Robotics

USI, Spring 2024

Prof. **Alessandro Giusti** – TAs: Elia Cereda, Simone Arreghini
Dalle Molle Institute for Artificial Intelligence (IDSIA) USI - SUPSI

Logistics

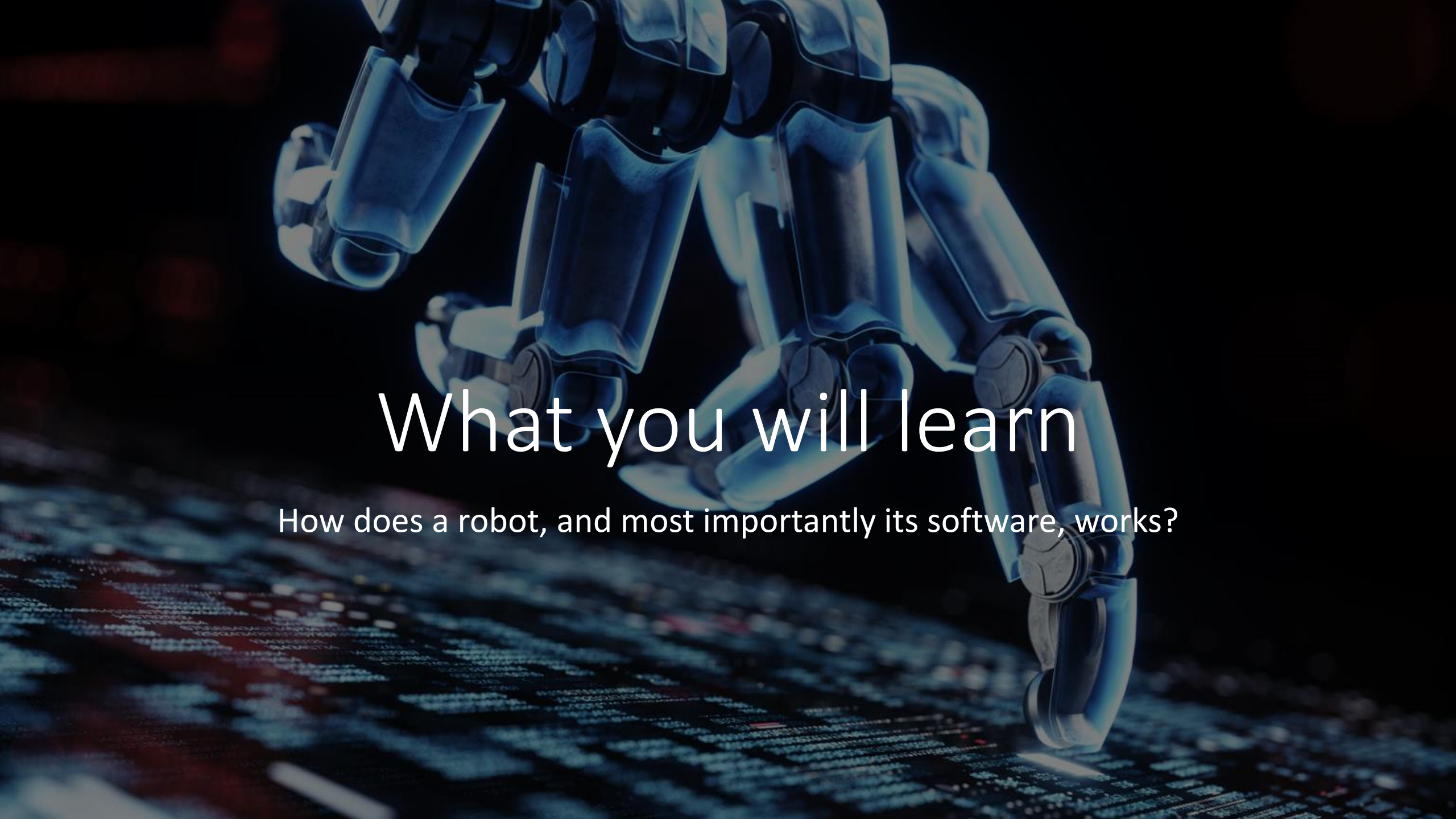
- Lectures:
  - Tue, 9:00 – 10:30
  - Fri, 11:00 – 12:30
- About 60% time on theory, 40% hands-on labs (exact schedule to be defined)
- Contact for questions etc:
  Alessandro Giusti alessandro.giusti@idsia.ch

Evaluation

- 1st lab project (10%)
- 2nd lab project (10%)
- Final project (30%)
- Final exam on theory topics (50%)

Course should be visible on iCorsi

Handouts and other reference material will be uploaded on the course website, typically just after the lecture



What you will learn

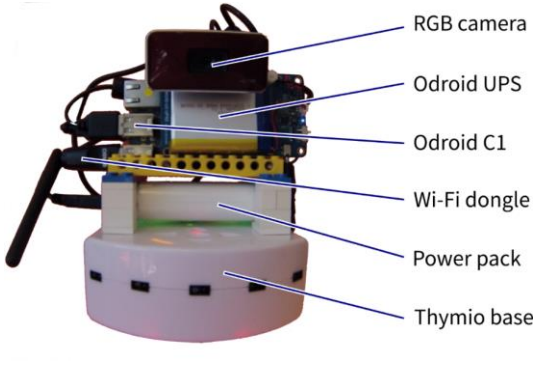
How does a robot, and most importantly its software, works?

Theory + Lab

Theory classes on mathematical and computational models about the fundamental problems in robotics

Lab+Project activities to experiment with the models and learn the tools

- physics-based realistic simulation using ROS and Coppelia SIM
- optional activities with real robots



python™

ROS

Open Source Robotics Foundation

GAZEBO

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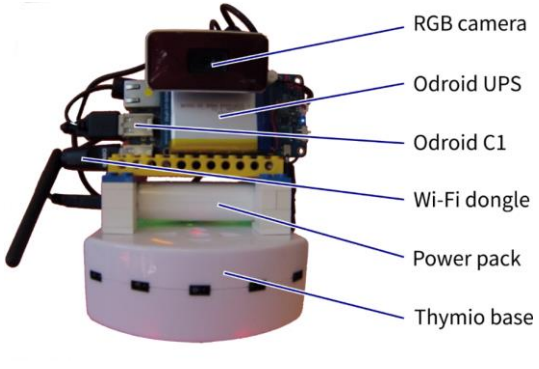

python™

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Syllabus for the theory part

- 2D and 3D pose representation and transformations
- Workspace, C-Space, Degrees of Freedom
- Kinematics for arms and wheeled robots
- Feedback-based control
- Sensors
- Localization, Mapping
- Path planning
- Individual seminars from guest speakers on:
  - Visual Servoing
  - Model-Predictive Control
  - AI-powered nano-drones

About the instructor

Who am I?

- PhD in Computer Vision (2009)
- Professor at IDSIA (an institute of USI and SUPSI) working on:
  - Computer Vision (since 2009)
  - Biomedical Image Analysis (since 2009)
  - Robotics (since 2012)
  - Data Science (since 2015)
- Lecturer at SUPSI, USI, Zurich University of Applied Sciences, Politecnico di Milano

Scuola universitaria professionale della Svizzera italiana
SUPSI

Università della Svizzera italiana

Zürcher Hochschule für Angewandte Wissenschaften
zhaw School of Engineering

POLITECNICO MILANO 1863

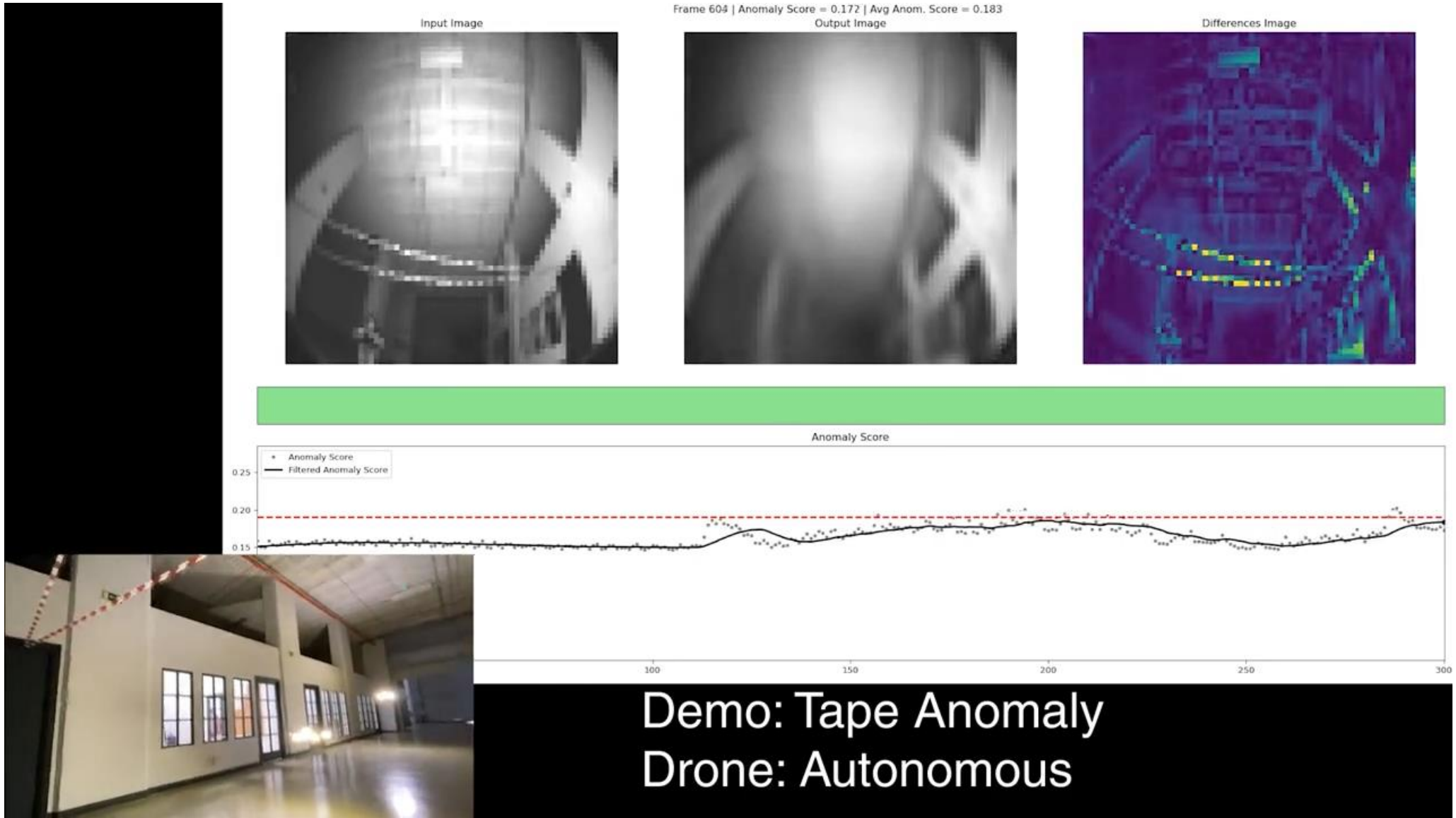
Machine Learning for Drones

Finalist,
AAAI video awards,
Phoenix, USA

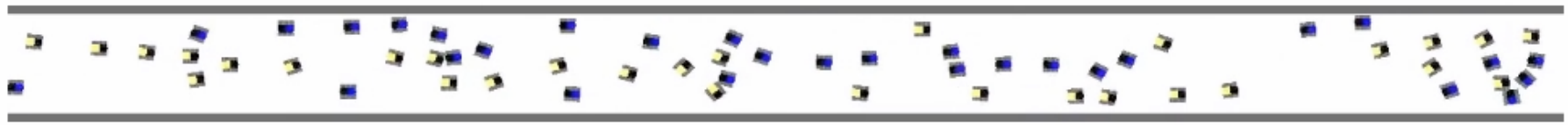
Giusti et al., RAL 2016 -- https://www.youtube.com/watch?v=umRdt3zGgpU

https://github.com/idsia-robotics/proximity-quadrotor-learning

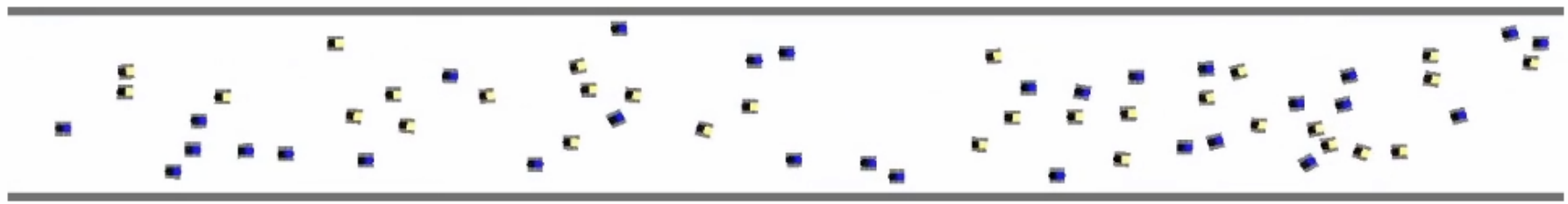
Note robustness to unseen users, strange poses, fast dynamics, lighting variations, multiple users


Frame 604 | Anomaly Score = 0.172 | Avg Anom. Score = 0.183
Input Image
Output Image
Differences Image
Anomaly Score
Anomaly Score
Filtered Anomaly Score
0.25
0.20
0.15
100
150
200
250
300
Demo: Tape Anomaly
Drone: Autonomous

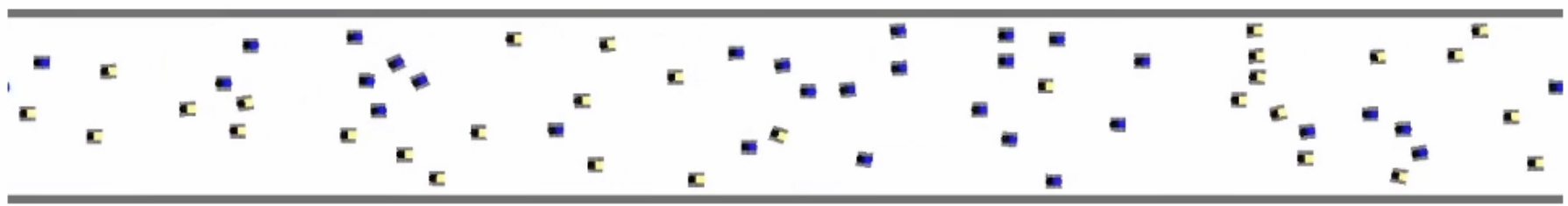
Opposite flows



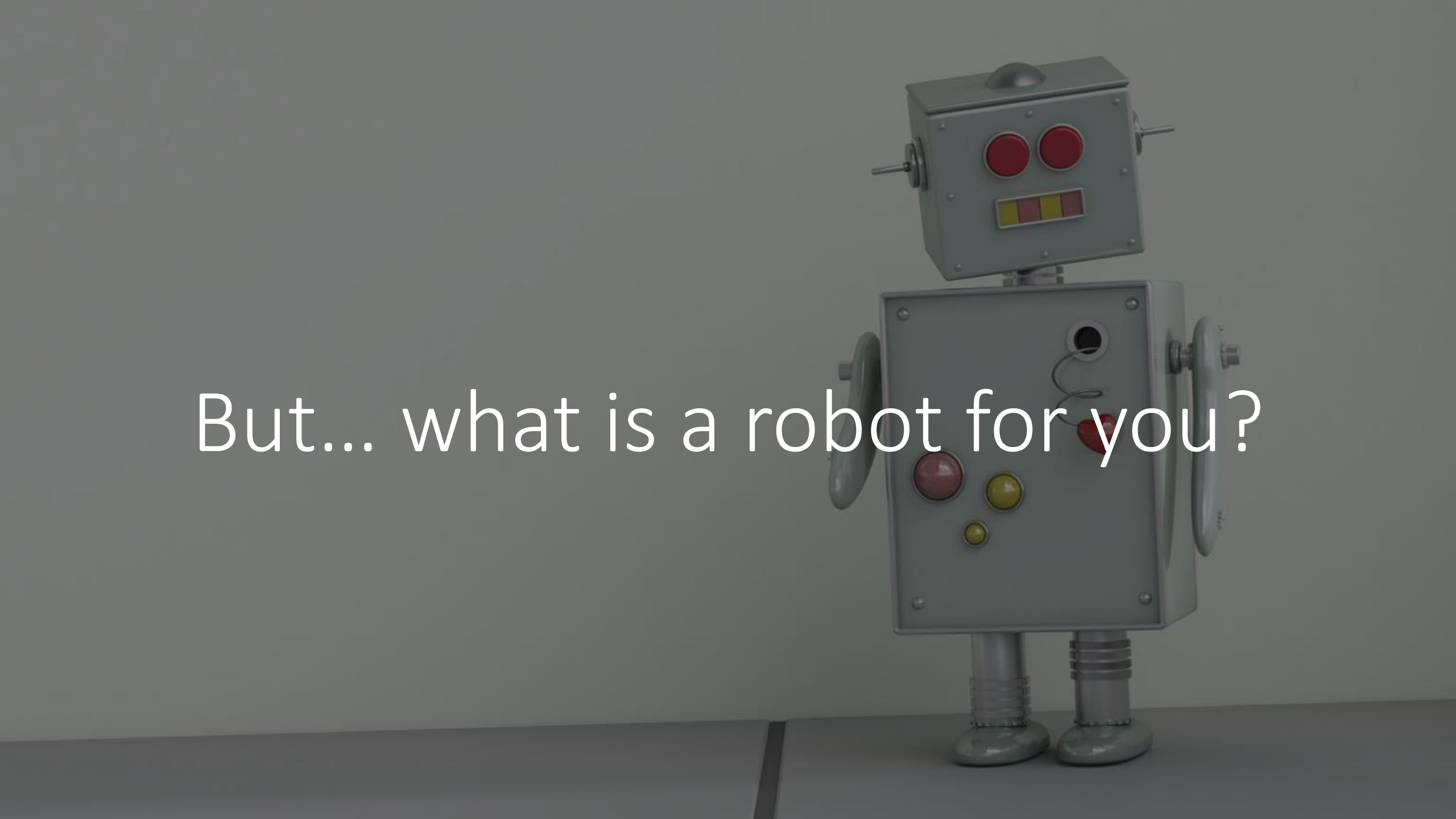
Different speeds



Different kinds (xenophobic)




http://people.idsia.ch/~gromov/proximity-hri-pipeline/


But… what is a robot for you?

1 Go to wooclap.com

2 Enter the event code in the top banner

Event code
RNKHIU

Industrial Robotics

Social Robotics

https://spectrum.ieee.org/children-beating-up-robot

Robotics for logistics

https://www.youtube.com/watch?v=HFupUT7YmCY

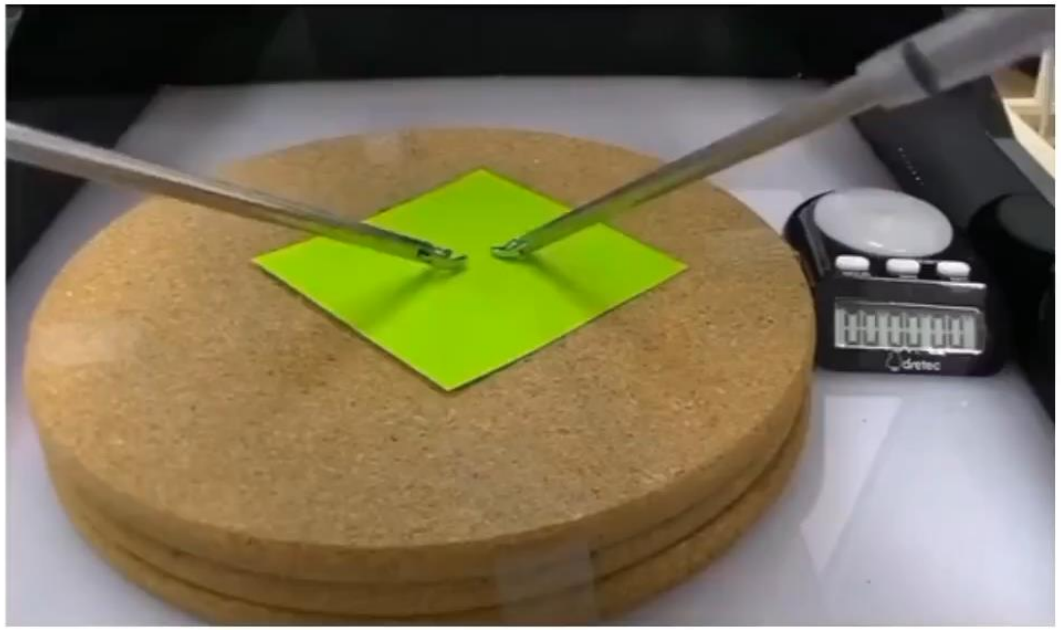
Milking robots

Cleaning robots

Robot toys

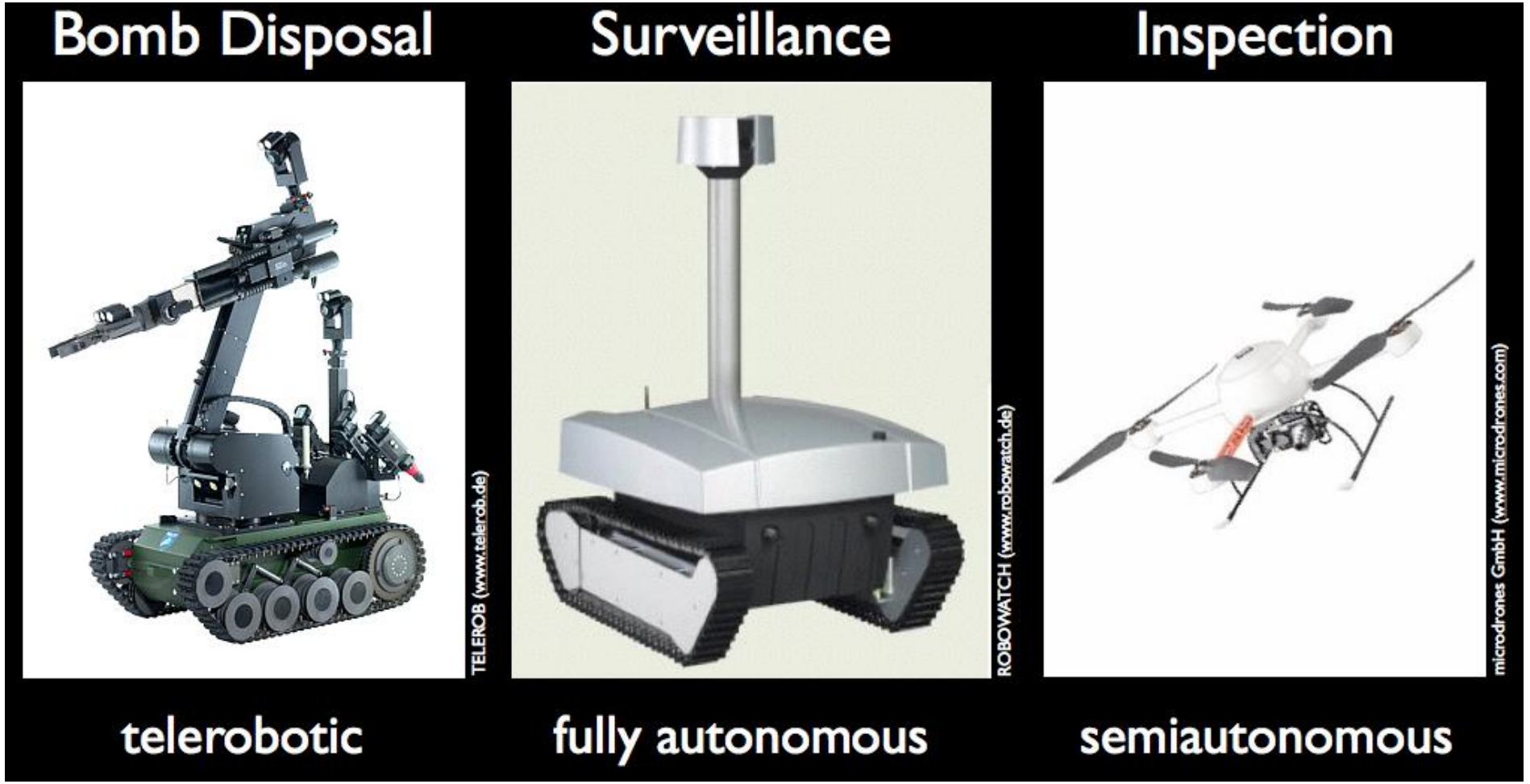
Medical/surgical robotics

Surgeon uses robotic arm to fold paper crane during laparoscopic surgery practice



https://www.instagram.com/reel/C3FVzVaCD-9

Autonomy


Bomb Disposal
Surveillance
Inspection
TELEROB (www.telerob.de)
ROBOWATCH (www.robowatch.de)
microdrones GmbH (www.microdrones.com)
telerobotic
fully autonomous
semiautonomous

Self-driving and shared autonomy

04 Mar 2022

The 2030 Self-Driving Car Bet

It's my honor to announce that John Carmack and I have initiated a friendly bet of $10,000* to the 501(c)(3) charity of the winner's choice:

> **By January 1st, 2030, completely autonomous self-driving cars meeting SAE J3016 level 5 will be commercially available for passenger use in major cities.**

I am betting *against*, and John is betting *for*.

Jeff Atwood
https://blog.codinghorror.com/the-2030-self-driving-car-bet/

Sel

SAE J3016™ LEVELS OF DRIVING AUTOMATION™

Learn more here: sae.org/standards/content/j3016_202104

	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	**You are driving** whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			**You are not driving** when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			**These are automated driving features**		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering **OR** brake/ acceleration support to the driver	These features provide steering **AND** brake/ acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering **OR** • adaptive cruise control	• lane centering **AND** • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/ steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

Some definitions

Definition – Wikipedia

- A robot is a mechanical or virtual artificial agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry.
- Robots can be autonomous or semi-autonomous and range from humanoids to industrial robots, collectively programmed swarm robots, and even microscopic nano robots.
- By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own.

Definition – Merriam-Webster

- A machine that looks like a human being and performs various complex acts (as walking or talking) of a human being.
- A device that automatically performs complicated often repetitive tasks
- A mechanism guided by automatic controls
- An efficient insensitive person who functions automatically

Definition – International Standards Organization (ISO)

An automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed, in place or mobile, for use in industrial automation applications.

Definition – Robotics Institute of America

- Handling devices with manual control
- Automated handling devices with predetermined cycles
- Programmable, servo-controlled robots with continuous of point-to-point trajectories
- Robots capable of the last specifications which also acquire information from the environment for intelligent

Definition – National Geographics Kids (Melissa Stewart)

A robot, or bot, is a machine that has movable parts and makes decisions. People design it to do a job by itself.

A robot collects information from its surroundings. Then it processes the information and figures out the best way to do its job.

Definition – Maja Mataric (The robotics primer)

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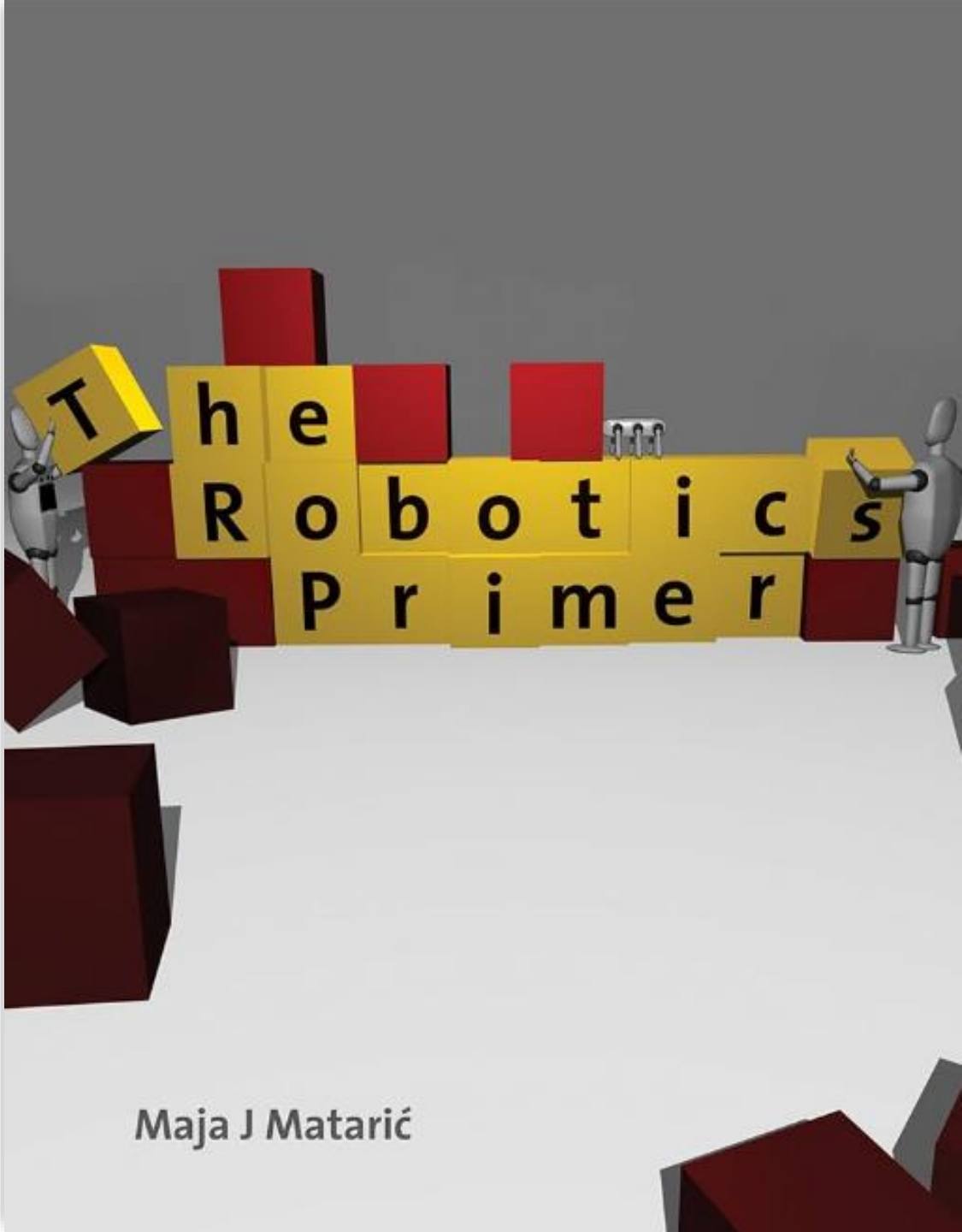


Some key features

- **AUTONOMOUS SYSTEM**: acts on the basis of its own (likely programmed) decisions, and is not (fully) controlled by a human (e.g., fully teleoperated systems).
- **PHYSICALLY EMBEDDED**: exists in the physical world, subject to the laws of physics (e.g., it does not live in a computer).
- **SENSE ITS ENVIRONMENT**: it has sensors to acquire world information.
- **ACT ON ITS ENVIRONMENT**: it has physical effectors/actuators
- **ACHIEVE GOALS**: it is not a random or meaningless entity

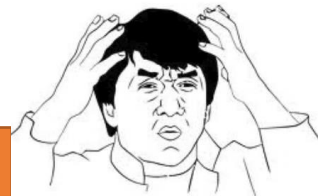
Excludes surgical robots!

Excludes chatbots

Excludes traditional Japanese automata

Excludes surveillance cameras

... still includes washing machines?



A general view of robot controllers