Industrial Robots for Everyone!

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Why Japan?

- 50% of industrial robots are Japanese

- Sushi

Mujin Origins

- Founded and managed OpenRAVE (8+ years)
  - Started at CMU Motion Planning Group (**James Kuffner**)
  - Planned for 1000+ robots
- Postdoc at Univ of Tokyo JSK Lab (**Masayuki Inaba, Kei Okada**)
- Co-founded with genius Japanese sales engineer in 2011
- Initial core team joined in 2012 (MIT, RPI)
- Today: *Selling motion planning products and scaling!*

Customer Feedback Drives Technology Progress

Industrial Robots Increase Manufacturing Productivity
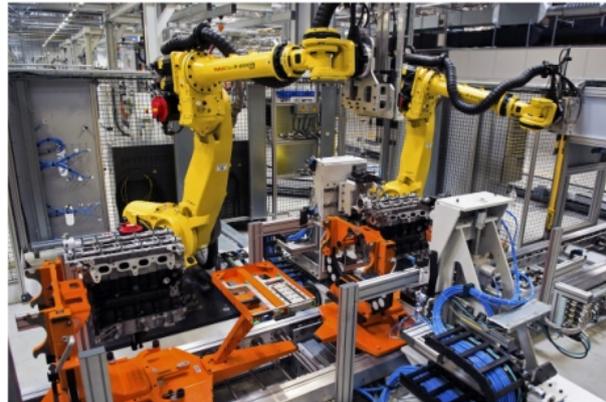

Engine Assembly

Real-time Bin-picking
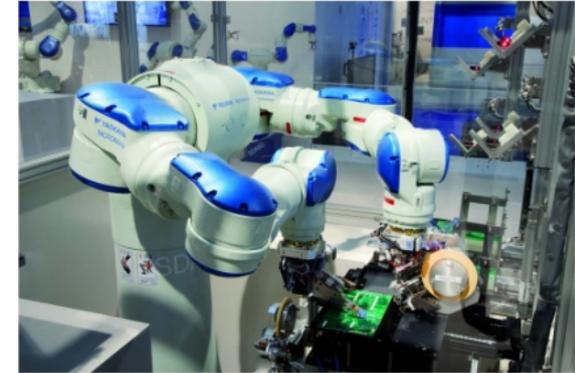
Simultaneous Dual-arm Planning

Part Inspection

Dual-arm Fluid Manipulation

7-DOF Planning

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Mujin Product Strategy

1. Replace offline teaching with cloud services
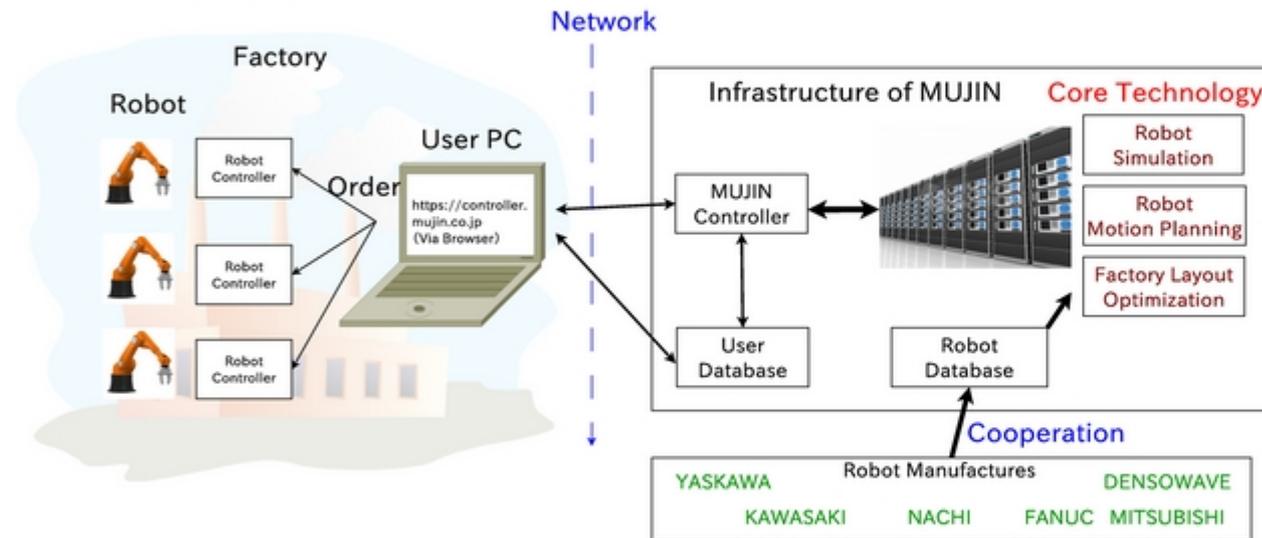
MUJIN controller

2. Offer new applications with Mujin Controller

MUJIN Laser Worker

MUJIN Pick Worker

Importance of Bin-picking
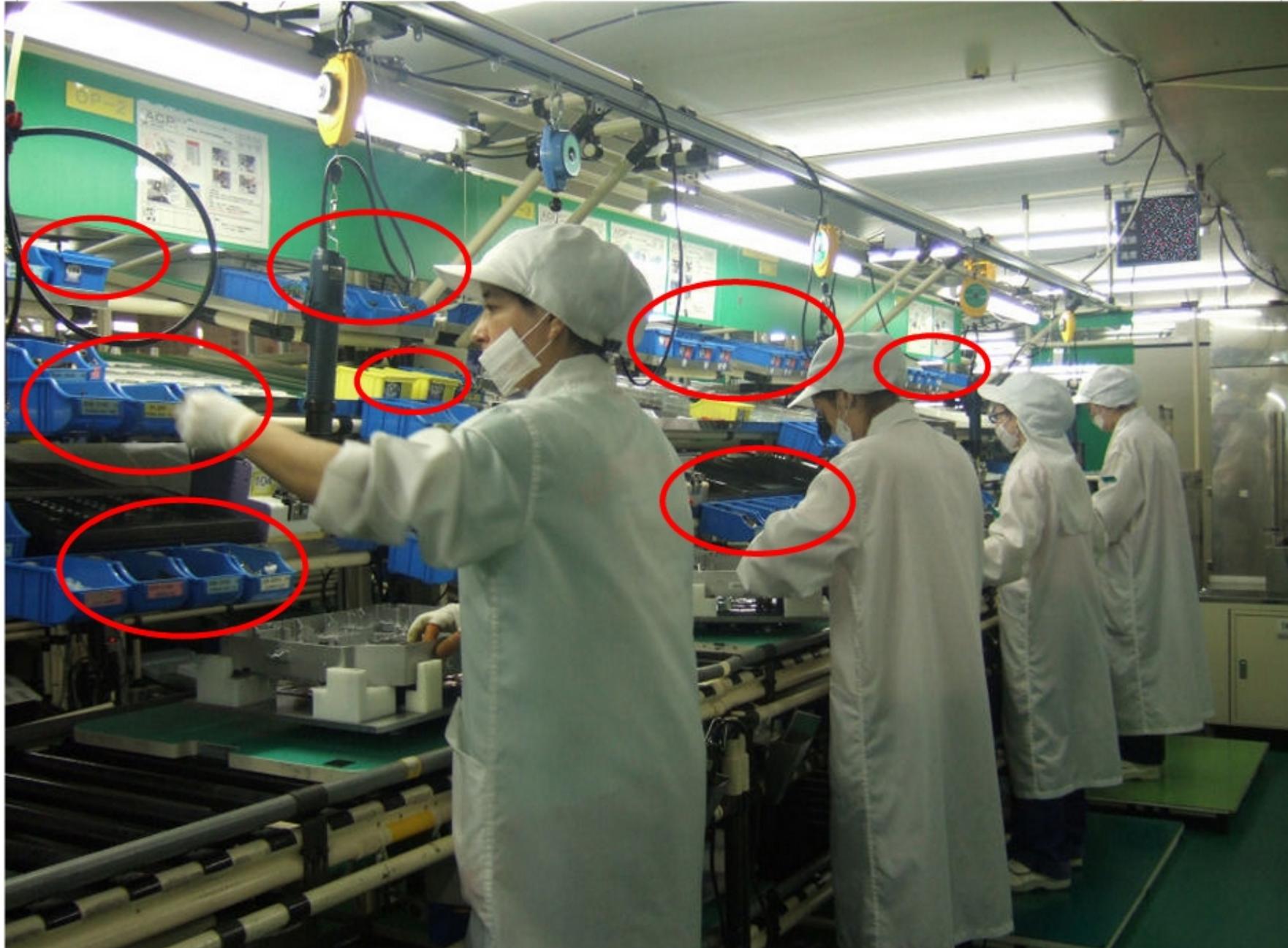
Mujin Binpicking

- https://www.youtube.com/watch?v=U_t04fC7L9U

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Arm Motion Planning Technologies

- COLLADA (ISO standard)

- Industrial Task Language (ITL)
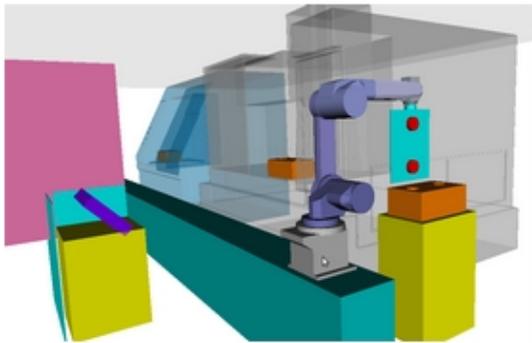
engine assembly
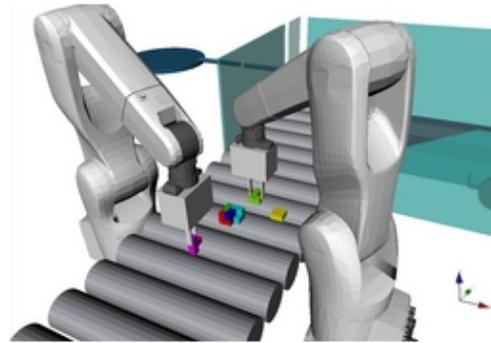
simultaneous dual-arm planning

real-time bin-picking
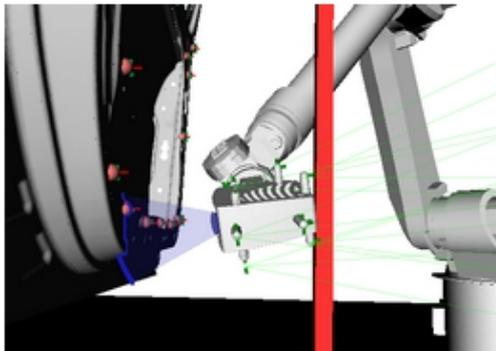
part inspection

dual-arm fluid-simulations

7-dof planning

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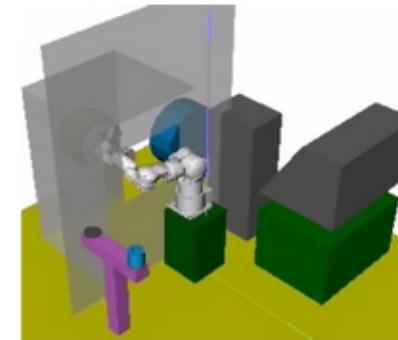
Robotics via HTTP

- Standardized on ISO/open 3D asset formats
  - 5 years writing all the infrastructure
- RESTful Web API for Motion Planning
  - 2 years of trial-and-error
  - Outside systems can easily integrate using any platform/language
- Browser
  - WebGL

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Product
Mujin Controller: World's First
Commercial Motion Controller for Factory Automation

3D models + high level task specification ➞ robot programs

```
 1  Set(tool,1)
 2  Set(clearance,0)
 3  Move(Translate(0,0,120)*p[pickup_jagariko1])
 4  MoveL(p[pickup_jagariko1])
 5  Grab(t[jagariko1])
 6  MoveL(Translate(0,0,120)*p[pickup_jagariko1])
 7
 8  Move(Translate(0,0,120)*p[P1])
 9  MoveL(p[P1],accuracy_dist=0.1)
10  Release(t[jagariko1])
11  MoveL(Translate(0,0,120)*p[P1])
12
13  Move(Translate(0,0,120)*p[pickup_jagariko2])
14  MoveL(p[pickup_jagariko2])
15  Grab(t[jagariko2])
16  MoveL(Translate(0,0,120)*p[pickup_jagariko2])
17
18  Move(Translate(0,0,120)*p[P3])
19  MoveL(p[P3],accuracy_dist=0.1)
20  Release(t[jagariko2])
21  MoveL(Translate(0,0,120)*p[P3])
```
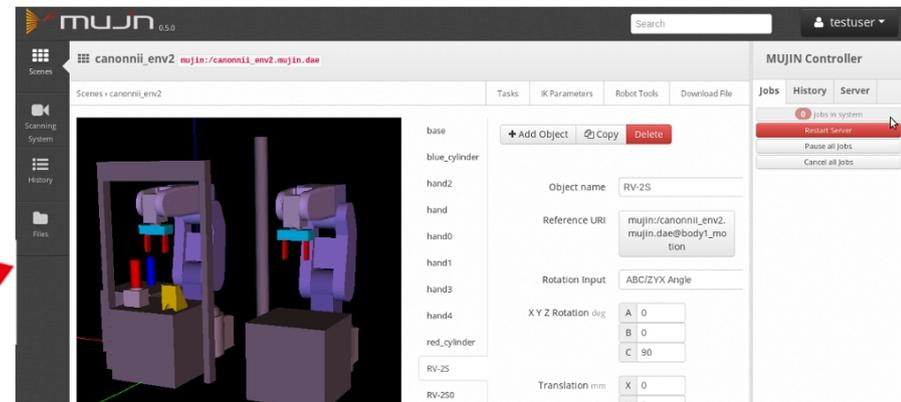
Industrial Task Language (ITL)

Browser interface with WebGL

- Create fast, efficient, and collision-free robot programs, **for any robot**
- **95%+** accuracy for real robot (<60% for other commercial simulators)
- Industrial Task Language
- model **any task**
- **Layout optimization**
- impossible without motion planning
- Browser interface with interactive 3D visualization

Industrial Task Language (ITL)
(pick-and-place)
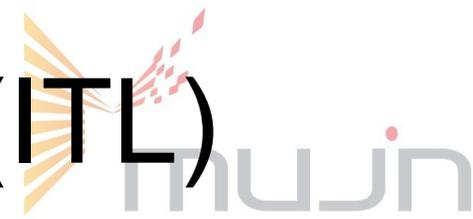
```
1  Set(tool,1)
2  Set(clearance,0)
3  Move(Translate(0,0,120)*p[pickup_jagariko1])
4  MoveL(p[pickup_jagariko1])
5  Grab(t[jagariko1])
6  MoveL(Translate(0,0,120)*p[pickup_jagariko1])
7
8  Move(Translate(0,0,120)*p[P1])
9  MoveL(p[P1],accuracy_dist=0.1)
10 Release(t[jagariko1])
11 MoveL(Translate(0,0,120)*p[P1])
12
13 Move(Translate(0,0,120)*p[pickup_jagariko2])
14 MoveL(p[pickup_jagariko2])
15 Grab(t[jagariko2])
16 MoveL(Translate(0,0,120)*p[pickup_jagariko2])
17
18 Move(Translate(0,0,120)*p[P3])
19 MoveL(p[P3],accuracy_dist=0.1)
20 Release(t[jagariko2])
21 MoveL(Translate(0,0,120)*p[P3])
```

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ITL Multi-robot

```
 1 # grab tool with right arm
 2 Set(tool, rightarm_torso)
 3 move(p[mountpoint1])
 4 grab(t[hand1])
 5 move(translation(0,0,80)*p[mountpoint1])
 6 # grab tool with left arm
 7 Set(tool, leftarm_torso)
 8 move(p[mountpoint2])
 9 grab(t[hand2])
10 move(translation(0,0,70)*p[mountpoint2])
11 # grab the assembly with left hand
12 Set(tool, tool1)
13 move(translation(0,0,20)*p[P7])
14 movel(p[P7])
15 grab(t[assembly_plate])
16 move(translation(0,0,50)*p[P6])
17 movel(translation(0,0,30)*p[P6])
18 release(t[assembly_plate])
19 movel(translation(0,0,50)*p[P6])
```

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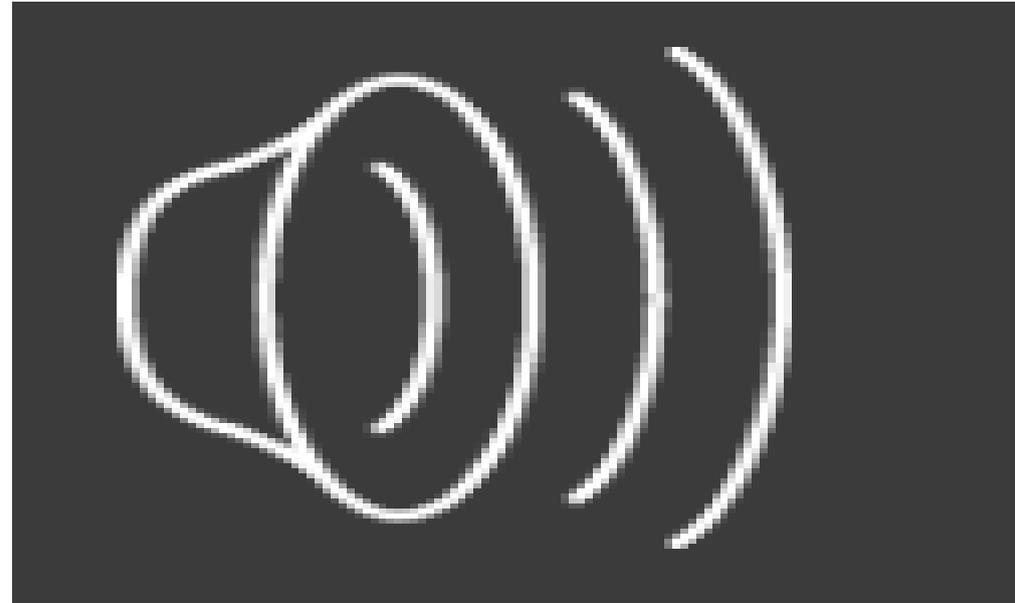
# ITL Compilation Graph
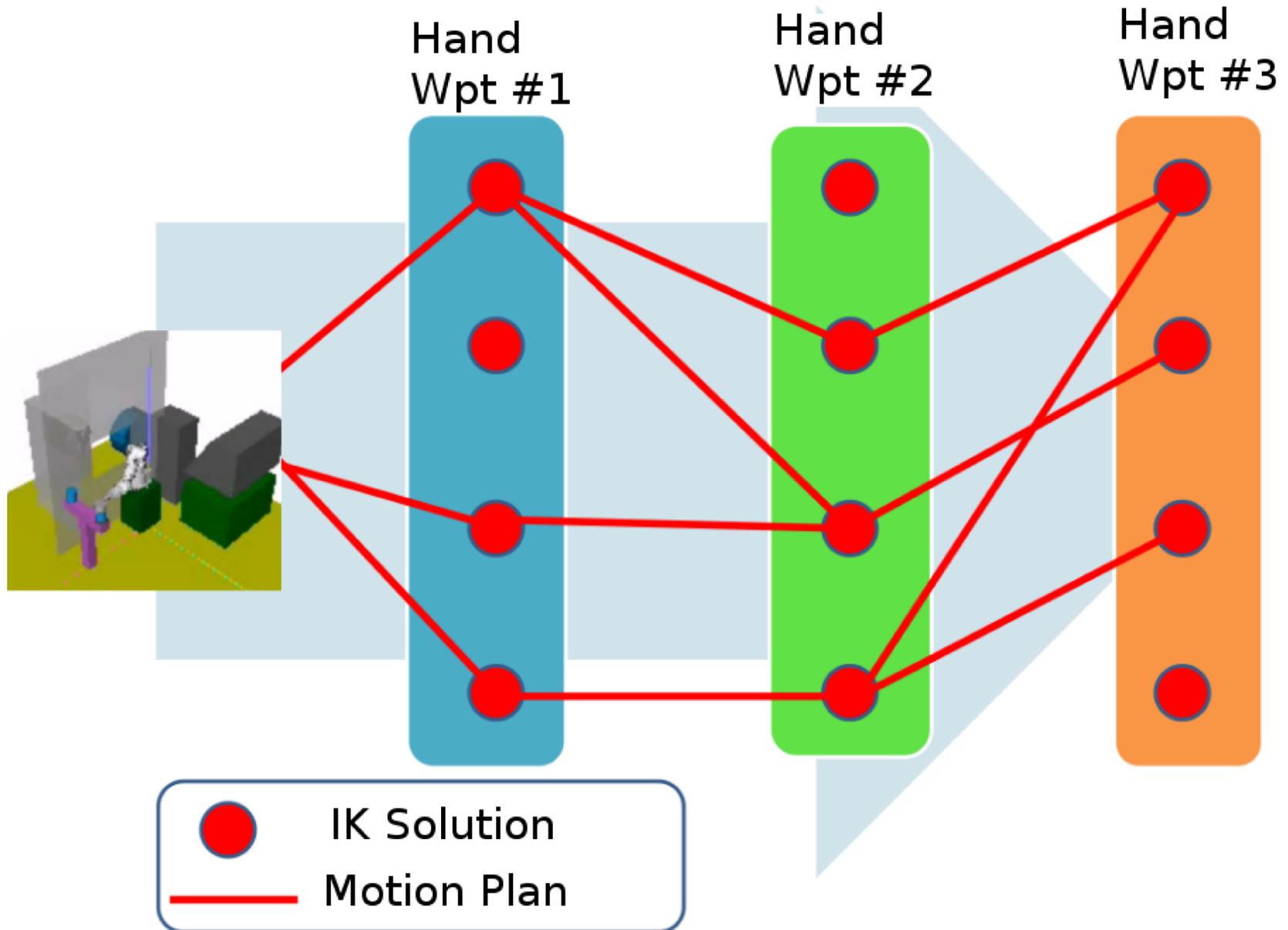
Who are we?

Senior Team:

...no CEO
...University of America (2007)
...Product Manager (2012)
...t Prize, Asia-Pacific Region Marketing Contest (2010)
...t Prize, Asia-Pacific Region Sales Contest (2010)

Rosen Diankov CTO

B.S., University of California, Berkeley (2006)

Ph.D, Carnegie Mellon University (2010)

JSPS Postdoctoral Fellow, The University of Tokyo (2012)

OpenRAVE - Founder and Active Developer (2007-)
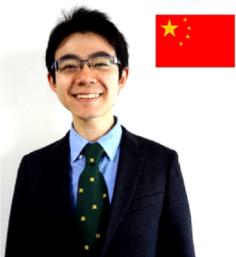
Huan Liu Chief of Software Development

B.S., MEng, MIT (2011)

Bilibot - Co-founder (2011)

Oracle America - Software Engineer (2012)

Advisors:

Professor Masayuki Inaba
Head of JSK robotics lab, The University of Tokyo
Graduated 300 students currently holding key
positions in major Japanese companies

Professor Takeo Kanade
Chief of Robotics Institute at Carnegie Mellon
University (-2001)
Chief of Quality of Life Technology Center (2006-)
Mentor of James Kuffner

Dr. Pham Quang Cuong
Assistant Professor at Nanyang Technological
University
Research focus on motion planning for industrial
robots
Mujin's Scientific Advisor