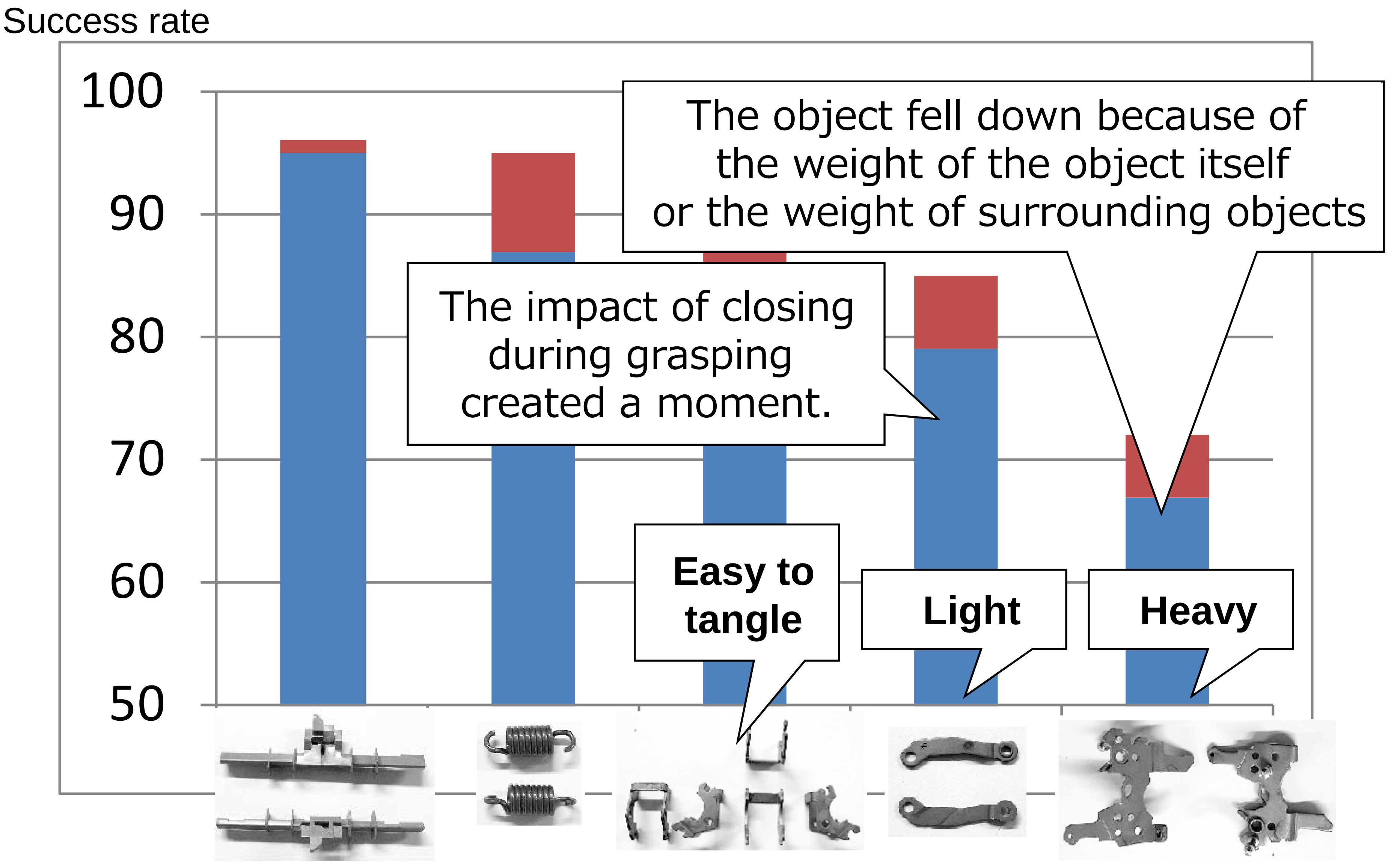
There are still some challenges···

1. Improvement of the Success rate

2. System downsizing

3. Full automation of the regrasping

Improvement of success rate



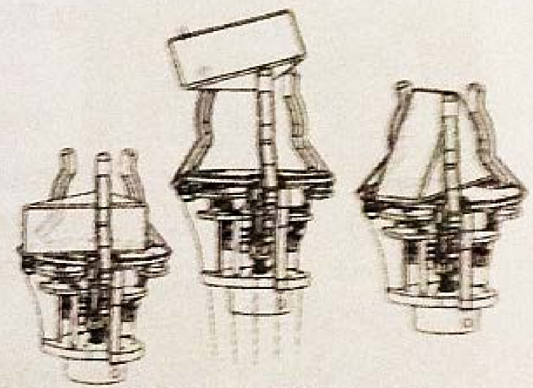
System downsizing

Need dexterous manipulation?

Regrasping Objects using Extrinsic Dexterity

Nikhil Chavan Dafle[1], Alberto Rodriguez[1], Robert Paolini[2], Bowei Tang[2], Siddhartha S. Srinivasa[2], Michael Erdmann[2], Matthew T. Mason[2], Ivan Lundberg[3], Harald Staab[3] and Thomas Fuhlbrigge[3]
[1]The Dept. of Mechanical Engineering, Massachusetts Institute of Technology, US
[2]The Robotics Institute, Carnegie Mellon University, US
[3] ABB Corporate Research Center, US

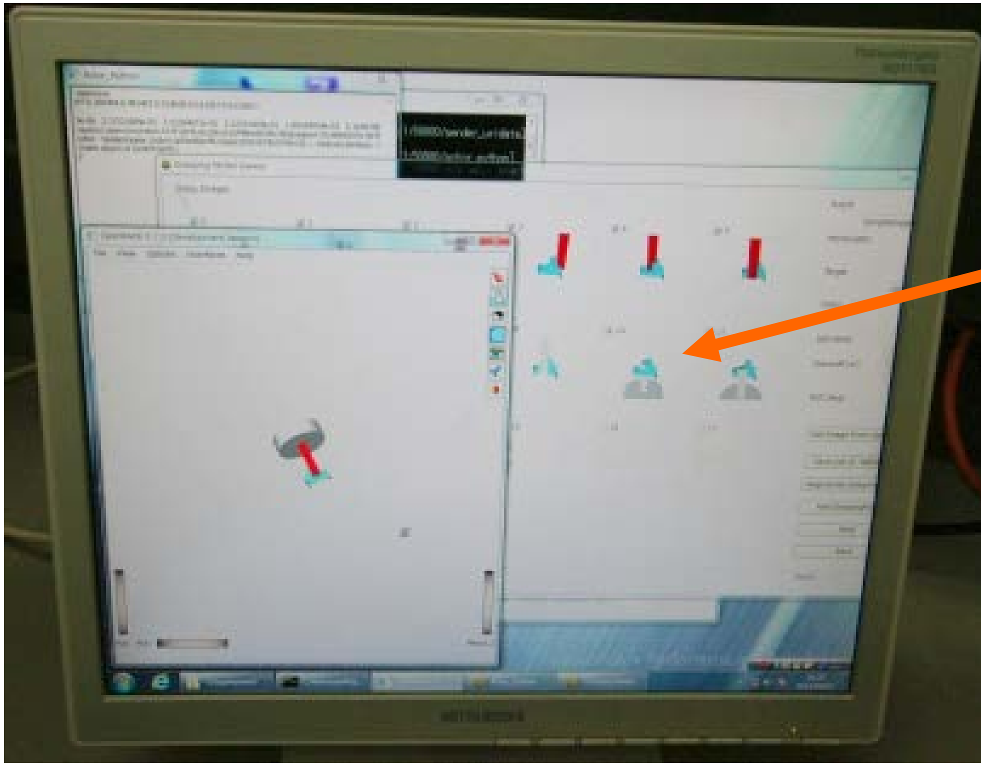
- Gravity, dynamic motions of a manipulator and external contacts can be exploited to regrasp objects in the hand.
- We demonstrate a repertoire of regrasp actions developed for a simple robotic hand.
- Sequence of regrasps shows compatibility of regrasp and broader manipulation capability of them when connected.

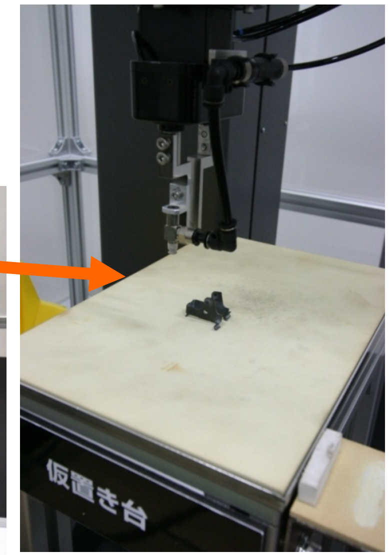


Throw and flip regrasp

Regrasping by single gripper (ICRA2014)

Full automation of regrasping





- We implement the regrip motion planning algorithm to S/W for assistance of robot teaching by manual labor.

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Hiroki Dobashi
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Thank you