Karlsruhe Institute of Technology

KONFERENZ ULTRAEFFIZIENZ FABRIK

Trends in der Digitalisierung

Ein Blick nach Silicon Valley

Prof. Dr.-Ing. Torsten Kröger

Intelligente Prozessautomation und Robotik (IPR) —— Institut für Anthropomatik und Robotik (IAR) —— Fakultät für Informatik

Content

- Non-exhaustive overview of US robotics activities
- Mostly based on personal experience

Outline

(Un)related Stories from Silicon Valley

Robot Arms and Grasping

Robots in Logistics for Higher Efficiencies

Open Source Robotics Foundation (OSRF)

- Willow Garage spinoff (May 2012)
- Non-profit organization
- Maintains ROS and Gazebo
- CEO: Brian Gerkey
- Current focus on developing ROS 2.0
- No safety, no proper real-time

Open Source Robotics Corporation (OSRC)

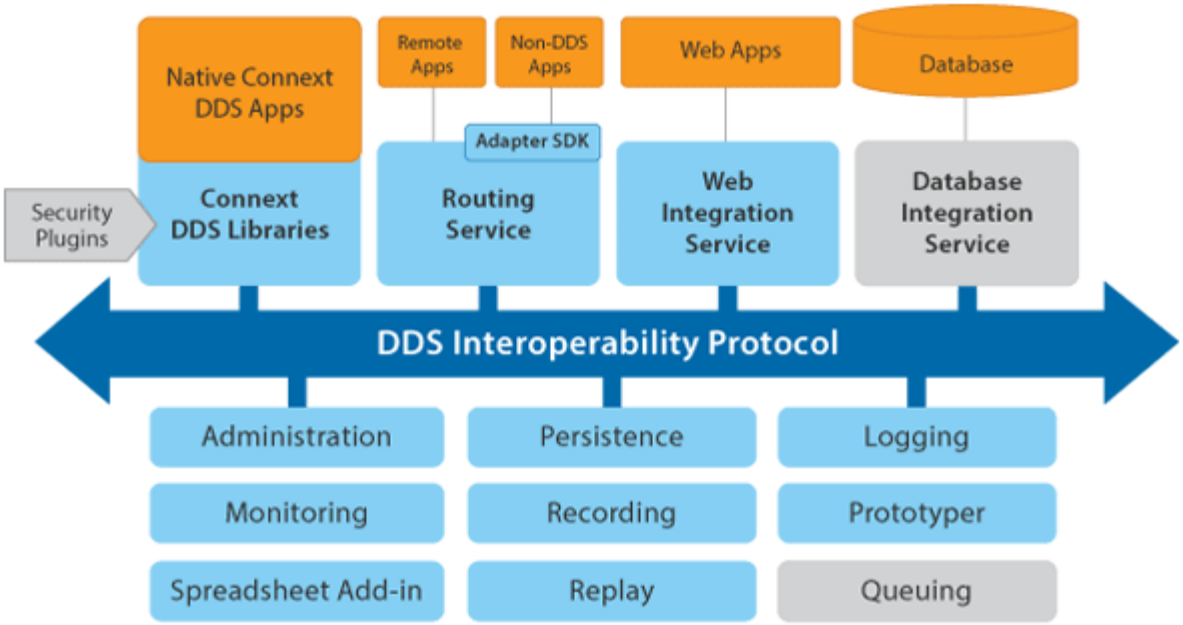
- Taxable subsidiary of OSRF (Sep 2016)
- For-profit
- Initially funded by Toyota Research Institute
- OSRF will keep holding software copyright
- New website: http://www.openrobotics.org

Southwest Research Institute

- Initiated ROS industrial (ROS-I)
- Non-safe, non-real-time connection to COTS industrial robots
- Head of ROS-I: Shaun Edwards

RTI – Real-Time Innovations

- RTI Connext DDS
- Distributed real-time middleware

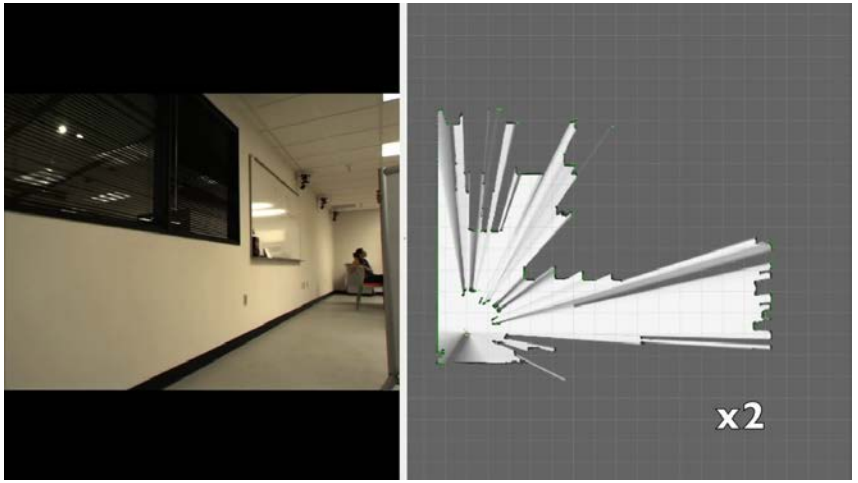


Toyota Research Institute (TRI)

- R&D in multiple robtoics domains:
  - Self-driving
  - Production and manufacturing
  - Autonomous mobile manipulation
- CEO: Gil Pratt
- CTO: James Kuffner

Toyota Research Institute (TRI)

- HSR, Human Support Robot



TOYOTA RESEARCH INSTITUTE

Huawei Technologies

- Mobile robot for kids and education
- Strong emphasis on social human-robot interaction

Mayfield Robotics (Bosch)

- Kuri
- Home robot
- Announced price: $699
- Inherently safe
- Focus on social human-robot interaction

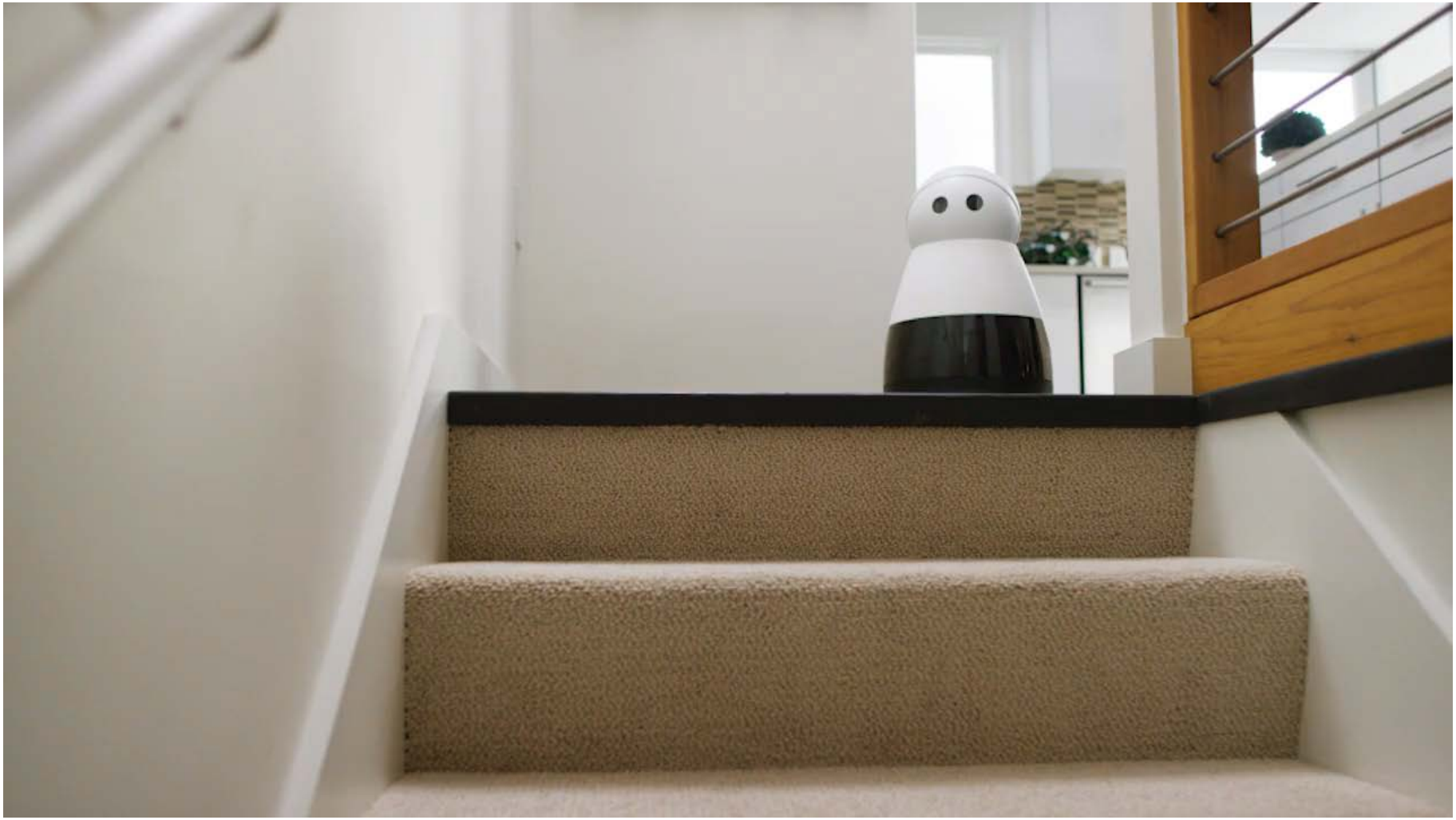
MAYFIELD ROBOTICS

kuri

Mayfield Robotics (Bosch)

Mayfield Robotics (Bosch)

Mayfield Robotics (Bosch)



Mayfield Robotics (Bosch)

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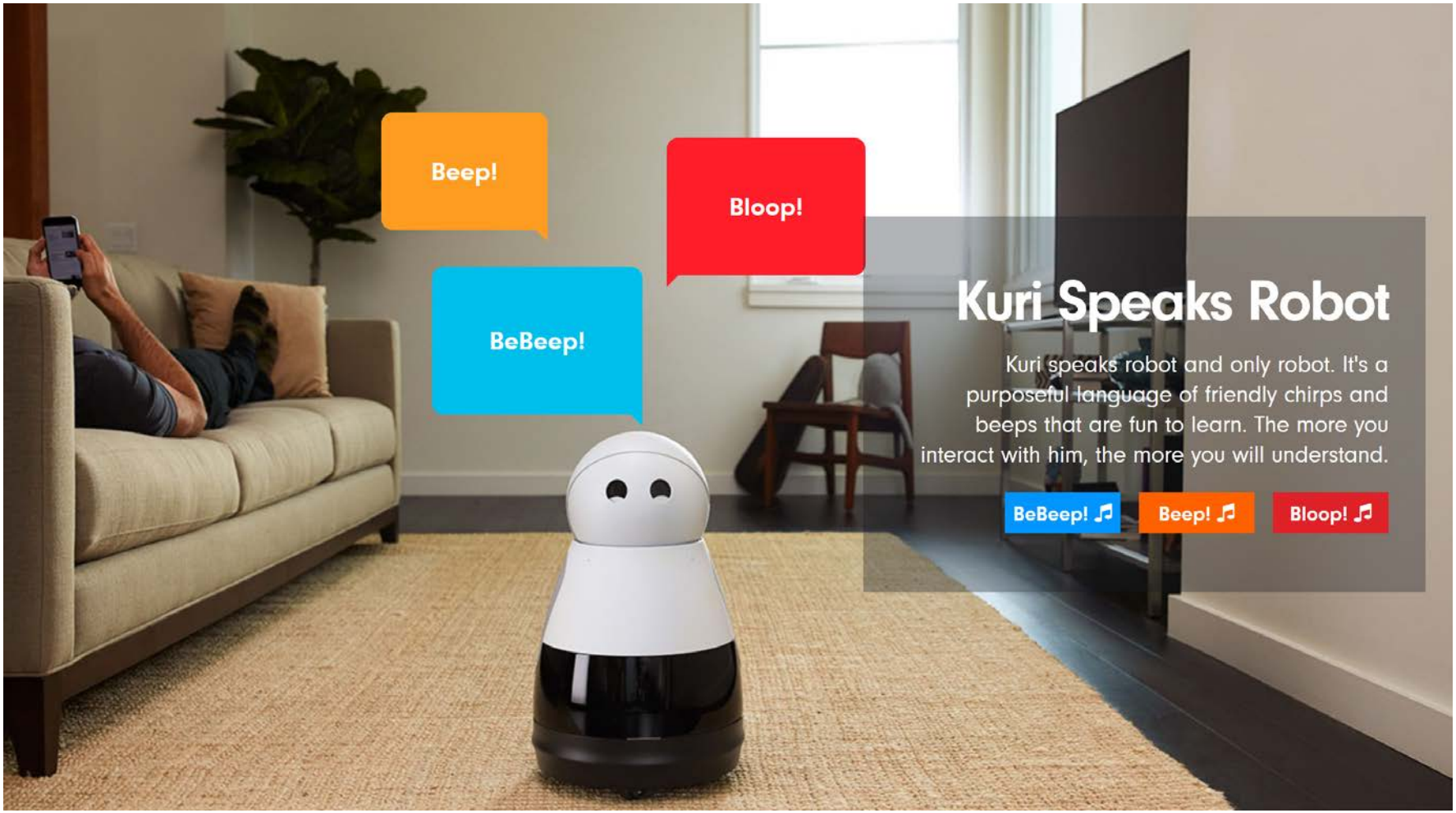
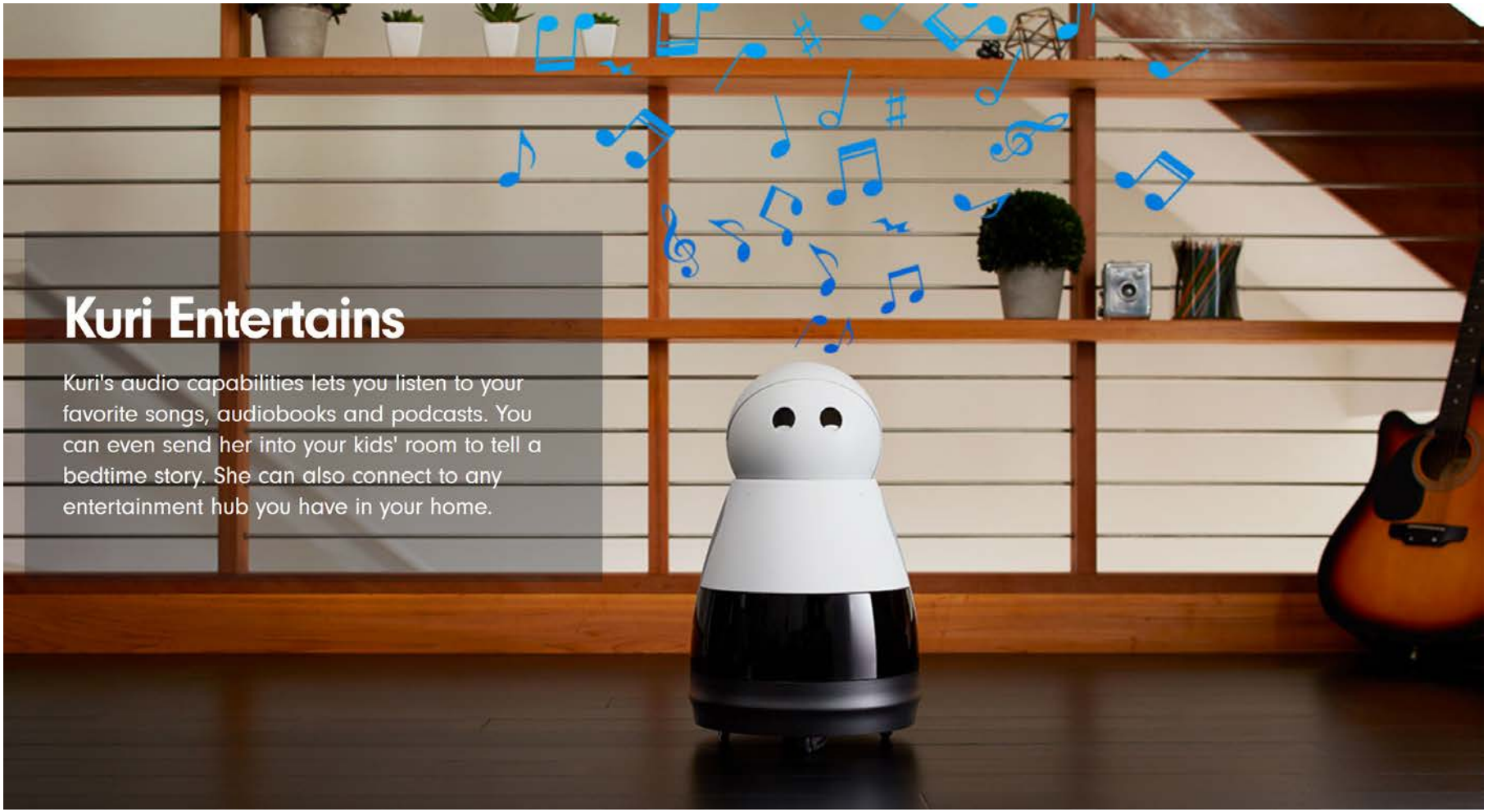


Mayfield Robotics (Bosch)



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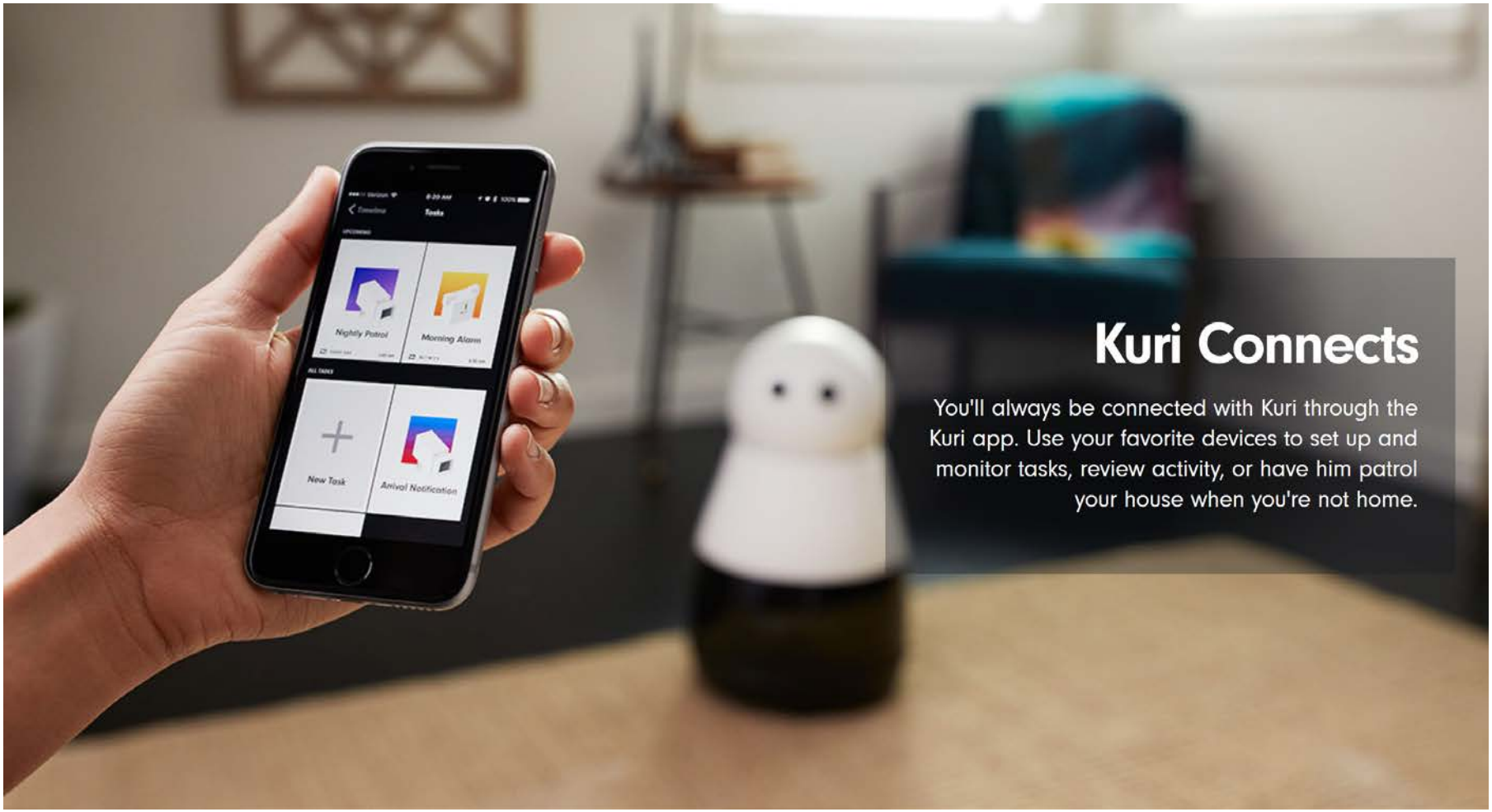
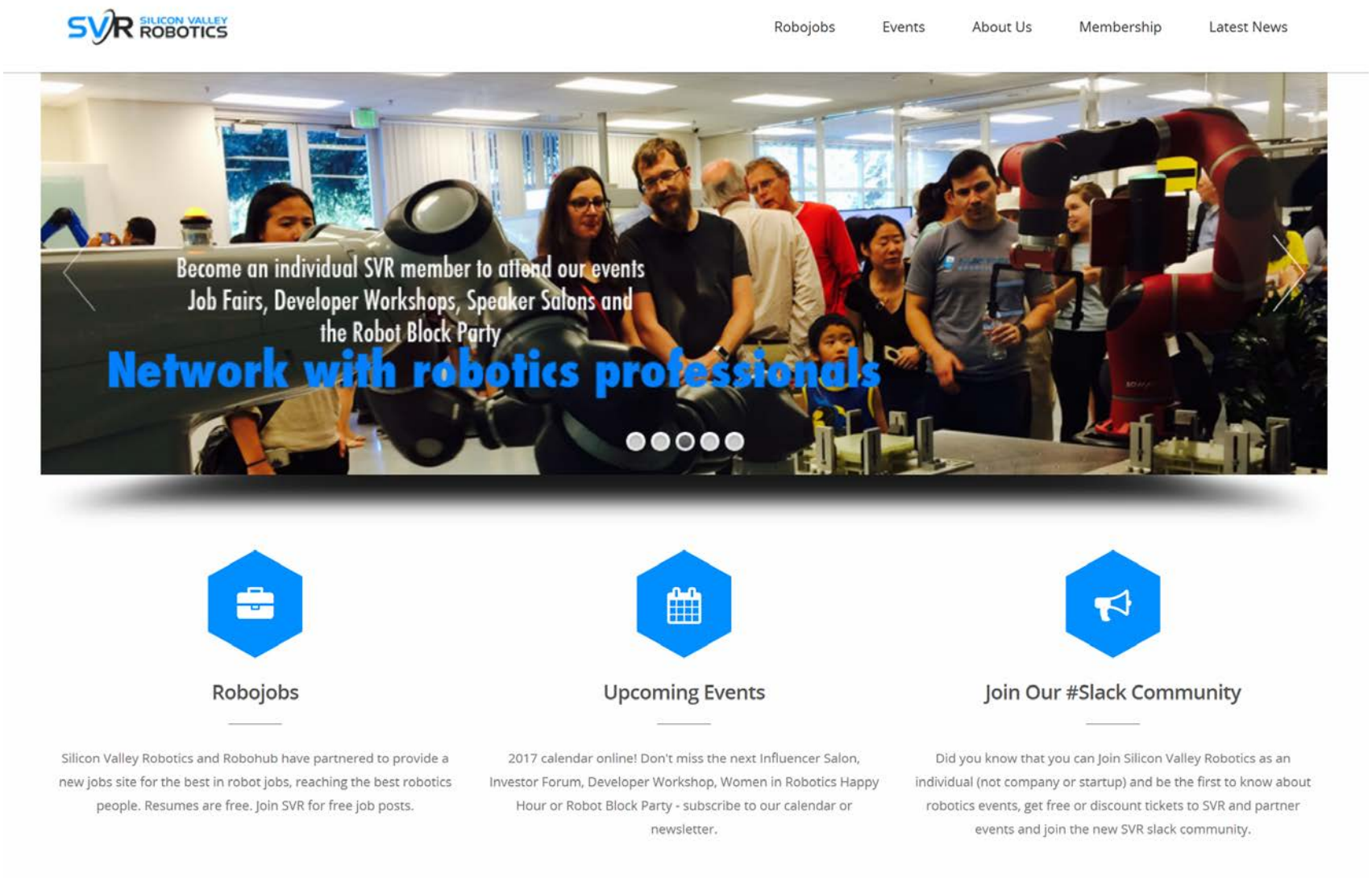


Savioke

- Delivery robot: Relay
- Hotels, logistics, home
- Founder and CEO: Steve Cousins

Savioke

Silicon Valley Robotics



Verb Surgical

- F(o)unded by J&J and Alphabet
- „Surgery 4.0“: digital surgery platform
  - Robotics
  - Visualization
  - Advanced instrumentation
  - Data analytics
  - Connectivity

Auris Health (formerly Surgical Robotics)

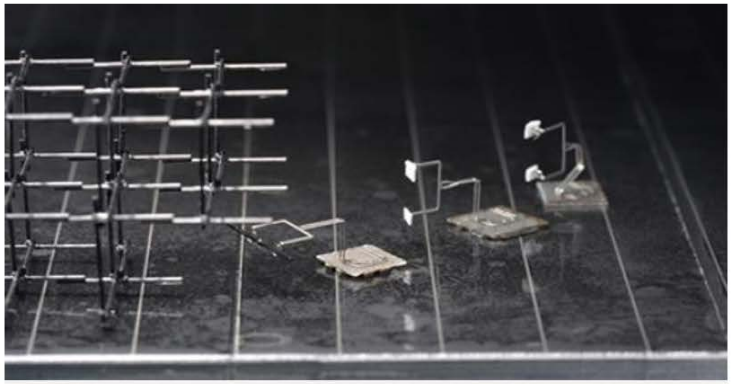
- Founded by Fed Moll
- Monarch: Auris Robotic Endoscopy System
- Out of stealth in 2018
- Acquisition of Hansen Medical
- Device FDA approved

Intuitive Surgical

- da Vinci Surgical System is still the sole product
- „Major“ product upgrade announced

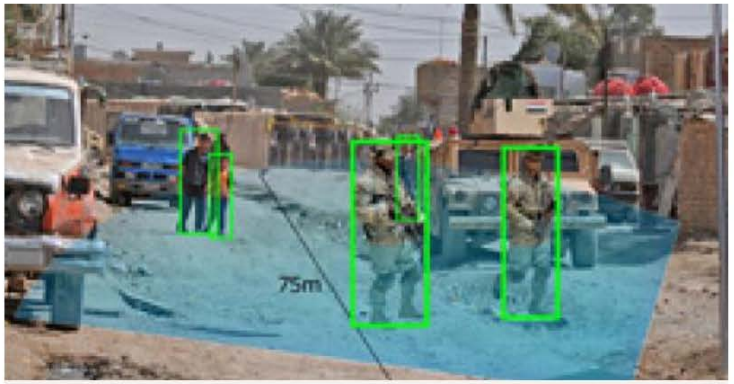
INTUITIVE SURGICAL®

SRI International



MicroFactory Platform for Smart Manufacturing

SRI is developing new technology to reliably control thousands of micro-robots for smart manufacturing of macro-scale products in compact, integrated systems.



Pedestrian Detection from Moving Unmanned Ground Vehicles

SRI's vision-based systems enable safe operations of moving unmanned ground vehicles around stationary and moving people in urban or cluttered environments.

SRI International

Visual Intelligence Grounded in Learning (VIGIL)

SRI's visual intelligence system could enable a new era in unmanned robotic surveillance.

Trauma Pod

With SRI as lead integrator, DARPA collaborators demonstrated how a remotely operated trauma pod could deliver emergency first-response treatment in the battlefield to stabilize patients for transport.

openAI

- F(o)unded by Elon Musk in 2015
- Non-profit
- Mission: „Friendly artificial intelligence“

OpenAI

Covariant.AI

- Learning robot motions from human demonstrations in VR
- Founder: Pieter Abbeel

Commonsense Robotics

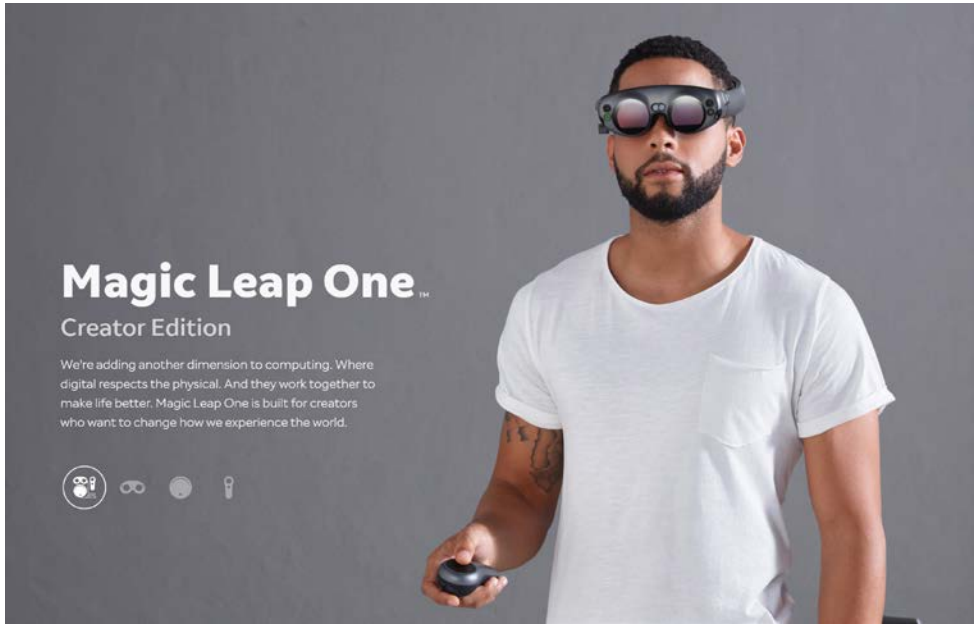
- On-demand supply-chains that enable profitable, one-hour delivery for online grocers.
- Based in Israel
- Investors from California

Symb.io

- Machine learning for robotics
- Still in stealth mode

Magic Leap

- Augmented realty devices and eco system
- Based in FL, CA, ,Switzerland, and Israel



ARRAIY

- Content creation for AR and VR using computer vision and deep learning
- Still in stealth phase

Lighthouse

LIGHTHOUSE

- Part of the Playground Global incubator
- Deep learning for visual object recognition

Lighthouse

LIGHTHOUSE

Karlsruhe Institute of Technology

Suitable Technologies

- F(o)under: Scott Hassan
- Tele-presence robots
  - Beam Pro
  - Beam Plus

Outline

(Un)related Stories from Silicon Valley

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Google Puts Money on Robots, Using the Man Behind Android

By JOHN MARKOFF DEC. 4, 2013

Andy Rubin is the engineer heading Google's robotics effort. He is the man who built the Android software for smartphones. Jim Wilson/The New York Times

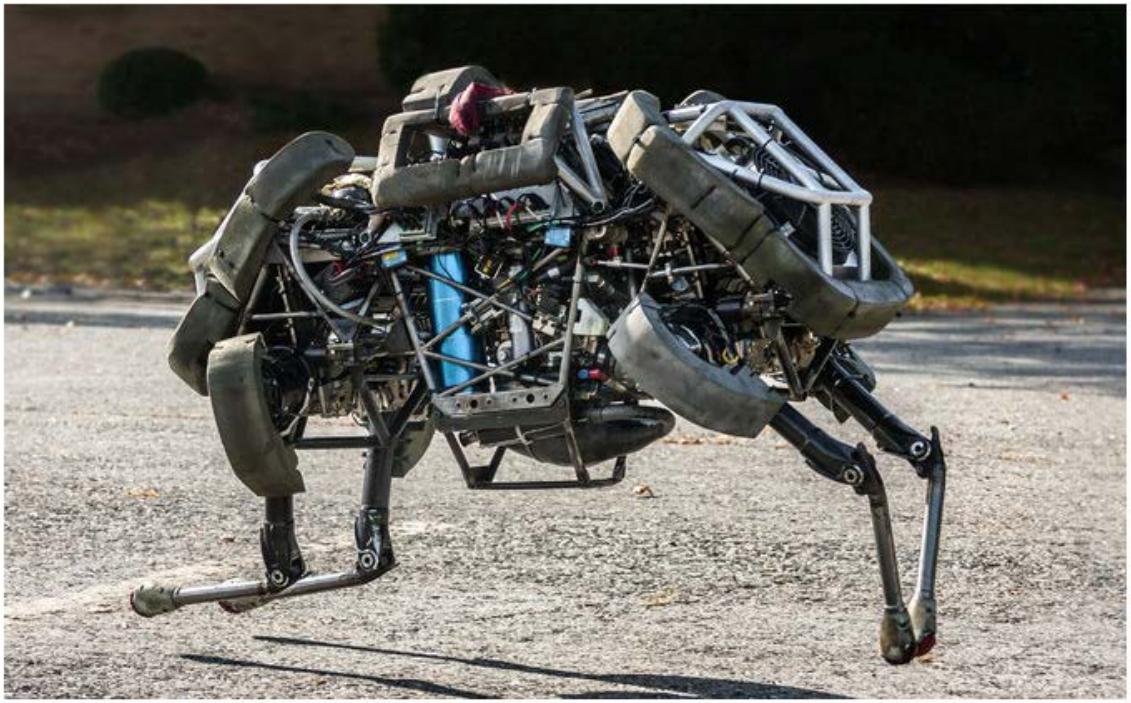
PALO ALTO, Calif. — In an out-of-the-way Google office, two life-size humanoid robots hang suspended in a corner.

If Amazon can imagine delivering books by drones, is it too much to think that Google might be planning to one day have one of the robots hop off an automated Google Car and race to your doorstep to deliver a package?

Google executives acknowledge that robotic vision is a "moonshot." But it appears to be more realistic than Amazon's proposed drone delivery service, which Jeff Bezos, Amazon's chief executive, revealed in a television

Google Adds to Its Menagerie of Robots

By JOHN MARKOFF DEC. 14, 2013



Boston Dynamics' four-legged robot named WildCat can gallop at high speeds. Boston Dynamics

SAN FRANCISCO — BigDog, Cheetah, WildCat and Atlas have joined Google's growing robot menagerie.

Google confirmed on Friday that it had completed the acquisition of Boston Dynamics, an engineering company that has designed mobile research robots for the Pentagon. The company, based in Waltham, Mass., has gained an international reputation for machines that walk with an uncanny sense of balance and even — cheetahlike — run faster than the fastest humans.

Alphabet

- Robotics acquisitions 2013 and 2014

ipi

BOT & DOLLY

Boston Dynamics

redwood robotics

meka

Holomni

Reflexes

Astro Teller, Captain of Moonshots at X, on the Future of AI, Robots, and Coffeemakers

By Erico Guizzo
Posted 8 Dec 2016 | 17:39 GMT

Interview from Dec 2016

Intelligent Machines

In Buying Boston Dynamics, SoftBank Is Betting Big on Walking Robots

Can the company make a go of the automatons that never did fit in at Google?

by Jamie Condliffe June 9, 2017

The technology conglomerate Softbank has acquired Boston Dynamics,

June 2017

Learning Hand-Eye Coordination for Robotic Grasping with Deep Learning and Large-Scale Data Collection

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Deirdre Quillen DEQUILLEN@GOOGLE.COM
Google

Abstract

We describe a learning-based approach to hand-eye coordination for robotic grasping from monocular images. To learn hand-eye coordination for grasping, we trained a large convolutional neural network to predict the probability that task-space motion of the gripper will result in successful grasps, using only monocular camera images and independently of camera calibration or the current robot pose. This requires the network to observe the spatial relationship between the gripper and objects in the scene, thus learning hand-eye coordination. We then use this network to servo the gripper in real time to achieve successful grasps. To train our network, we collected over 800,000 grasp attempts over the course of two months, using between 6 and 14 robotic manipulators at any given time, with differences in camera placement and hardware. Our experimental evaluation demonstrates that our method achieves effective real-time control, can successfully grasp novel objects, and corrects mistakes by continuous servoing.

Figure 1. Our large-scale data collection setup, consisting of 14 robotic manipulators. We collected over 800,000 grasp attempts to train the CNN grasp prediction model.

1. Introduction

When humans and animals engage in object manipulation behaviors, the interaction inherently involves a fast feedback loop between perception and action. Even complex manipulation tasks, such as extracting a single object from a cluttered bin, can be performed with hardly any advance planning, relying instead on feedback from touch and vision. In contrast, robotic manipulation often (though not always) relies more heavily on advance planning and analysis, with relatively simple feedback, such as trajectory following, to ensure stability during execution (Srinivasa et al., 2012). Part of the reason for this is that incorporating complex sensory inputs such as vision directly into a feedback controller is exceedingly challenging. Techniques such as visual servoing (Siciliano & Khatib, 2007) perform continuous feedback on visual features, but typically require the features to be specified by hand, and both open loop perception and feedback (e.g. via visual servoing) requires manual or automatic calibration to determine the precise geometric relationship between the camera and the robot's end-effector.

In this paper, we propose a learning-based approach to hand-eye coordination, which we demonstrate on a robotic grasping task. Our approach is data-driven and goal-centric: our method learns to servo a robotic gripper to

Learning Hand-Eye Coordination

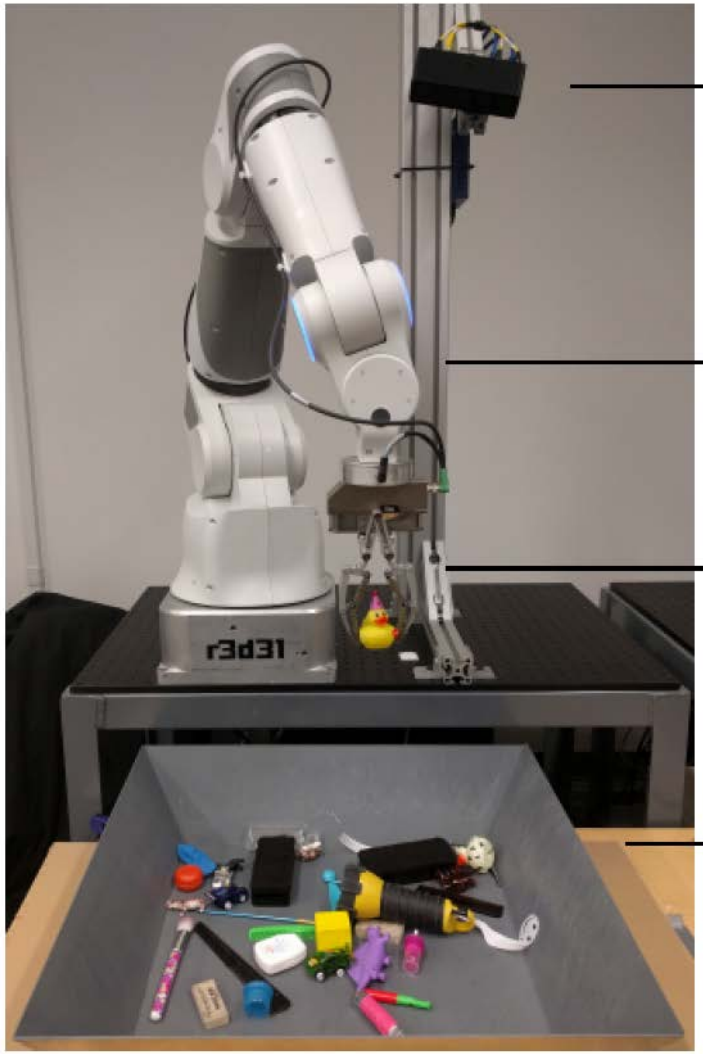
Input

512x512 pixels

Finger position

Output

Task space gripper motion



Learning Hand-Eye Coordination

800,000 attempts

14 robot arms

Two months

CNNs for deep reinforcement learning

Shared models

Data Driven Robotics

Different Objects, Different Grasping Strategies

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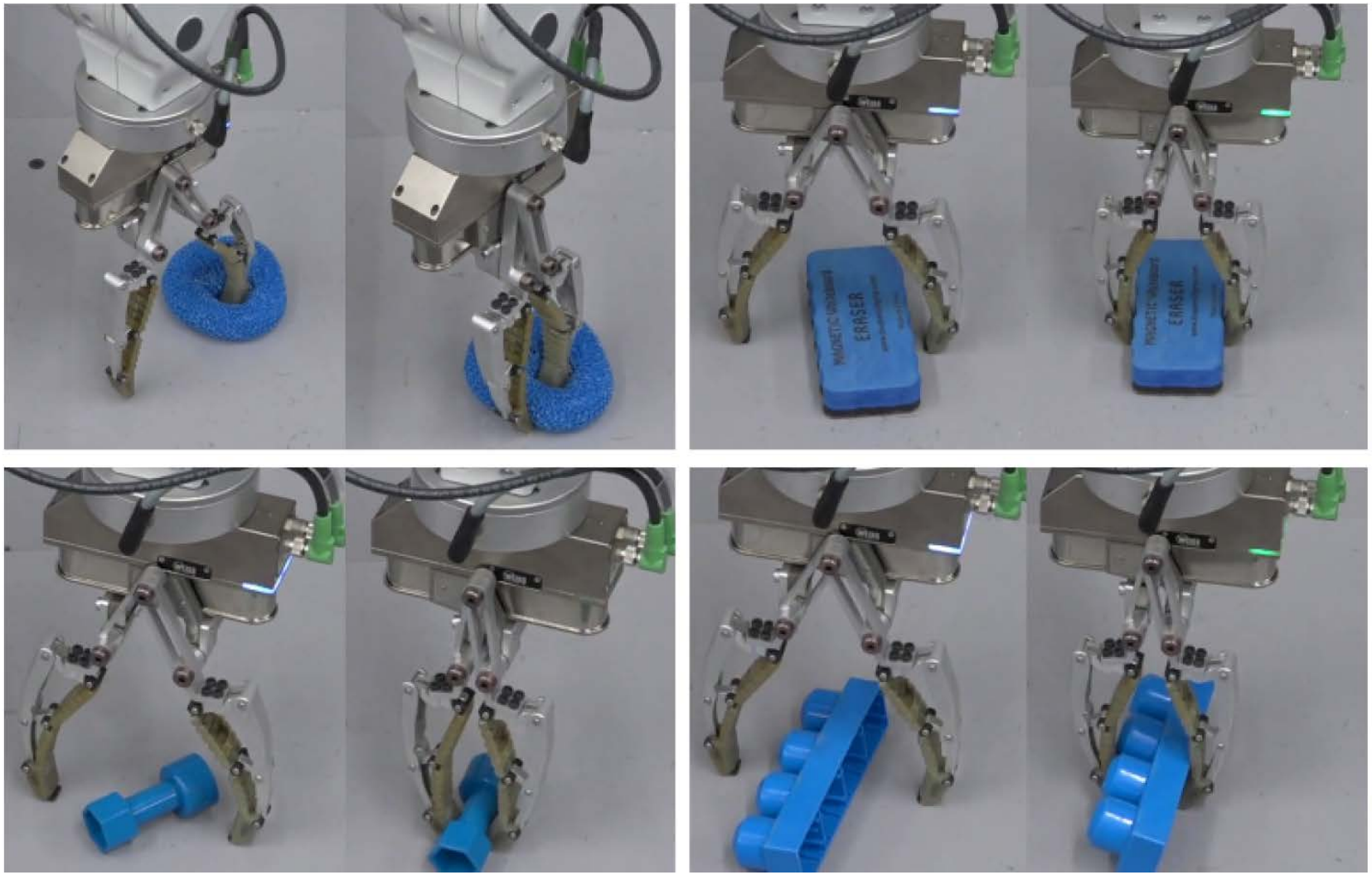
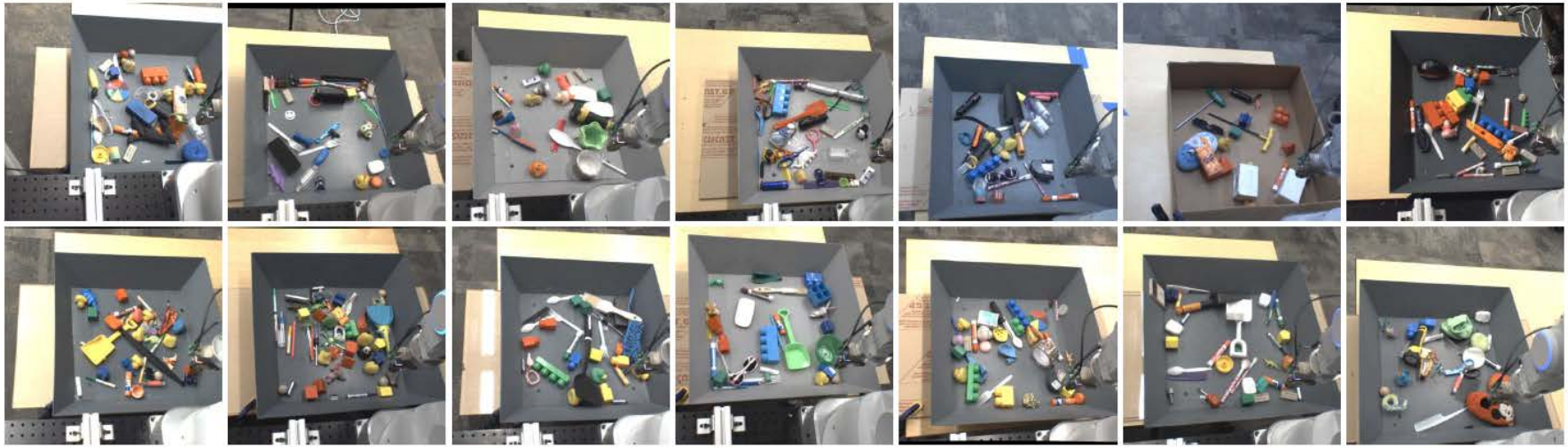
Different Objects, Different Grasping Strategies

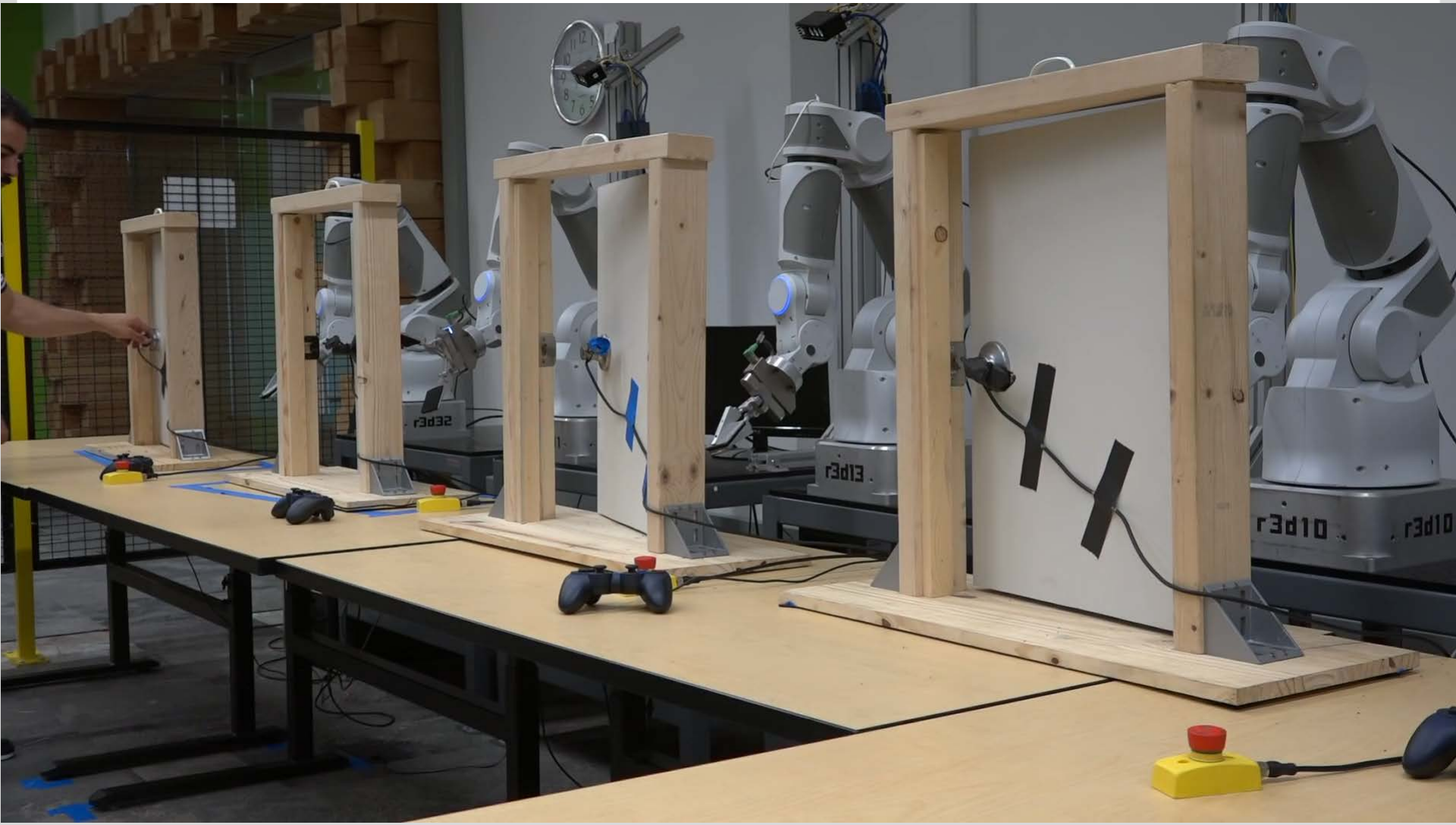


Different Objects, Different Grasping Strategies

New (Unknown) Objects



X, Google Research



Next Generation Arm Farm

DexNet 2.0 (UC Berkeley)

Dex-Net 2.0

99% Precision Grasping

AUTOLAB

BAIR
BERKELEY ARTIFICIAL INTELLIGENCE RESEARCH

CITRIS
PEOPLE AND ROBOTS
INITIATIVE

Berkeley
Engineering

Outline

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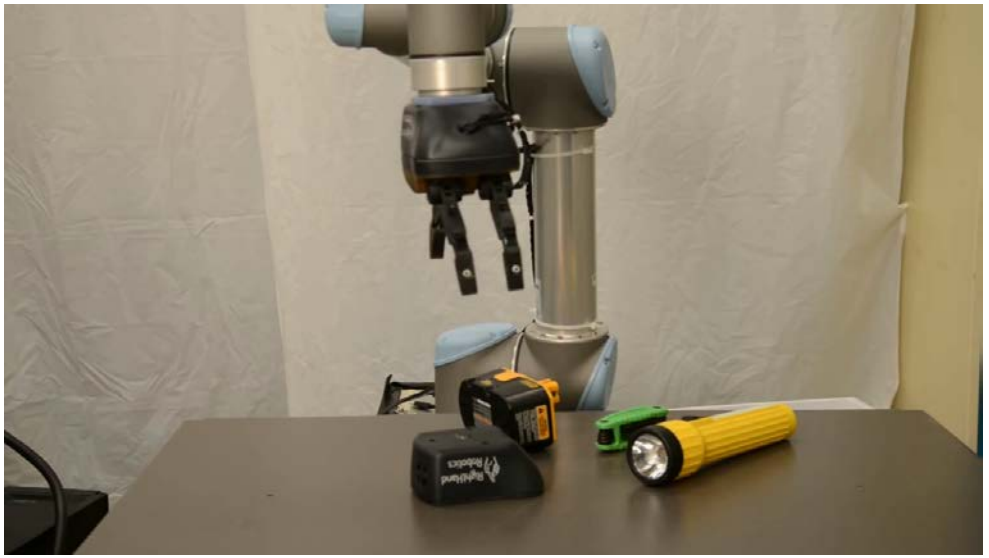
RightHand Robotics

- Based in Massachusetts
- Autonomous picking for e-commerce order fulfillment

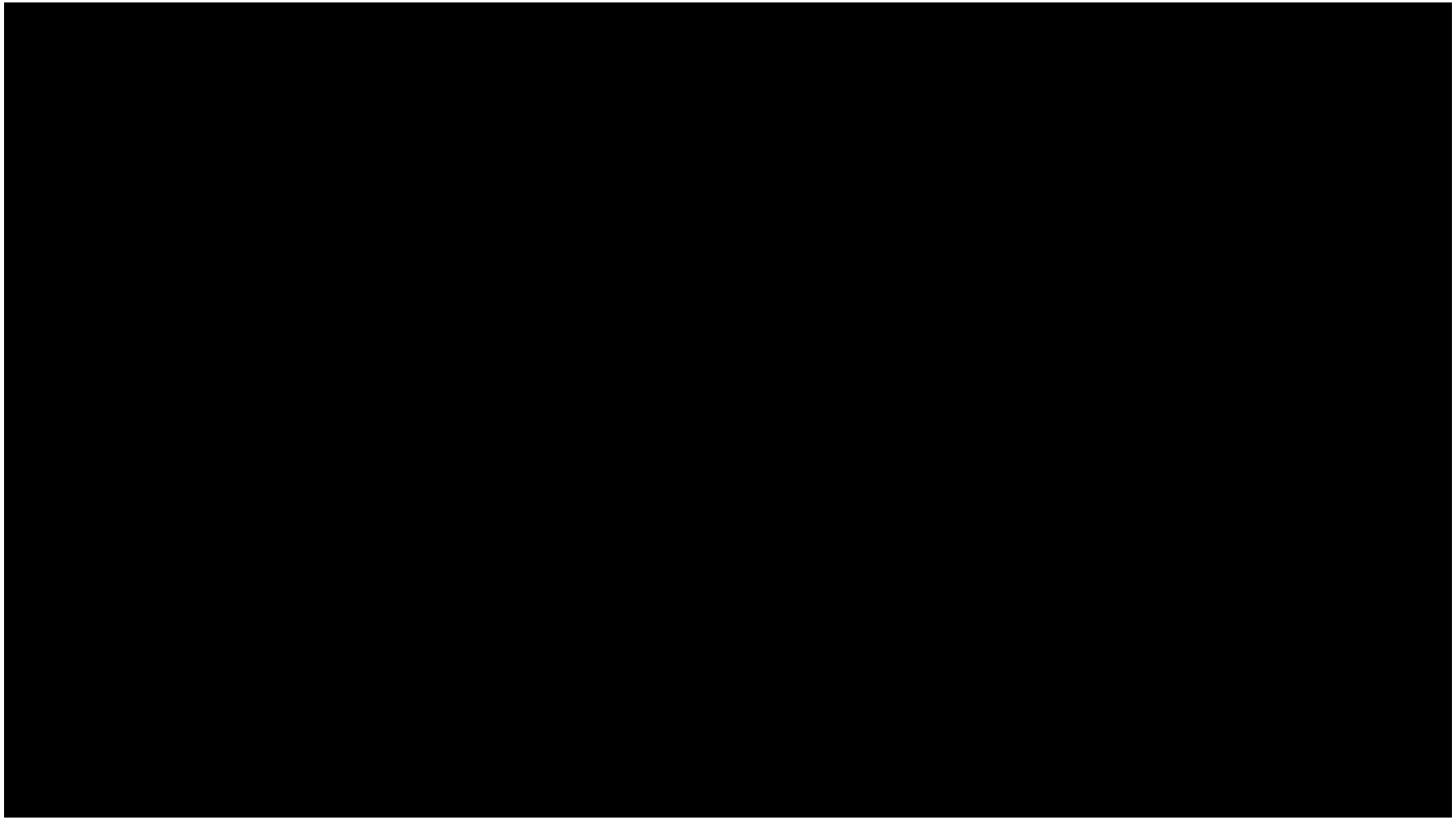
RIGHTHAND robotics



Kinema Systems

- Robot paletizing
- 3D vision using deep learning
- Founder: Sachin Chitta

Kinema Systems



Fetch Robotics

- Autonomous mobile robots for warehouses
- Founder: Melonee Wise
- ROS

Fetch Robotics

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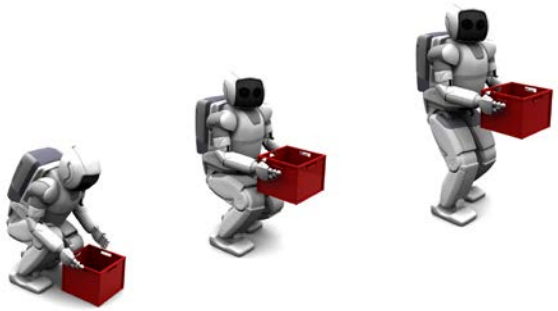
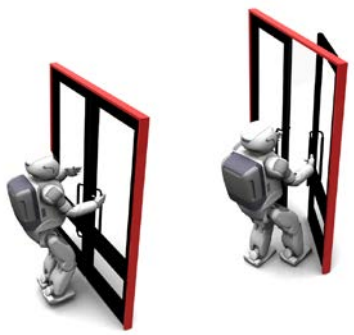


Thank you!

torsten@kit.edu



De-hyping AI

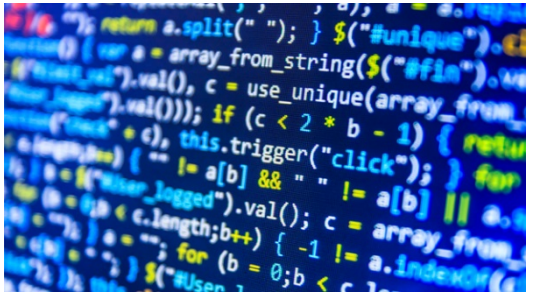
1. Machine learning means learning from data; **AI is a buzzword**

2. Machine learning is about data and algorithms, **but mostly data**

3. Unless you have a lot of data, you should stick to **simple models**

Simplified: The “Four Revolutions”

1. Mechanical hardware
2. Electrical hardware
3. Software
4. **Data**



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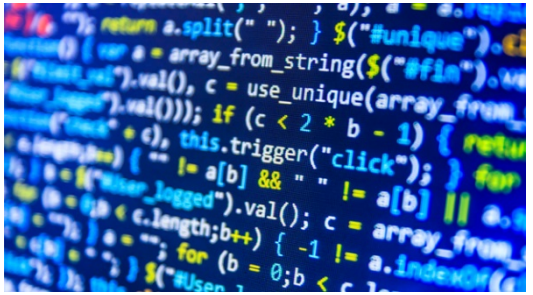

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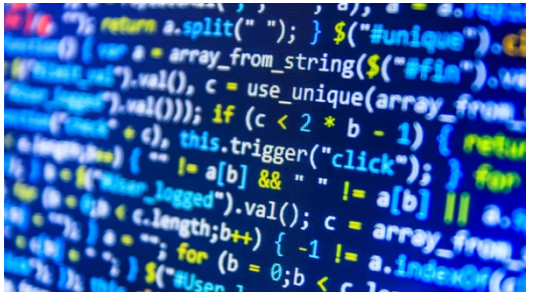

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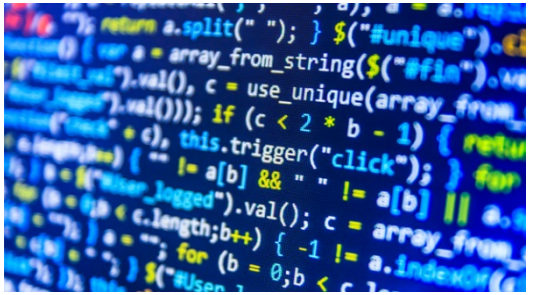

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