July 3, 2015

ADDING A LITTLE INTELLIGENCE TO FACTORY ROBOTS

RODNEY BROOKS

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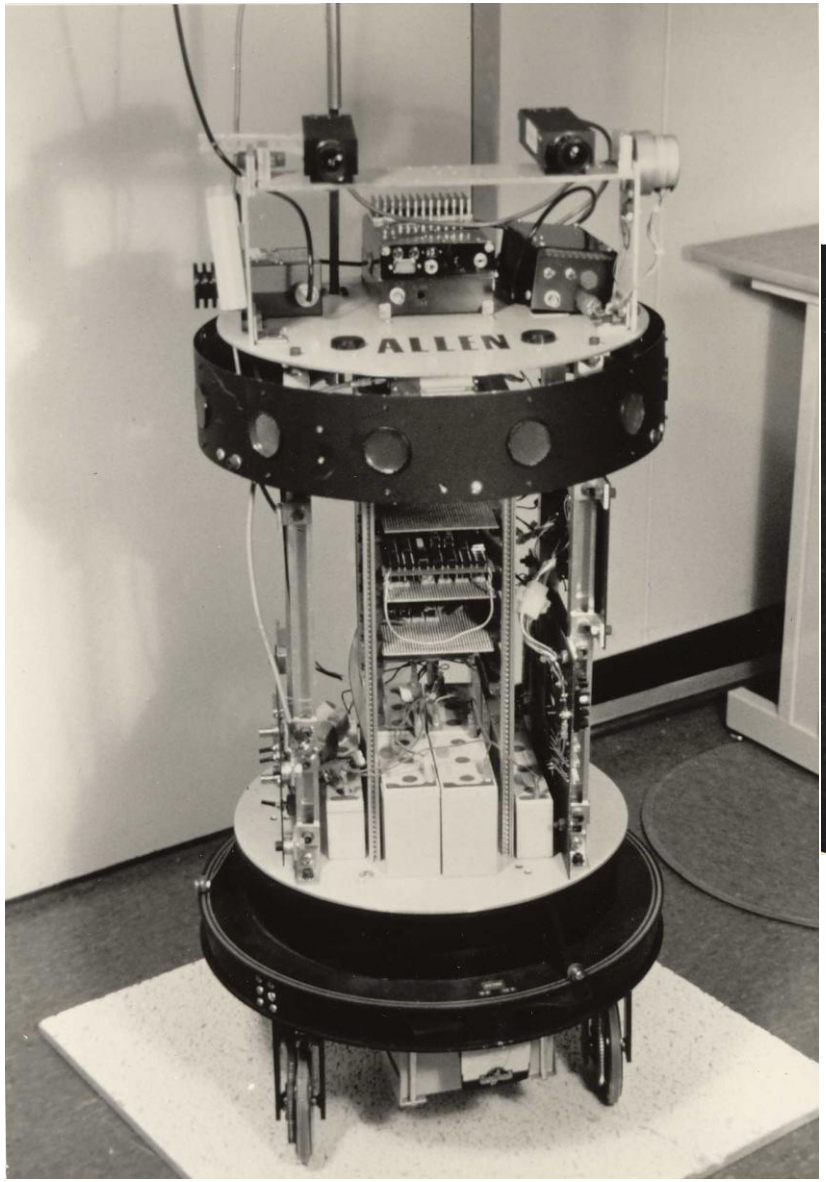

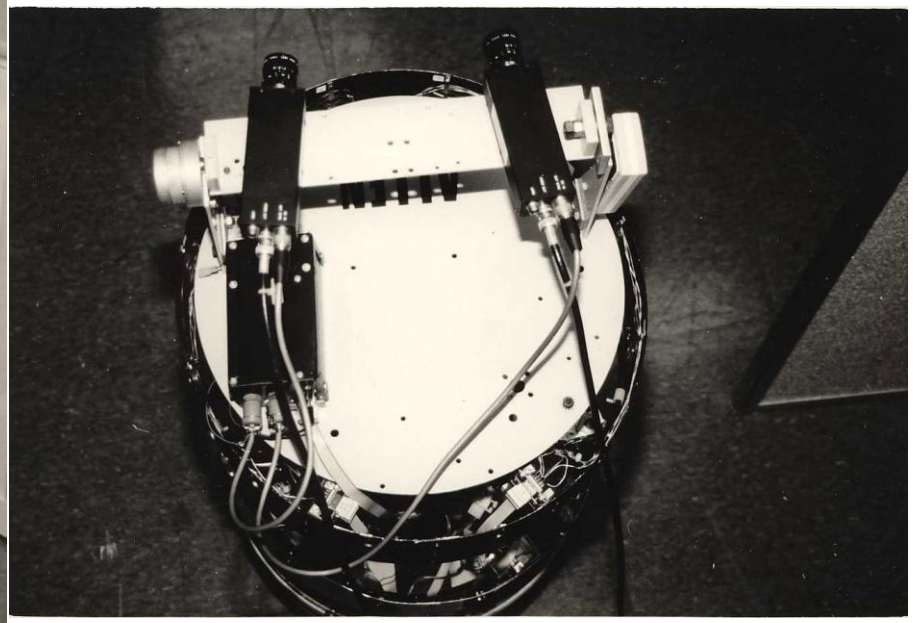

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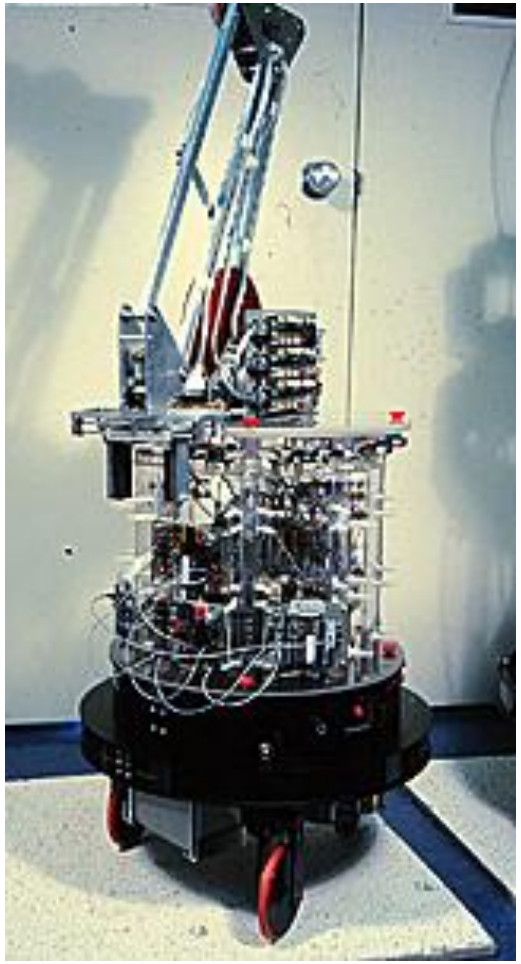

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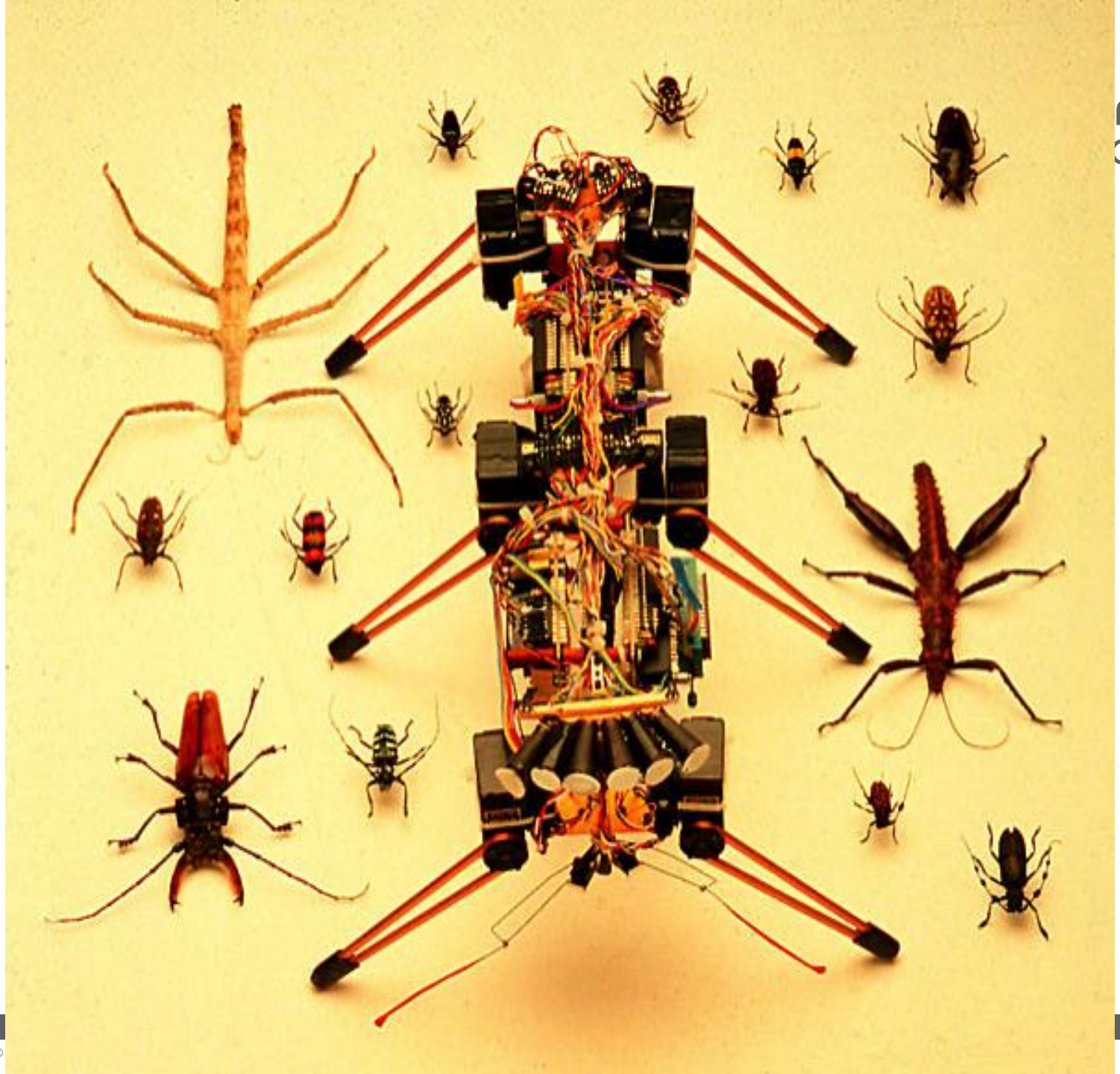

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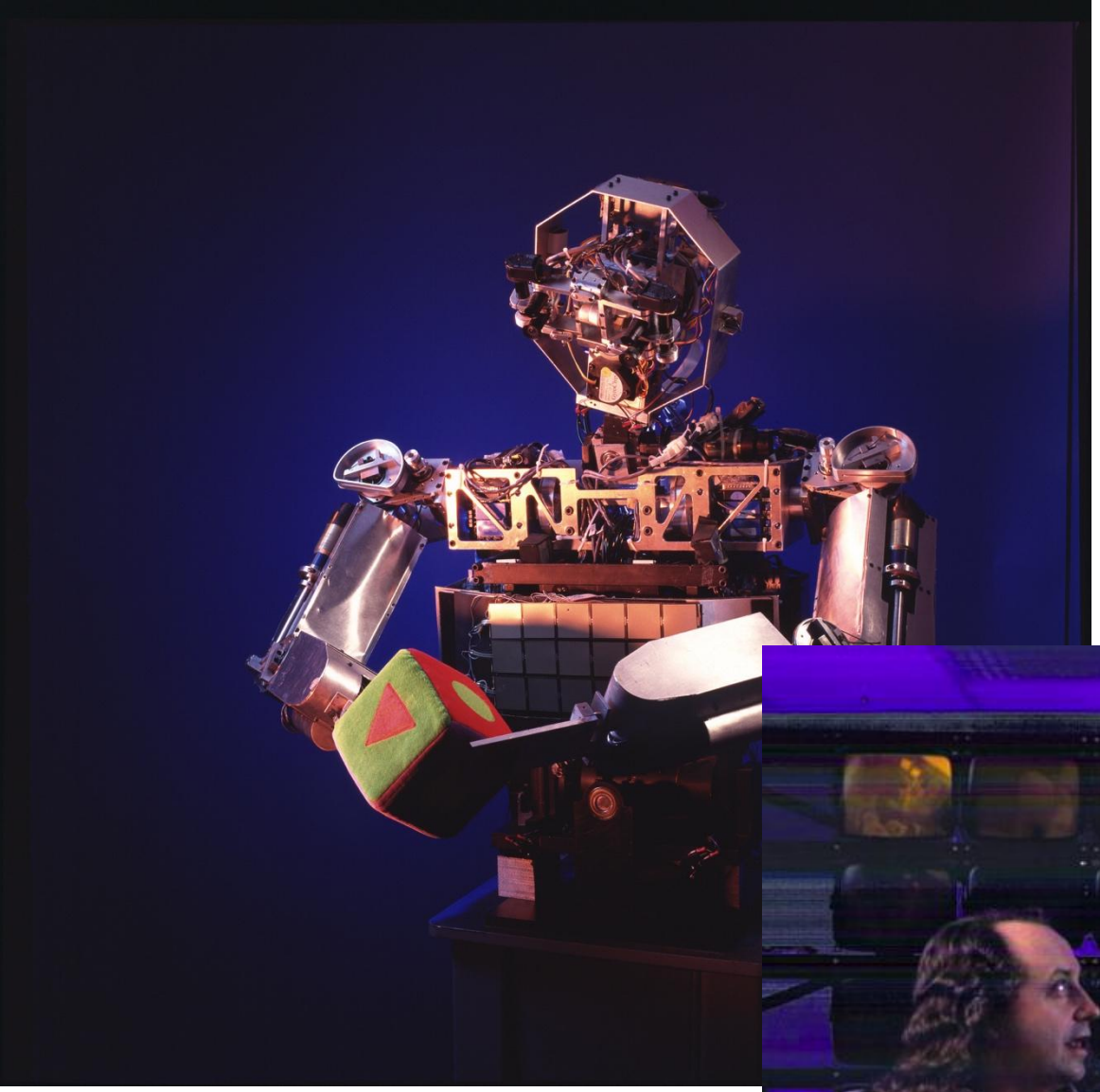

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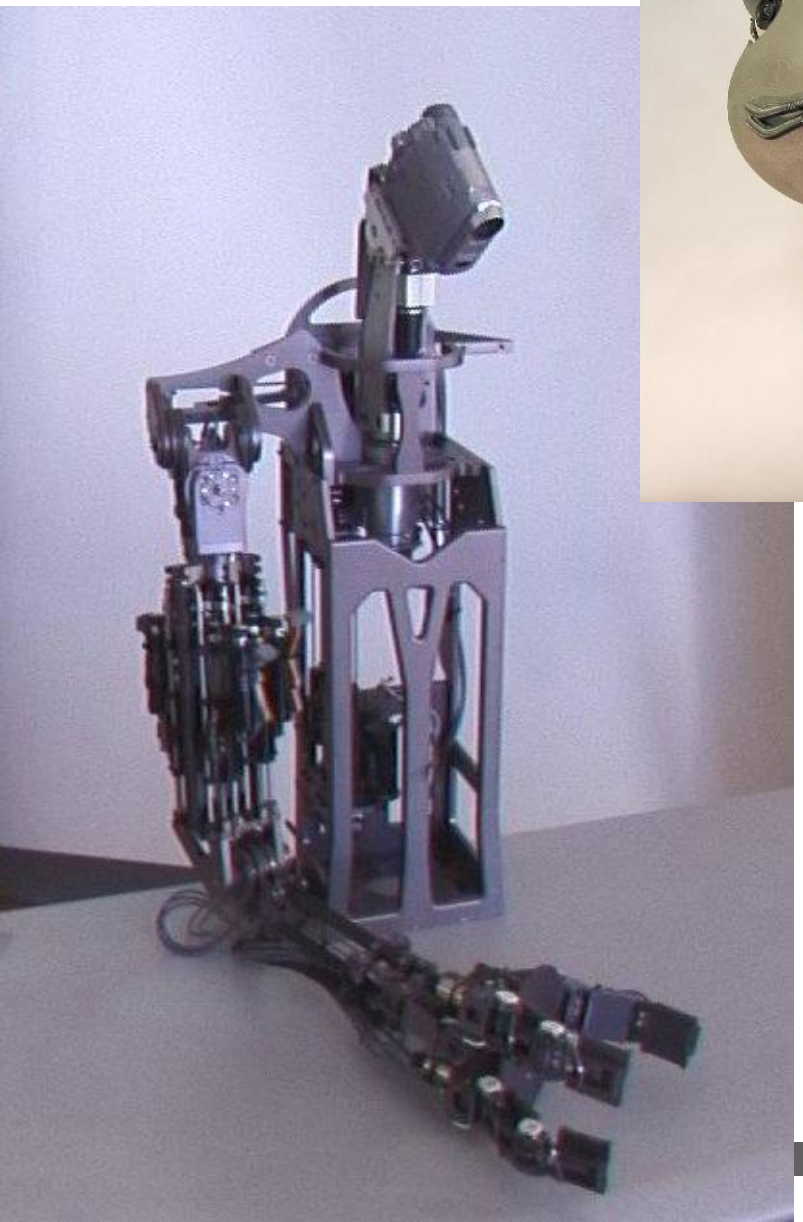

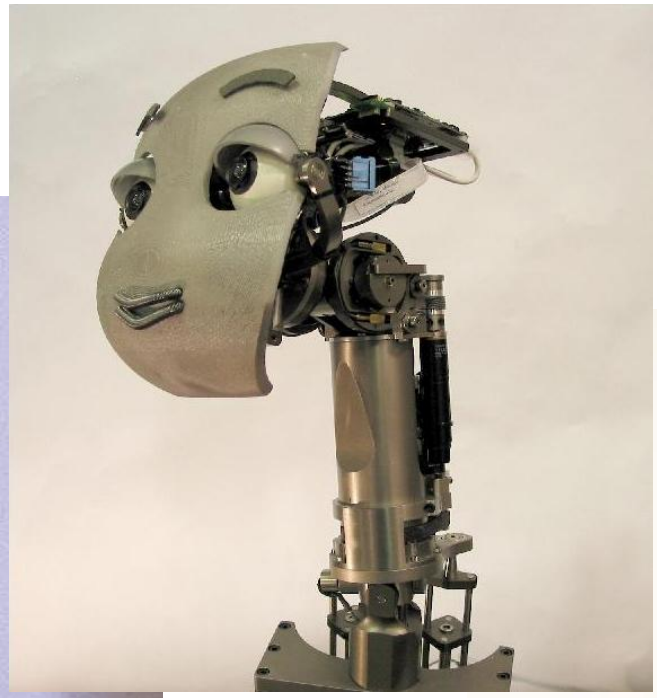

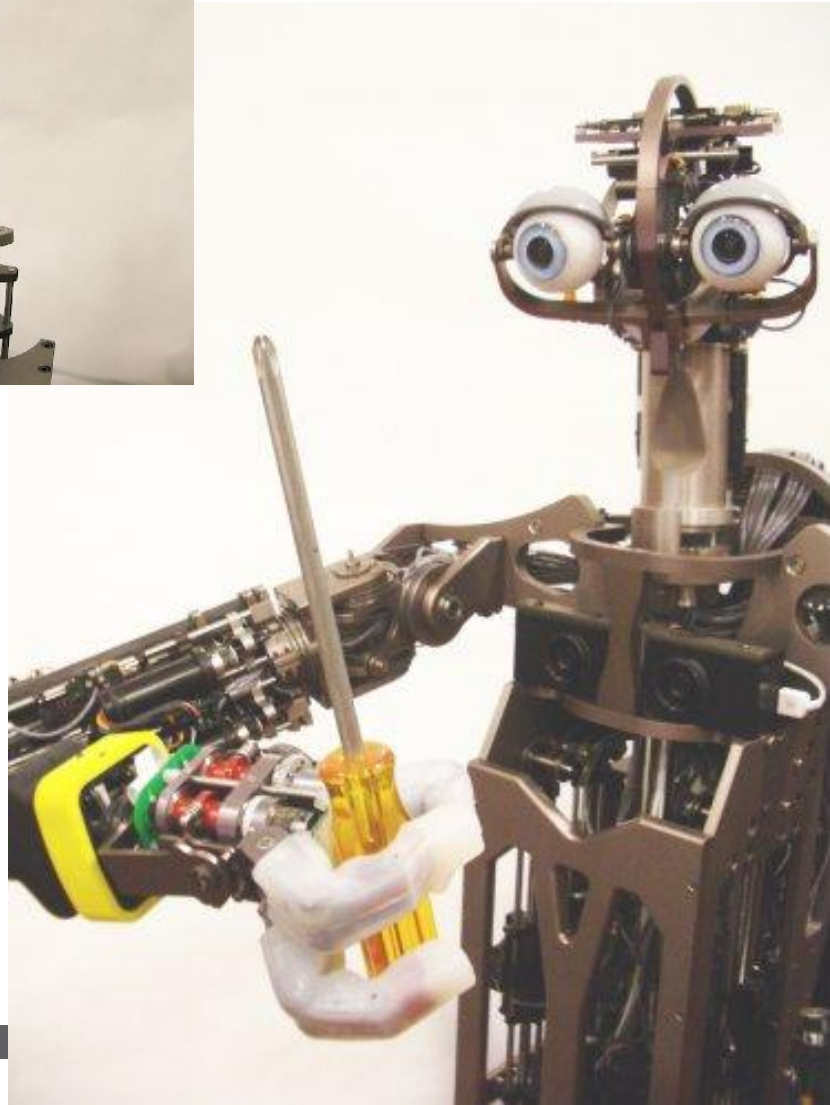

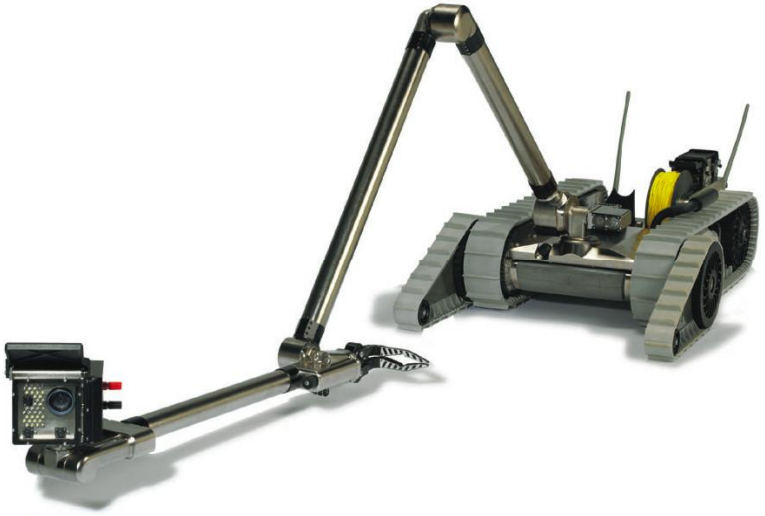

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AUTONOMY VS. PRICE OF ROBOT

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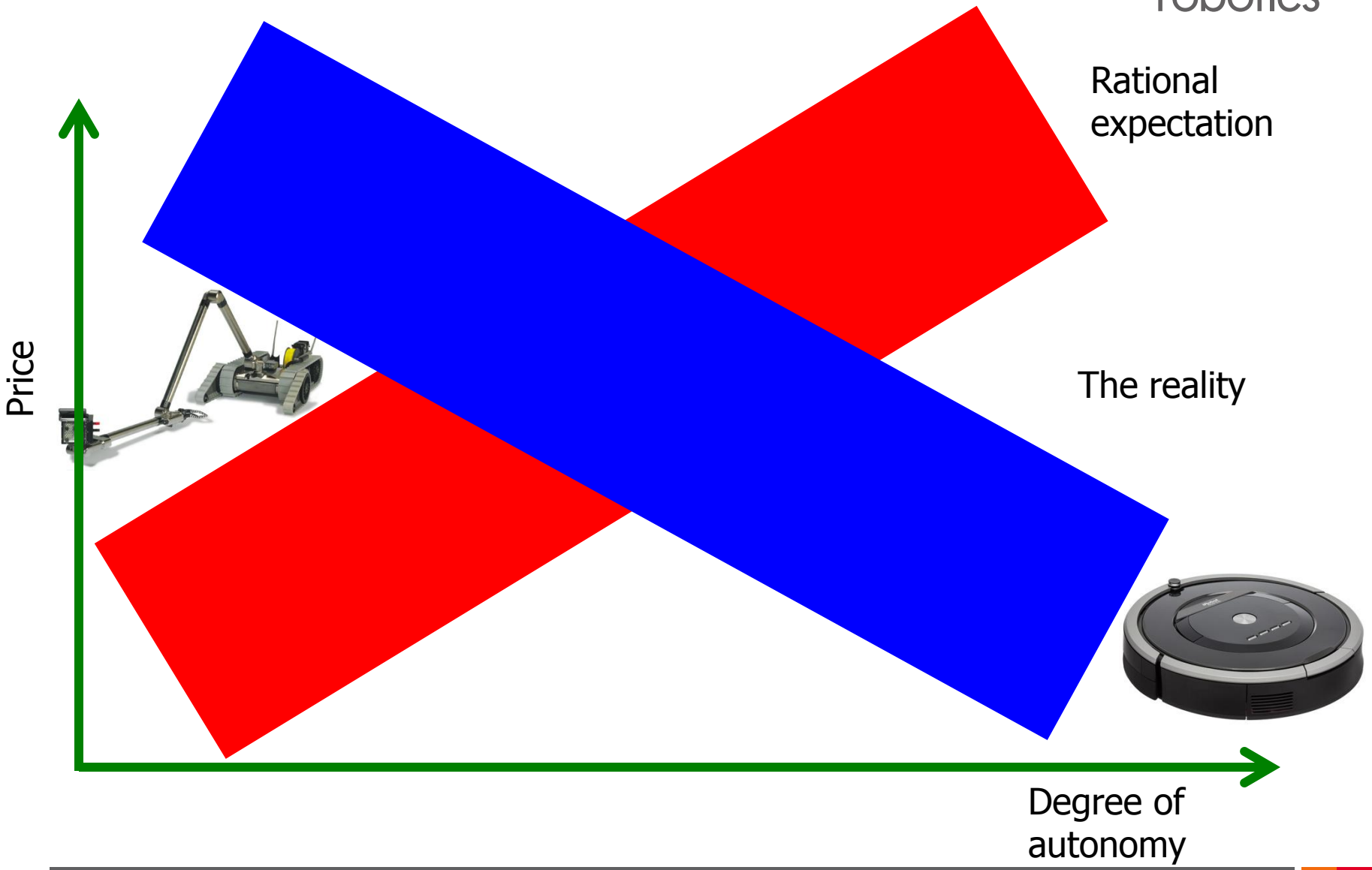

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IROBOT ROOMBA

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THE ROOMBA WAS NOT THE FIRST HOME CLEANING ROBOT

Electrolux Trilobite: 2,000 Euros

iRobot Roomba: $200

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EVOLUTION OF THE ROOMBA INTERFACE

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Quality corner 質量角 Quality corner
Quality corner 質量角 Quality corner

3
4
5

US Manufacturing Since WW2

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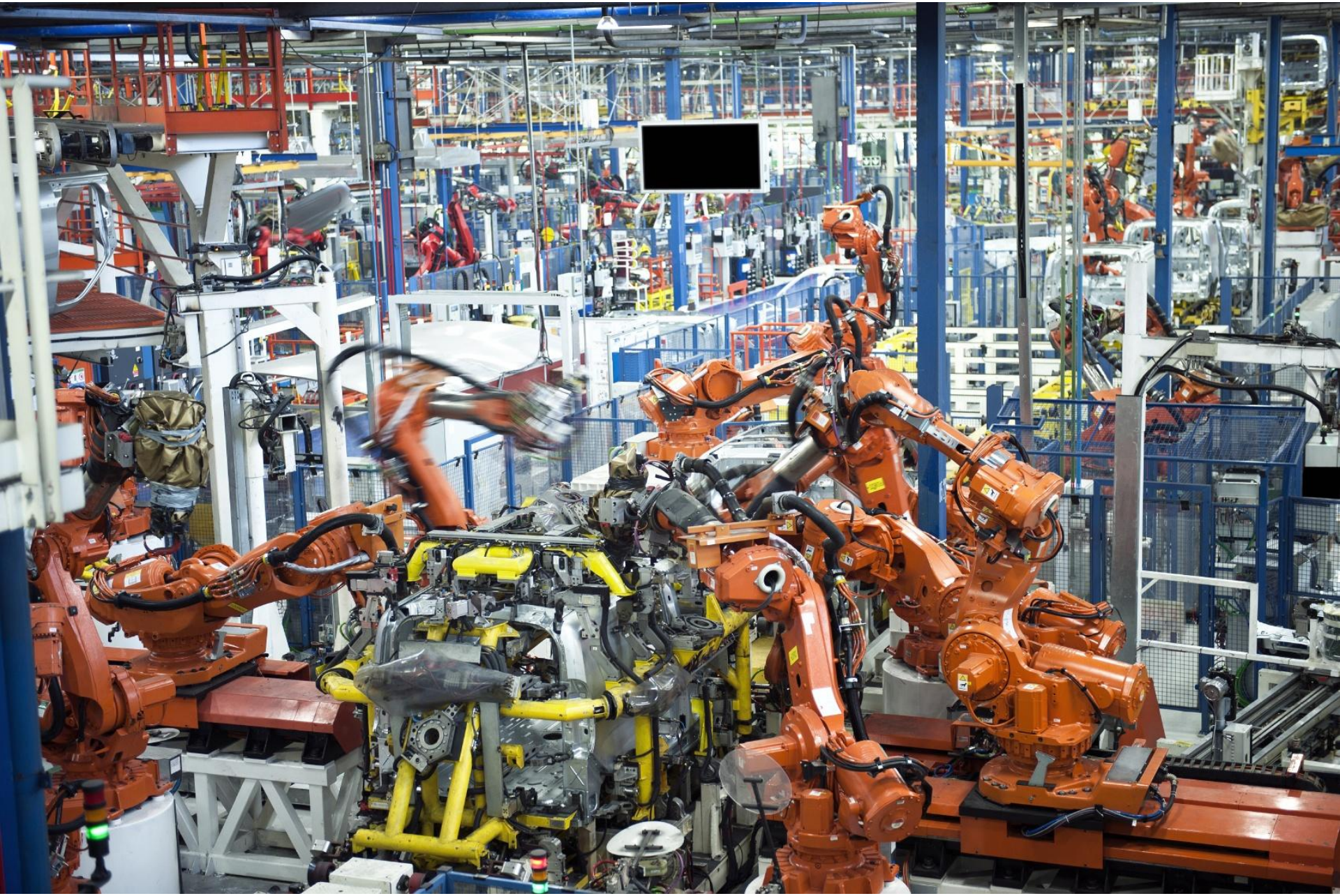

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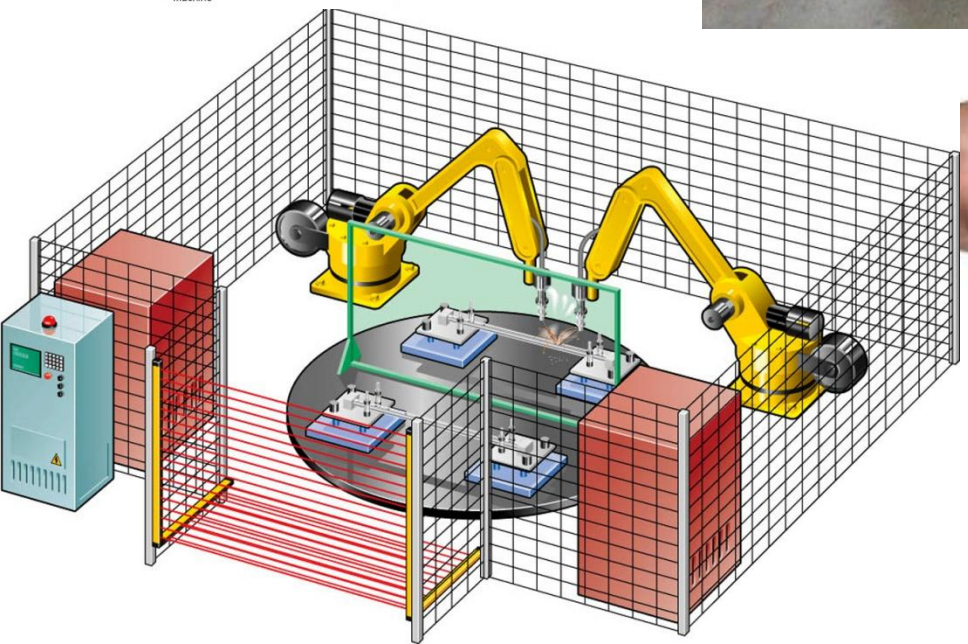
Enable/Disable Switch
Turn pendant on/off
Emergency Stop
Rear buttons and features:
- USB Port
- Deadman switch
PREV
Go to previous page on screen
NEXT
Advance to next screen shown
Selection Keys
Select options viewed on screen above
MAIN TEACH FUNCTION KEYS
Main buttons for programming
FCTN
Displays additional function menus
CURSOR/ARROW KEYS
Moves the cursor
SHIFT
Vary functions by pressing this key in conjuction with another
DISP
Toggles between screen displays
GROUP
Toggles between motion groups
STEP
Switches between step and cycle execution
HOLD
Pauses the robot not to be used as a safety stop
RESET
Clears the alarm
FORWARD
Executes the next statement in a rogram
BACK SPACE
Deletes letter or number before cursor
BACKWARD
Executes the previous statement in a rogram
ITEM
Selects a line item by number
JOG KEYS
NUMBER KEYS
COORD
Selects the coordinate system or other group
JOG SPEED KEYS
Adjusts the speed of the robot
DIAG/HELP
Diagnostics/Help button. Pull up operator manuals
BACK UP
Returns to main screen
POSN
Displays position screen
- Relative
- Absolute
- Distance To Go
- Machine
I/O
Displays I/O screen
STATUS
Displays current position screen
MAIN FCTN
Displays function menu
EQUIP
Toggle between tool functions and robot functions.

ABB



COGNEX
COGNEX
COGNEX
COGNEX

hello.

iRobot

AT&T
12:02 PM
Fingerprints
Success
Touch ID is ready. Your print can be used for unlocking your iPhone.
Continue

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A NEW CATEGORY OF ROBOT

Smart . Simple . Fast . Cheap

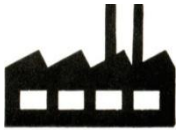
- Software + Sensing = Intelligence
- Simple, ubiquitous, manual tasks
- Fast deployment and change-over
- Payback in a year
- Safe around people

Robots in the field

Large Manufacturers

GE, Genco, FLEXTRONICS, Steelcase, TRANE, Nypro, Continental, TESLA, Apple

Small & Medium Enterprise



STENNER PUMPS, Vanguard Plastics Corporation, CLAYTON KENDRICK INCORPORATED, KING INNOVATION, THE RODON GROUP, Federal Reserve, KAISER PERMANENTE, Schneider Electric, PRAXIS Packaging Solutions, PANDUIT, Medtronic

Research & Education

MIT, Carnegie Mellon University, Harvard, The University of Edinburgh, Cornell University, 東京大学 THE UNIVERSITY OF TOKYO, CPE

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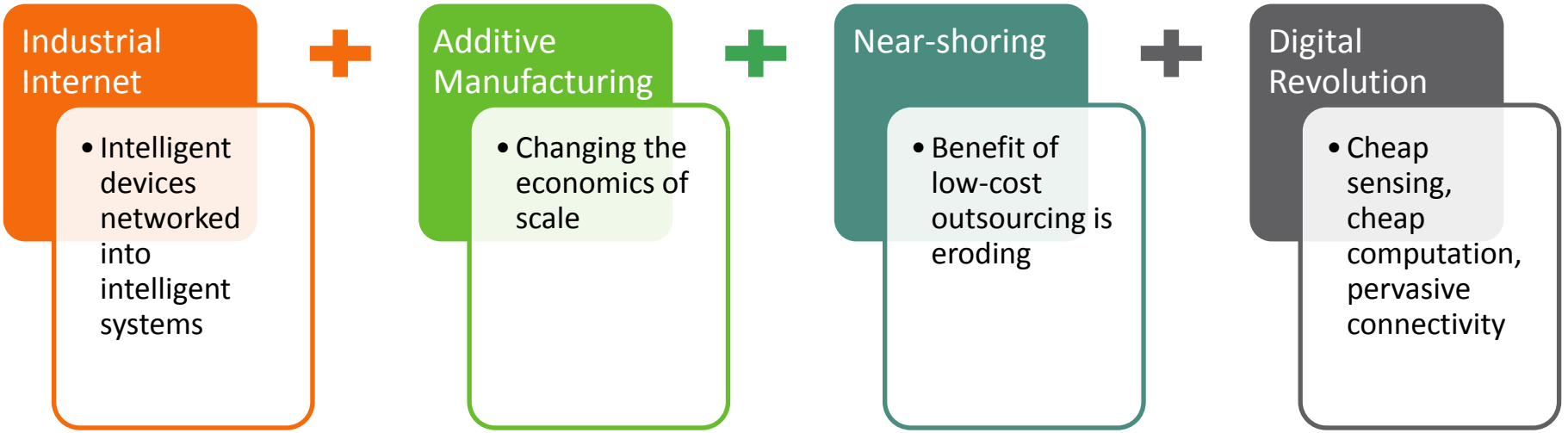
CONVERGENCE: THE TIME IS NOW



Radical rethinking of manufacturing strategies is underway

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THE INTEGRATED WORKFORCE

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Interactive robots

Working side-by-side with skilled labor

Deliver productivity, flexibility, and reduced direct labor cost

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BASED ON MANY CAPABILITIES COMBINED

DEEP TECHNOLOGY

- Compliant arm with Series Elastic Actuators
- High-resolution force sensing and control
- Behavior-based task execution
- Integrated vision system

Multi-robot software platform and open developer environment

INTELLIGENT MACHINES

- Inherently safe robots working with people
- Self-localization in moving environments
- UI for non-experts enables fast re-use
- Intelligent response to perceived change

High performance movement and manipulation

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BASED ON MANY CAPABILITIES COMBINED

Compliant arm with
Series Elastic Actuators

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FORCE SENSING AND CONTROL
≠ TRADITIONAL POSITION CONTROL

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COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS

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TECHNOLOGY

- Compliant arm with Series Elastic Actuators
- High-resolution force sensing and control
- Behavior-based task execution
- Built-in sensing

Software platform and open developer environment

INTELLIGENT MACHINES

- Inherently safe robots working with people
- Self-localization in moving environments
- UI for non-experts enables fast re-use
- Intelligent response to perceived change

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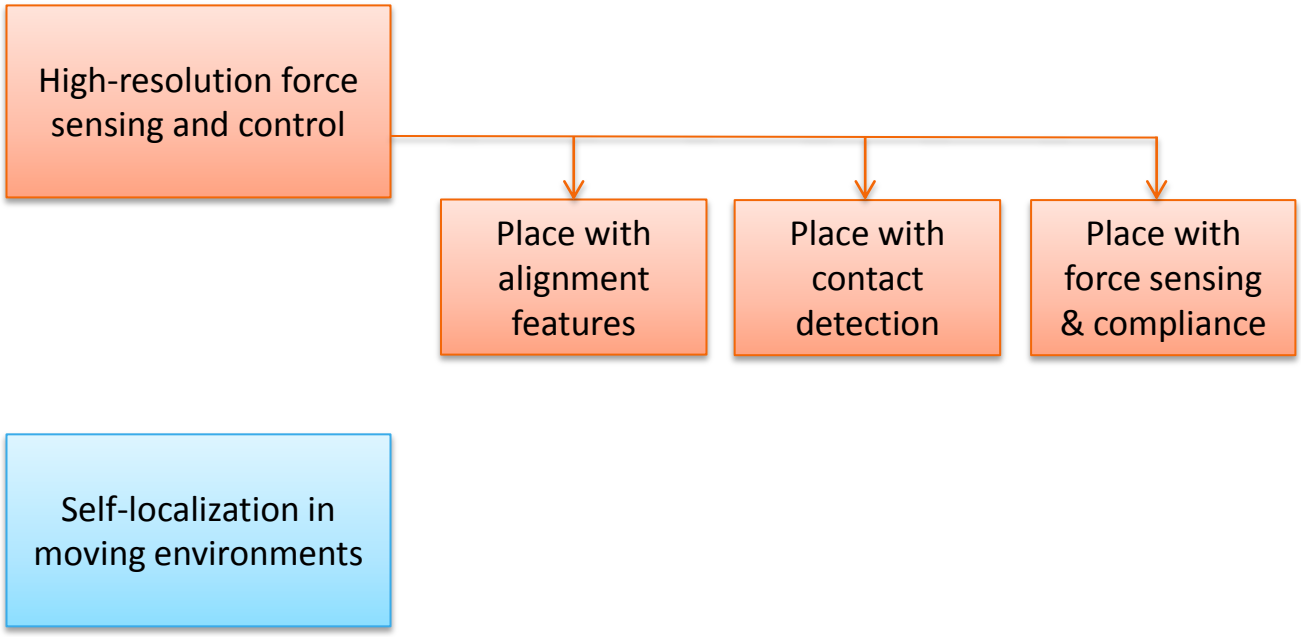
COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS



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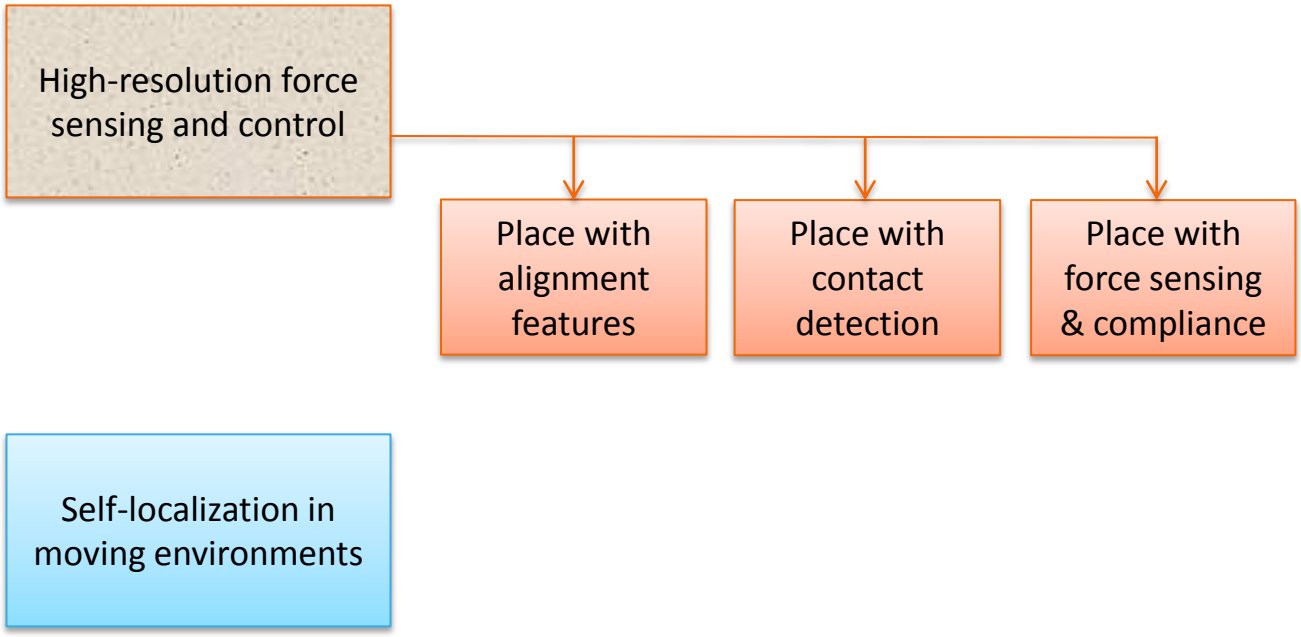
COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS



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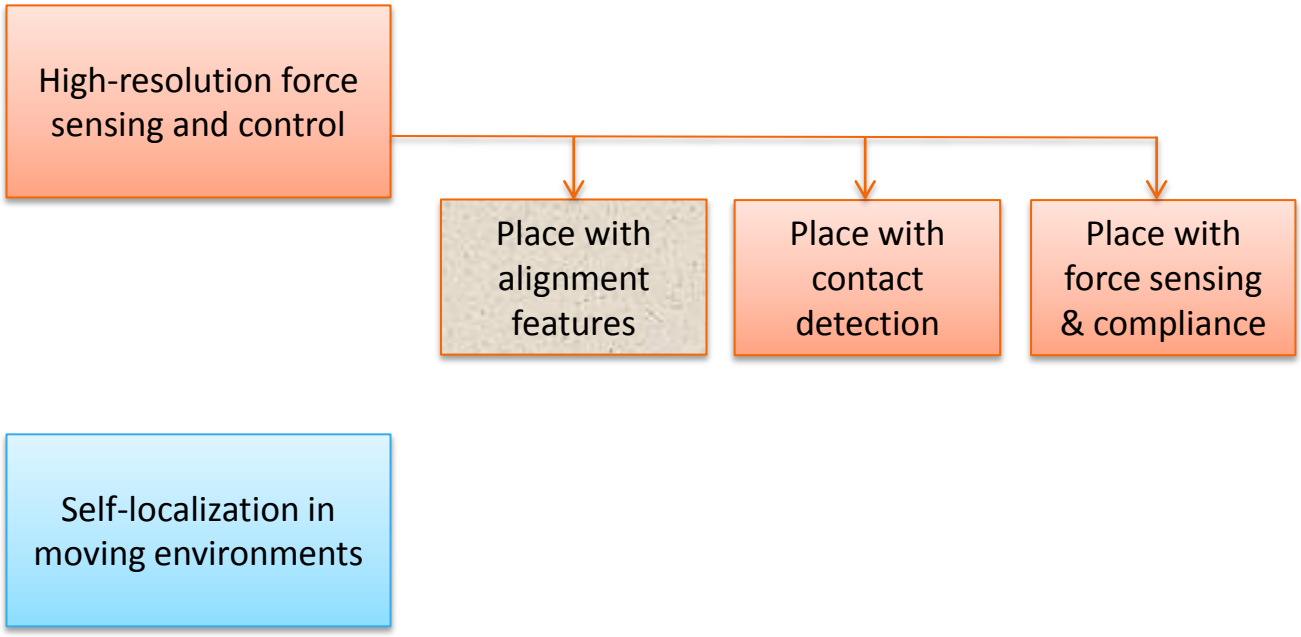
COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS



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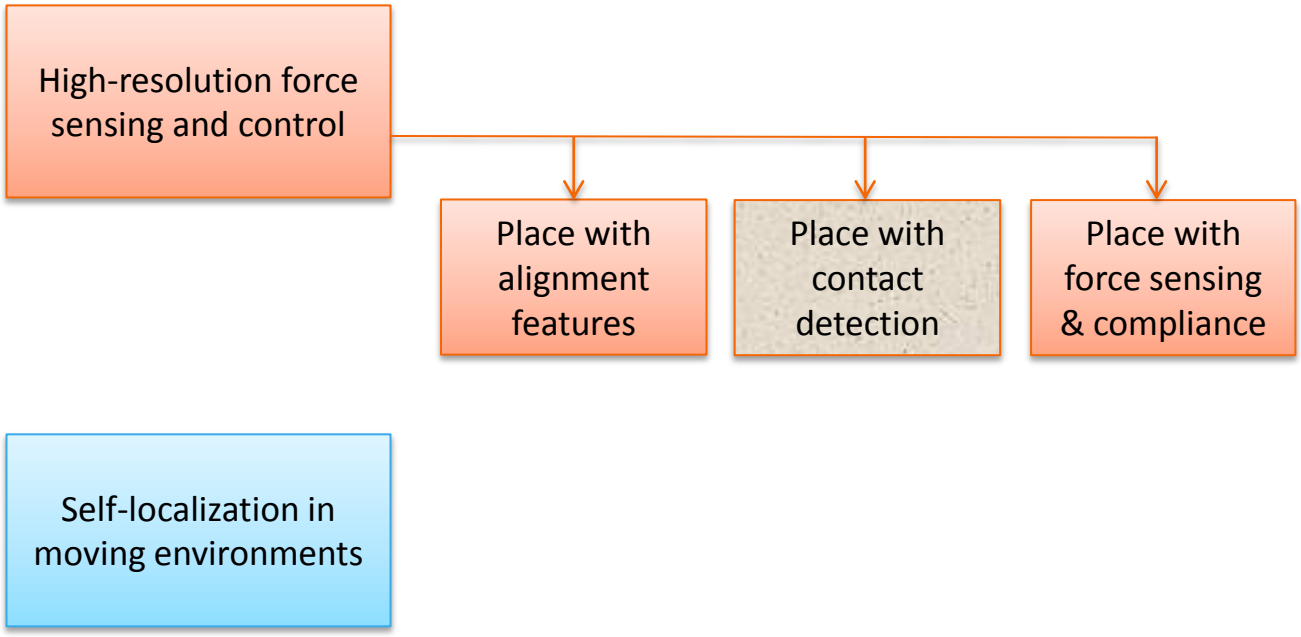
COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS



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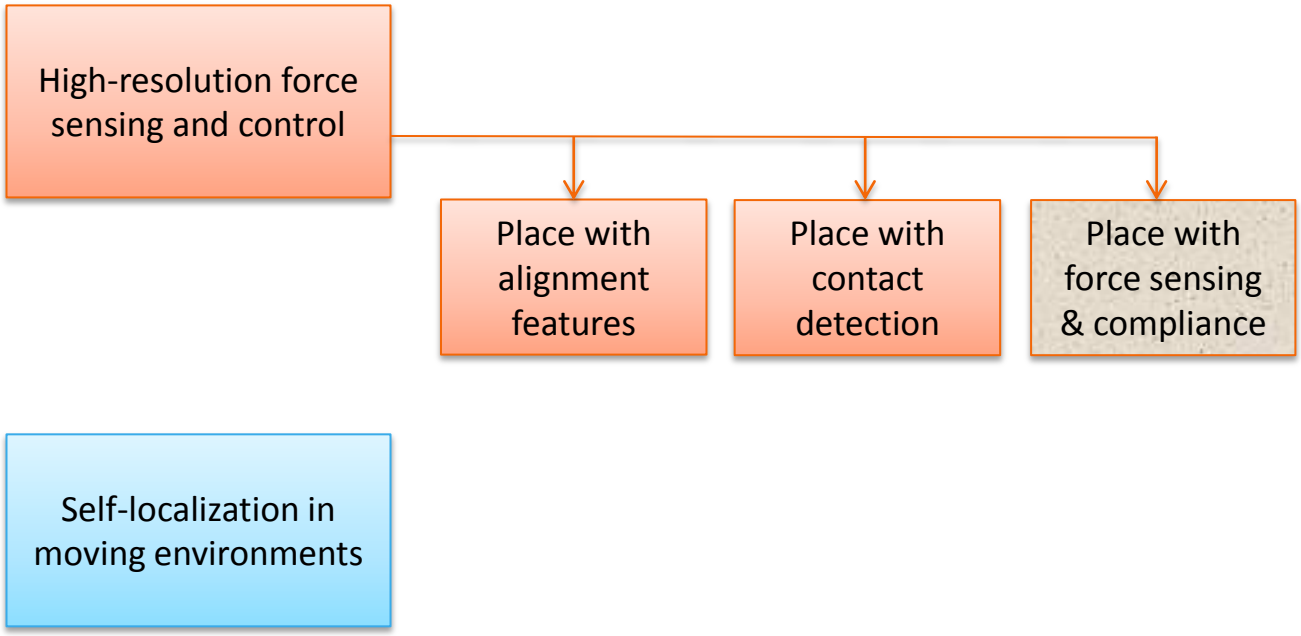
COMPONENTS FOR COLLABORATIVE, INTERACTIVE, AND INTEGRATED ROBOTS



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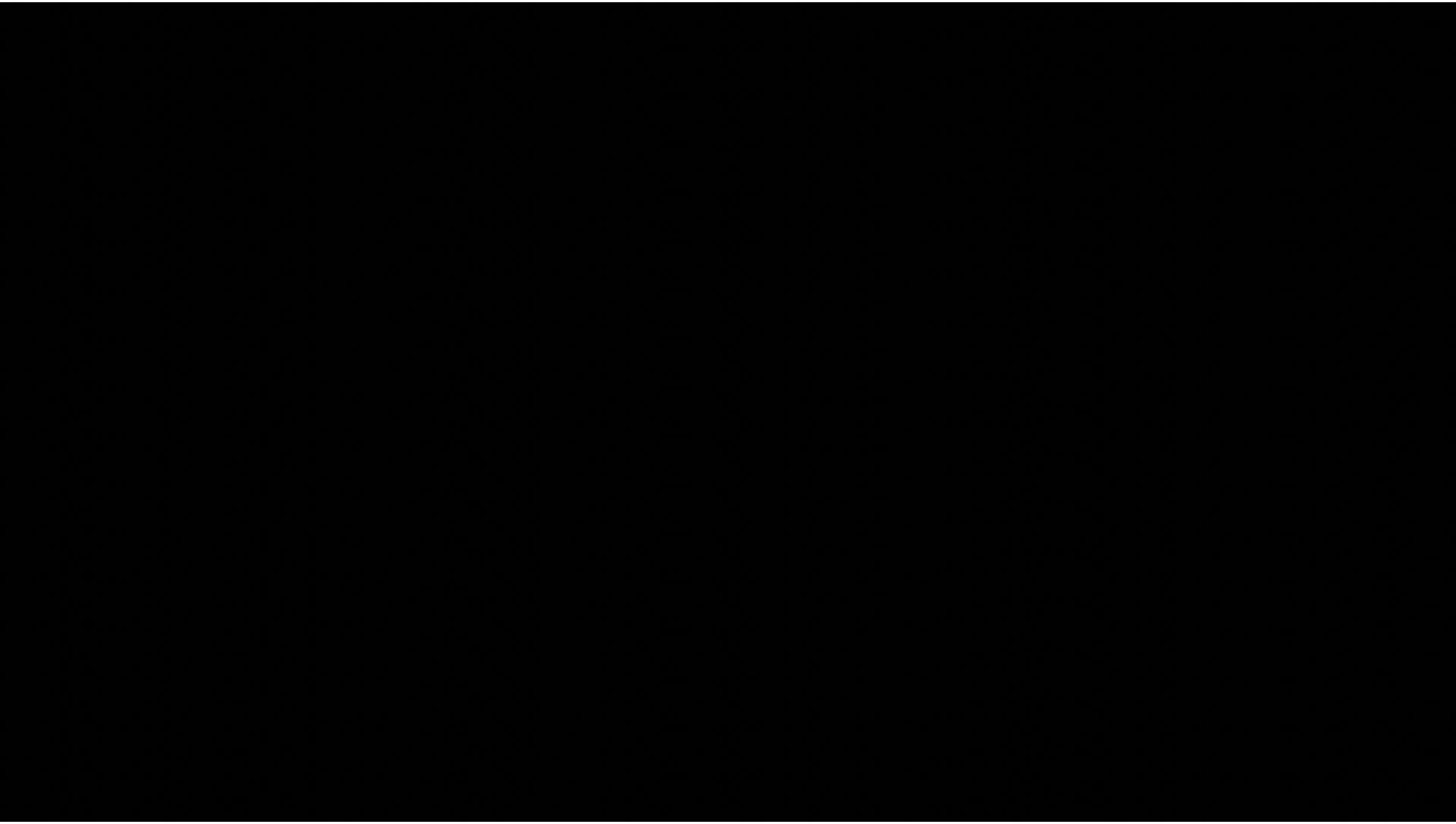

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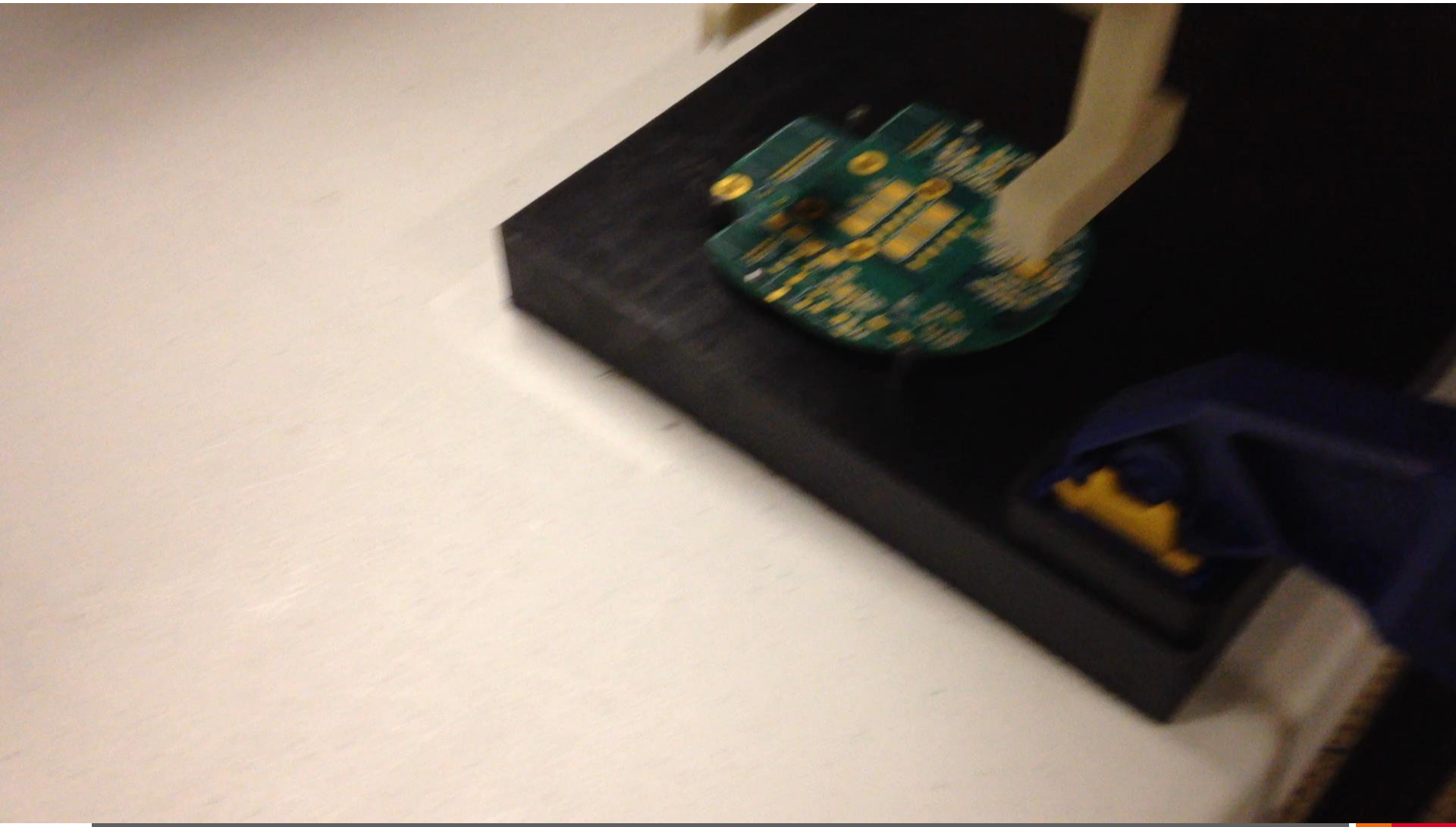
BAXTER PLACING CIRCUIT BOARD WITH 200 MICRON ACCURACY; SENSING FORCES



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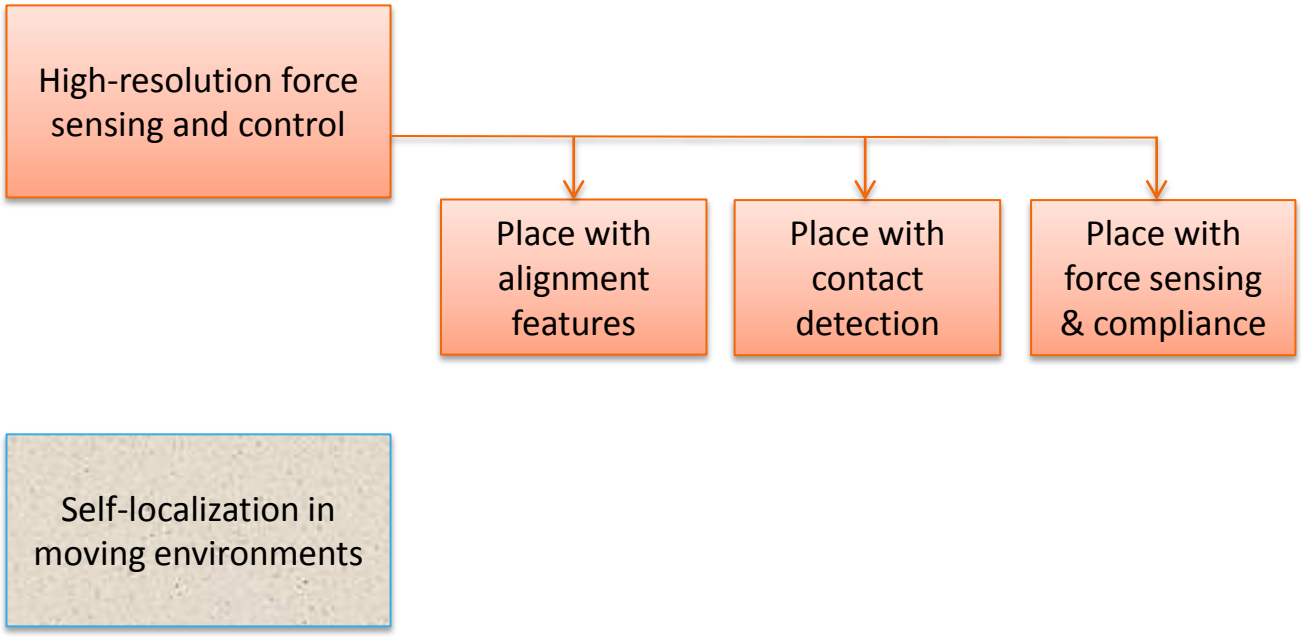

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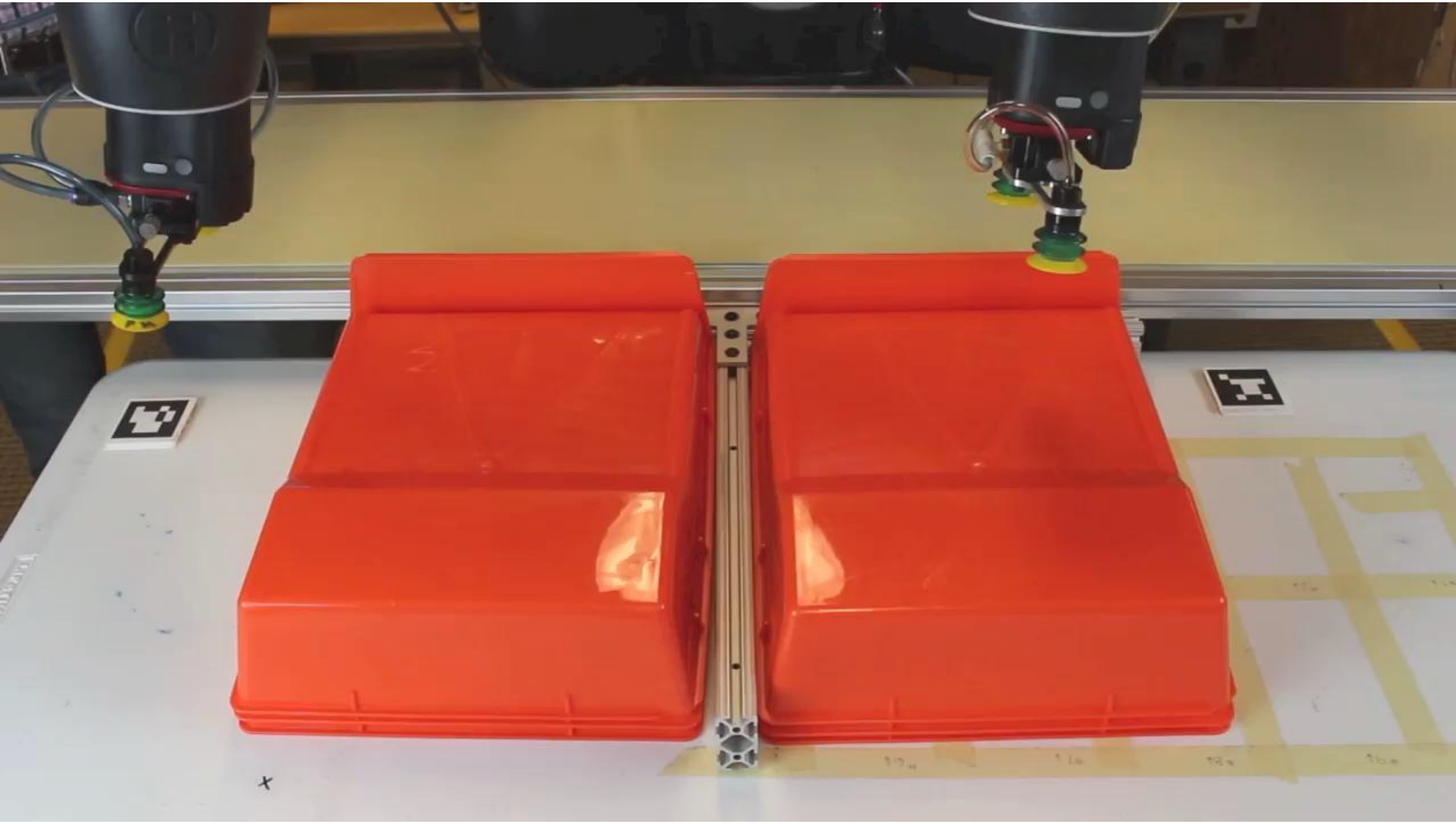

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It knows what you mean and it does what you want.

Simple things are simple to train. Complex things are possible.

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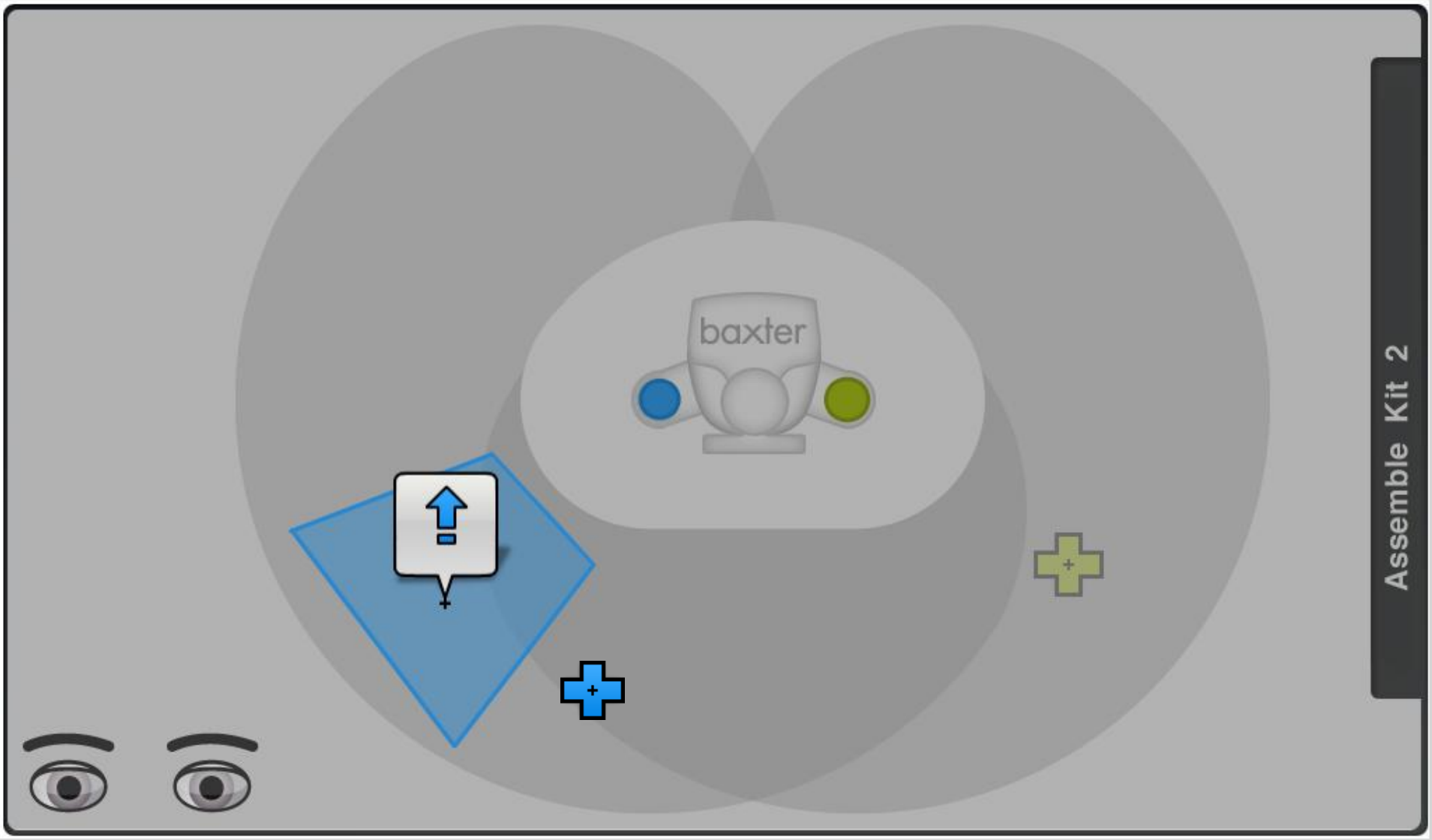

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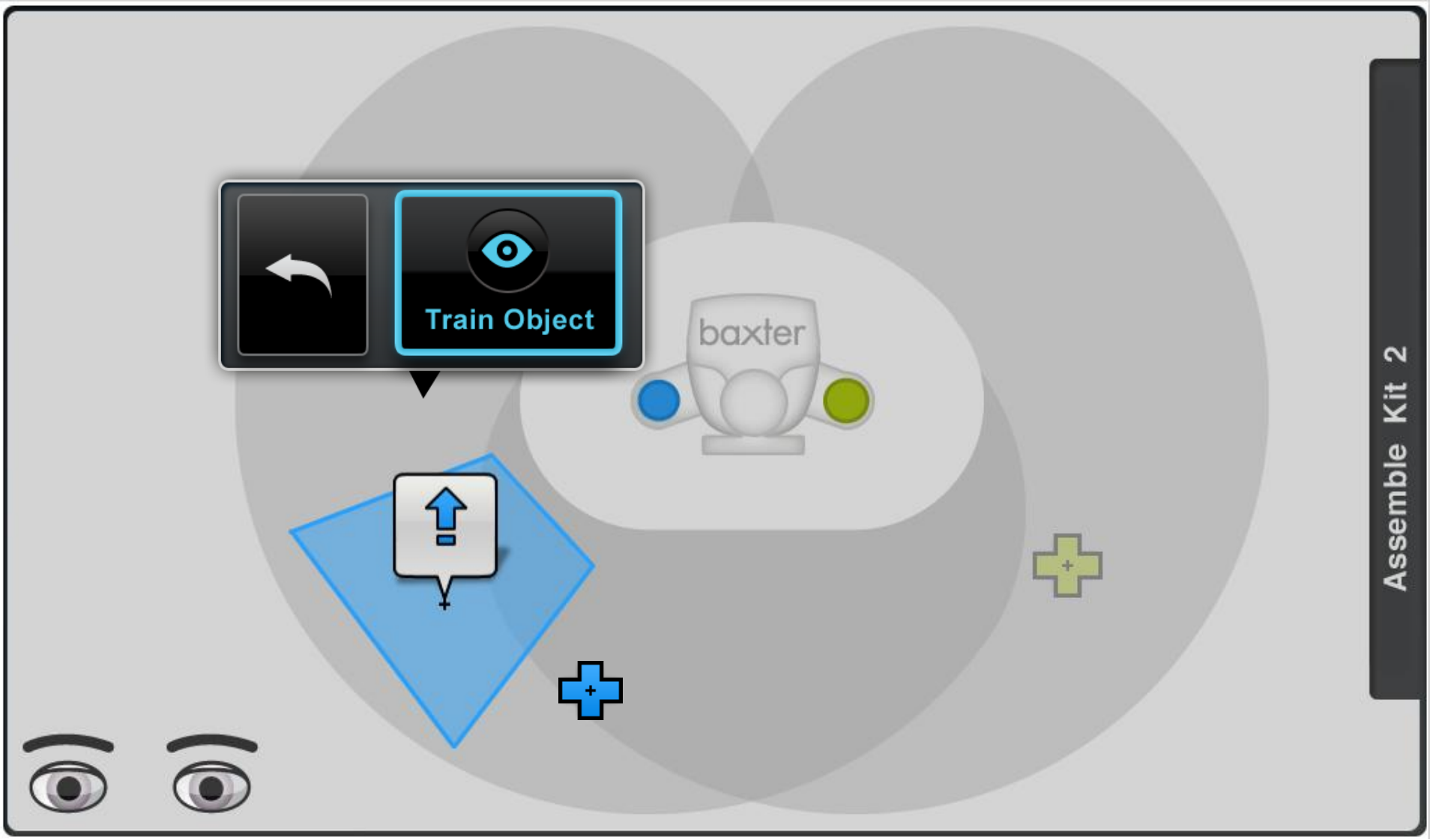

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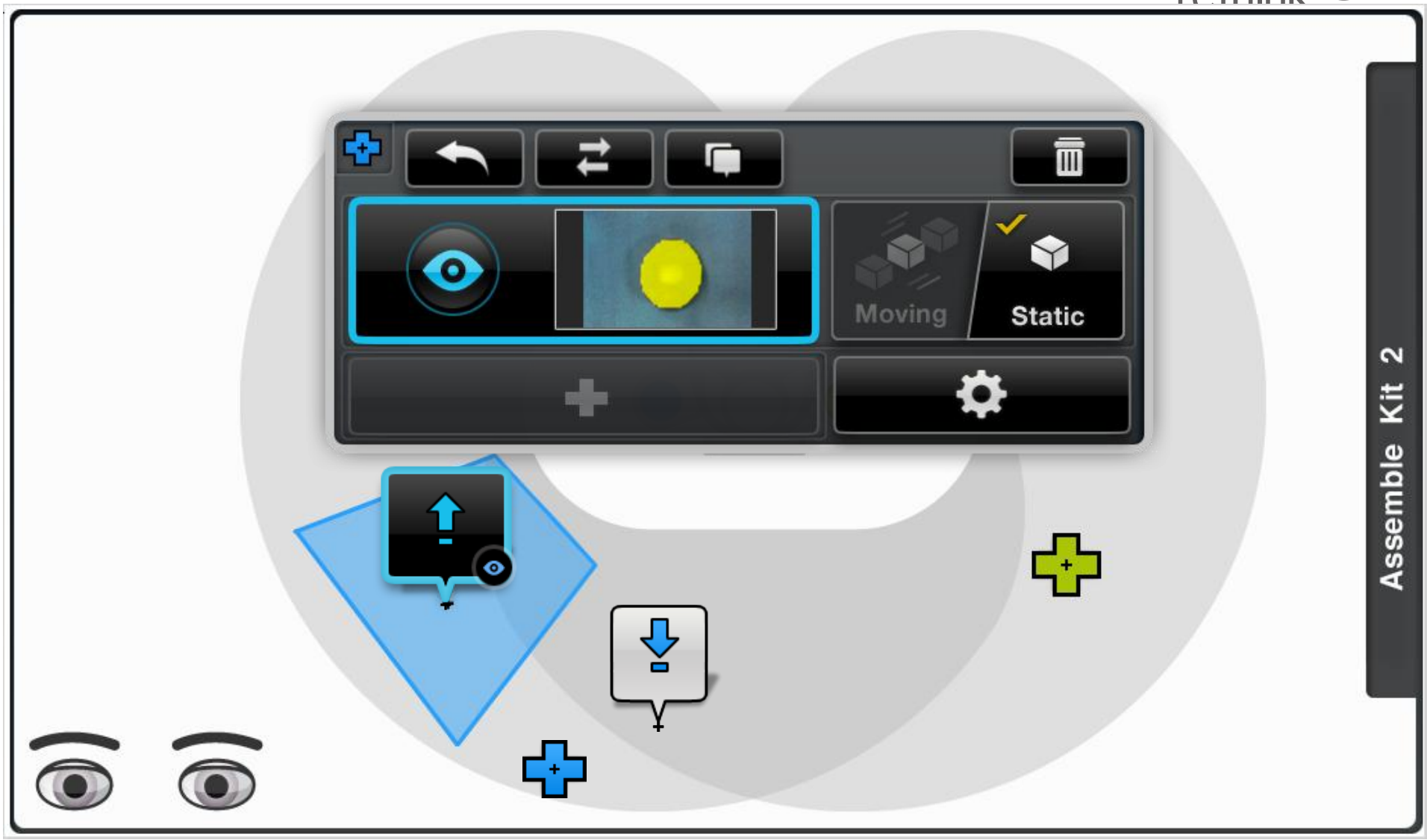

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AT CUSTOMER SITES

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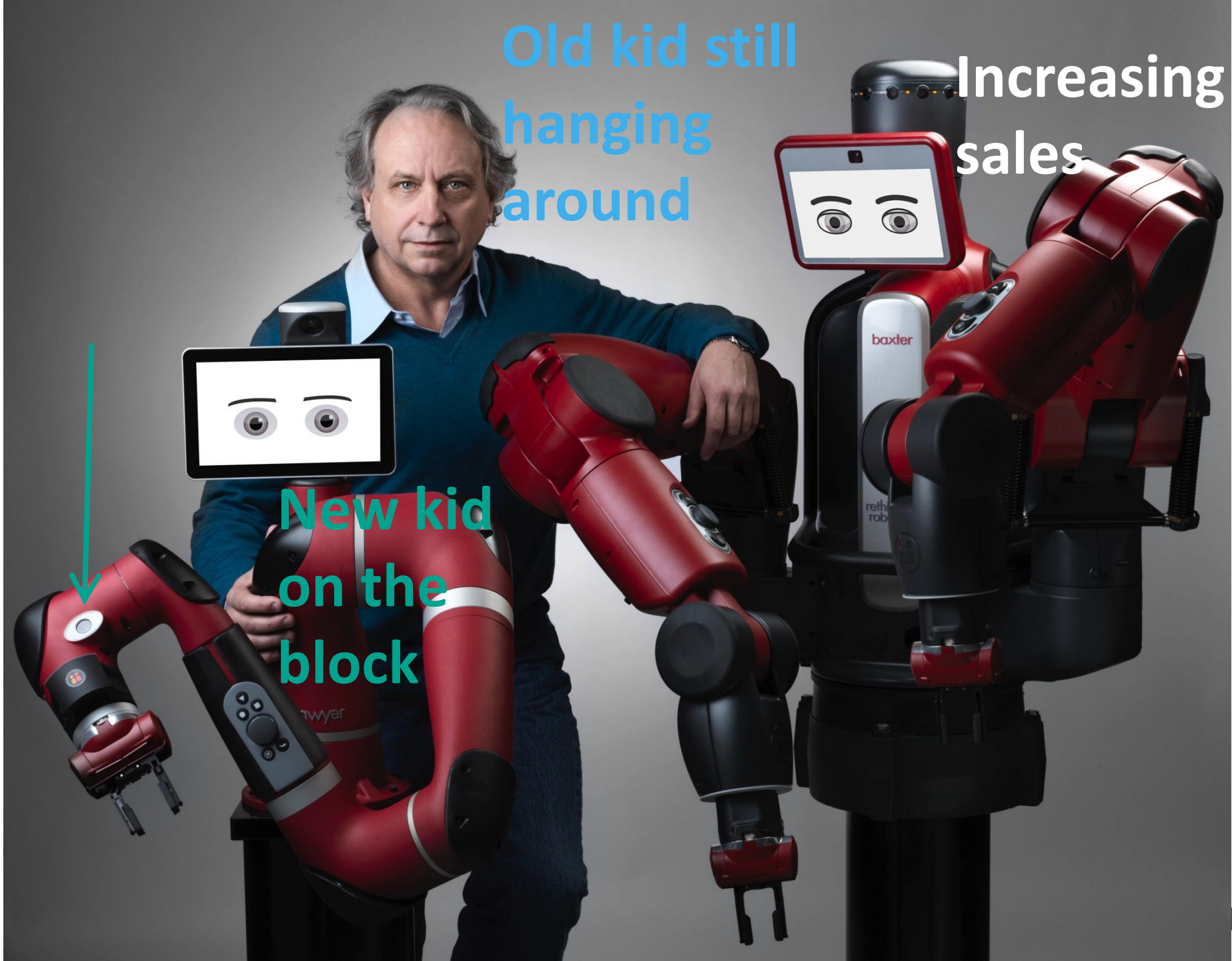
Old kid still hanging around
Increasing sales
New kid on the block
baxter

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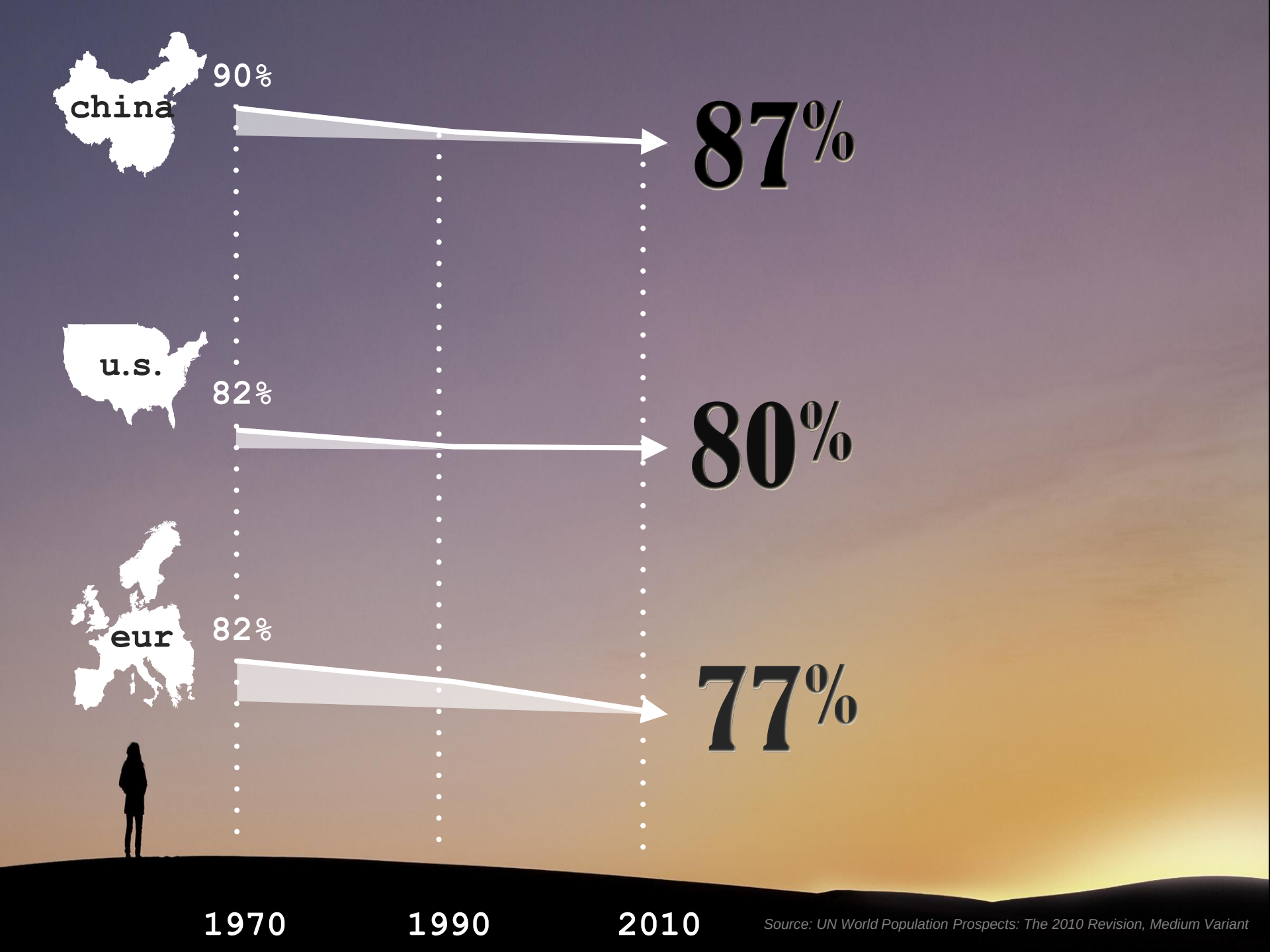
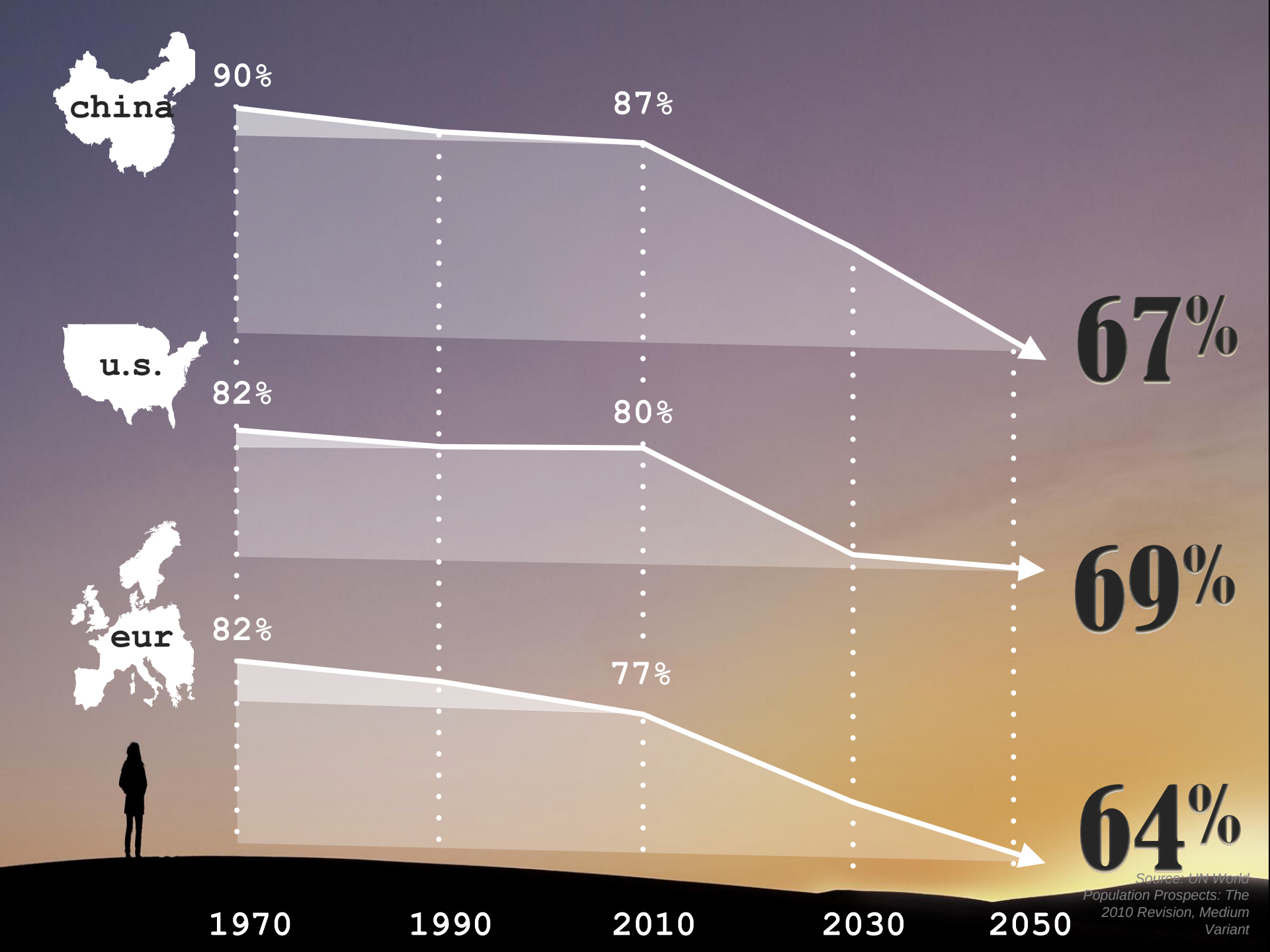
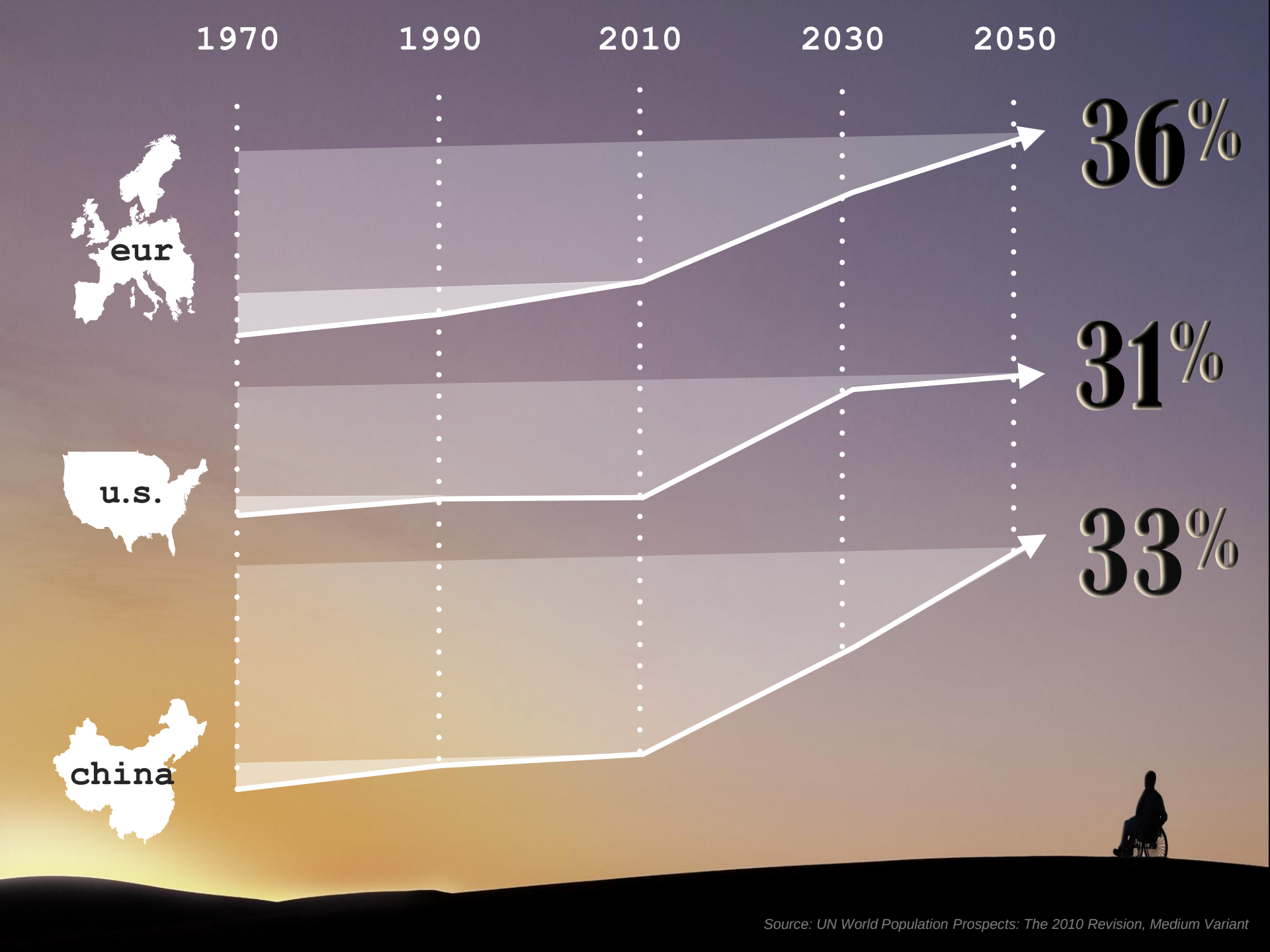

china
90%
87%
u.s.
82%
80%
eur
82%
77%
1970
1990
2010
Source: UN World Population Prospects: The 2010 Revision, Medium Variant


china
90%
87%
67%
u.s.
82%
80%
69%
eur
82%
77%
64%
1970
1990
2010
2030
2050
Source: UN World Population Prospects: The 2010 Revision, Medium Variant



Source: UN World Population Prospects: The 2010 Revision, Medium Variant

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Surgery

Disaster relief

Driving

Fulfillment

Manufacturing

Elder care

lower cost

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Mobility

Messiness

Manipulation

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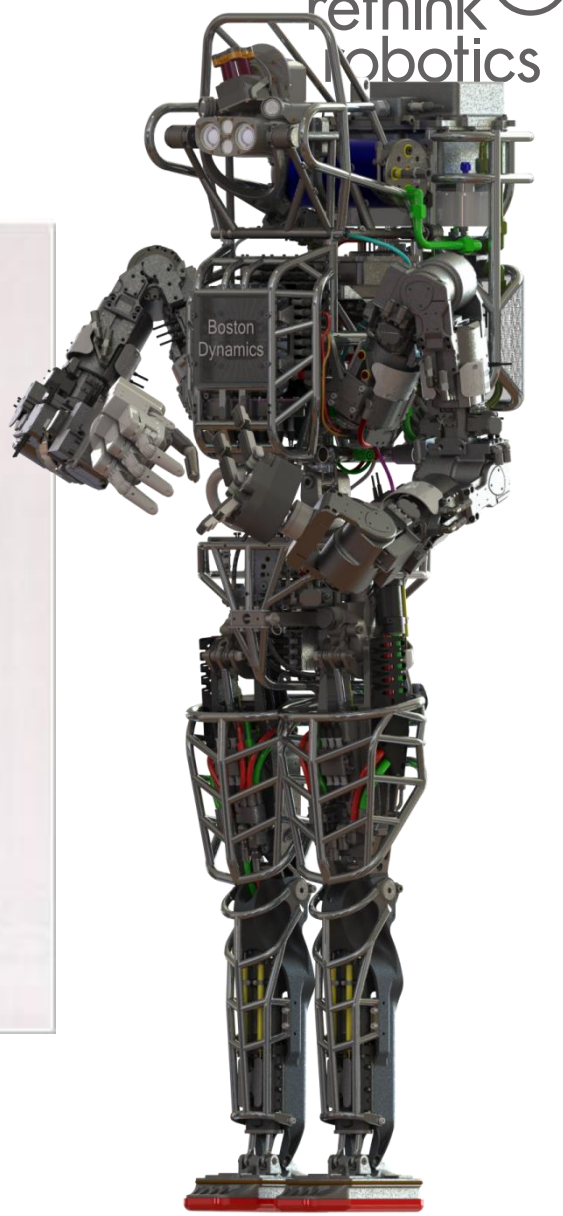

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Aaron Edsinger, Ph.D. thesis defense, 2006.

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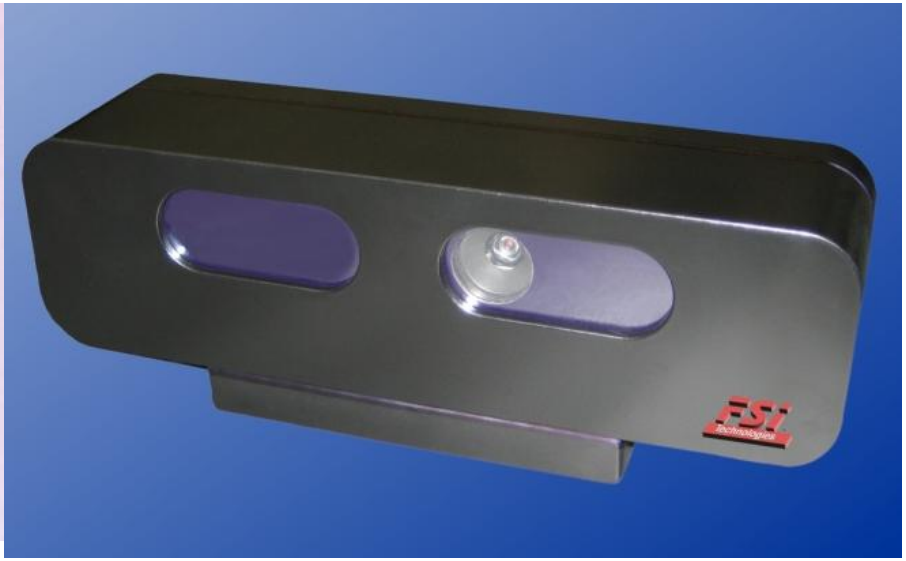

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KIVA PICKING

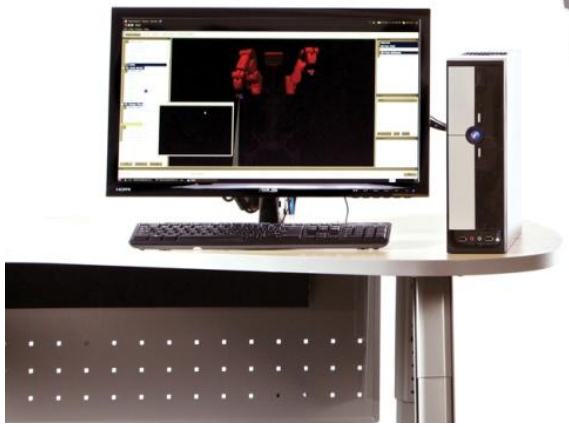
baxter™
research robot

rethink robotics

Robust and growing developer community sharing code and applications

Uses the Unified Robot Descriptor Format (URDF) for collaboration across groups

Uses open source ROS framework, the standard in academia and corporate research



Complete robotics platform with low-level control for custom application development

Interface for custom end-effector development

Safety behaviors always operating

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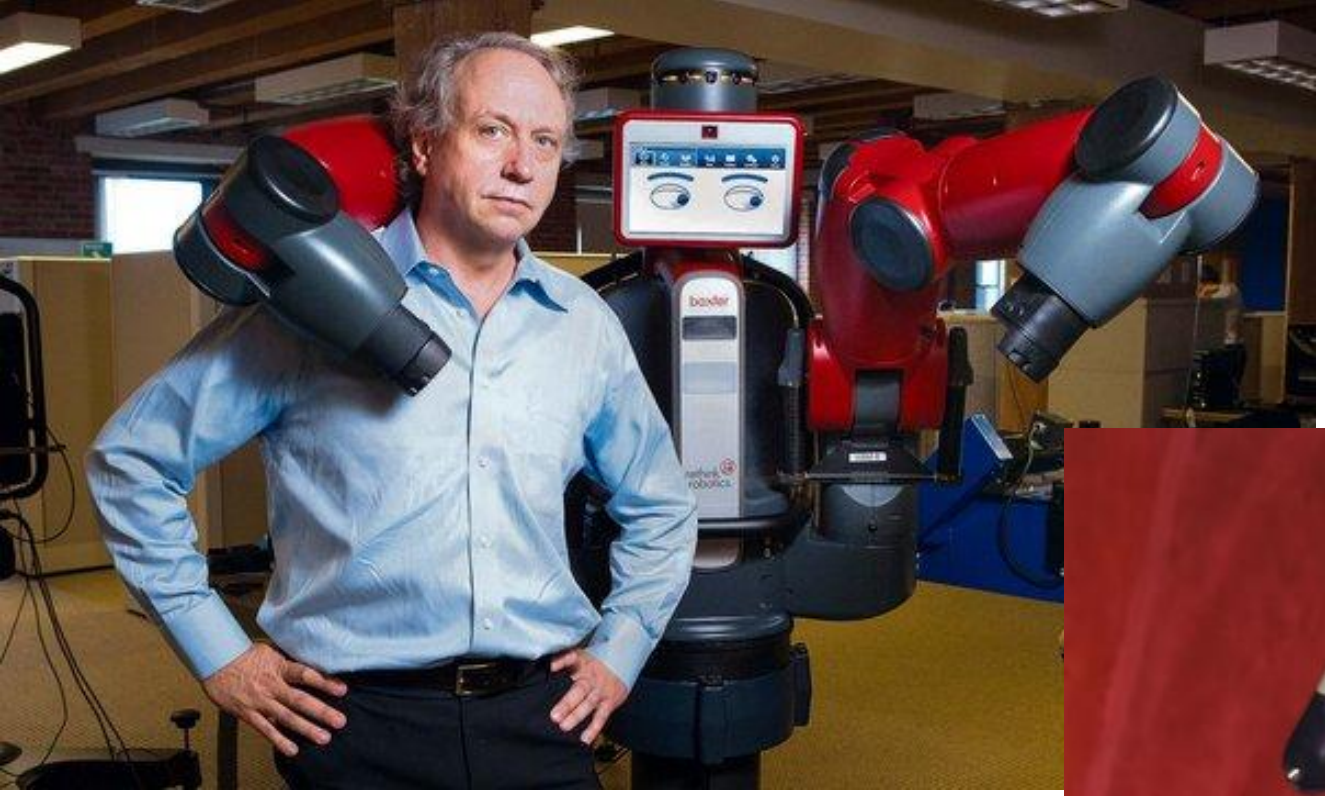

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Mechanisms

Sensors

Materials

Algorithms

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