Seminars in Artificial Intelligence and Robotics

Computer Vision for Intelligent Robotics

Introduction

DIPARTIMENTO DI INGEGNERIA INFORMATICA
AUTOMATICA E GESTIONALE ANTONIO RUBERTI

SAPIENZA
UNIVERSITÀ DI ROMA

Alberto Pretto

Contacts

Teachers:

- Mario Gianni <gianni.mario@dis.uniroma1.it>
- Alberto Pretto <pretto@dis.uniroma1.it>

Classes

- Wednesday h. 10-12 room A7
- Friday h. 12:30-15 room A6

Meetings for advice

- Gianni: TBD
- Pretto: B115. Wednesday h. 16 or better **please book an appointment**.

Course web page:

- https://elearning2.uniroma1.it/course/view.php?id=4936

Overview

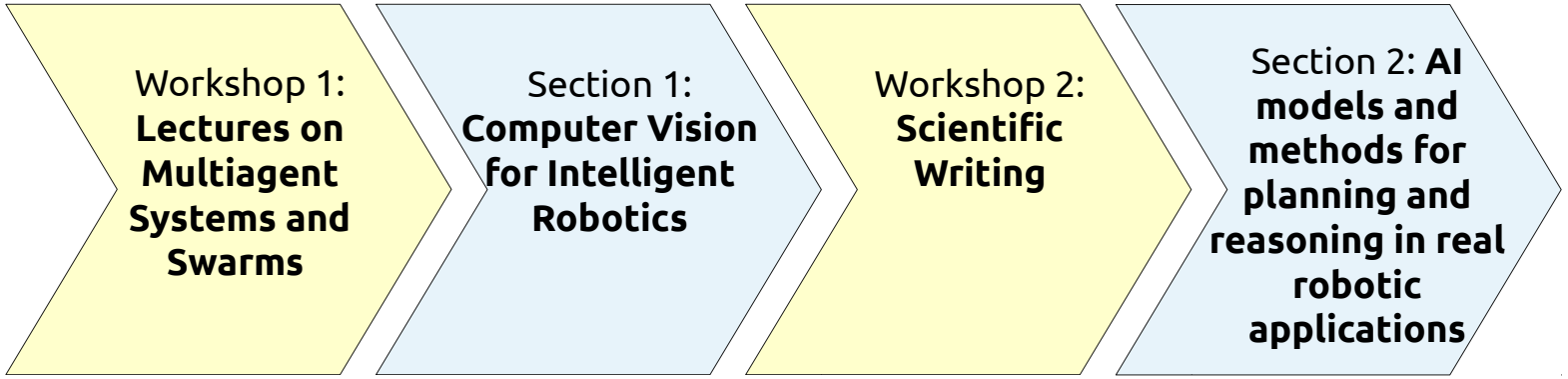
Two consecutive, independent seminar series

- **Computer Vision for Intelligent Robotics** (Alberto Pretto)
- **Artificial Intelligence models and methods for planning and reasoning in real robotic applications** (Mario Gianni)

Two 3-days workshops

- **Lectures on Multiagent Systems and Swarms** (Prof. Sean Luke)
- **Scientific Writing** (Rishelle Wimmer)

Schedule


Workshop 1: **Lectures on Multiagent Systems and Swarms**
Section 1: **Computer Vision for Intelligent Robotics**
Workshop 2: **Scientific Writing**
Section 2: **AI models and methods for planning and reasoning in real robotic applications**

Worksh tation

Ask him for a master's thesis!

Lectures on M tiagent Systems and Swarms

Prof. Sean Luke
Department of Computer Science, George Mason University

Prof. Luke will introduce basic concepts and issues in multiagent systems, with an emphasis on scenarios with large numbers of agents (swarms). His lecture will introduce multiagent systems and swarms swarms, and also cover topics in agent-based modeling and simulation, multirobotics, swarm robotics, and multiagent learning.

For each section

Introductory lectures

- Introduction by the teacher about the research area, with an overview of the the state-of-the-art and the current trends.

Seminar lectures

- Two or three research papers for each lecture will be presented and discussed by the students.

Final poster session

- Each student will present a paper through a poster, interacting with the audience

Presentations

Prepare no more than 20 slides.

You should cover:

- Aims and objective of the paper
- Some related work
- The main contributions of the paper
- Methods
- Presented experiments
- ...

Discussions

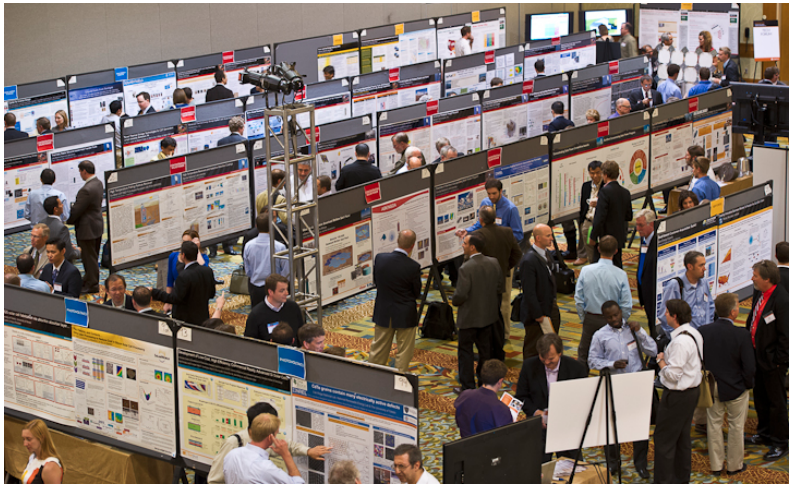
You should critically focus on:

- Impact of the presented paper, i.e. relevance and applicability
- Novelty
- Soundness
- Main limitations
- ...

Poster session

Prepare a cool poster with:

- Aims and objective of the paper
- The main contributions of the paper
- Methods
- Presented experiments



Interact with the audience that will ask questions, etc..

Paper Selection

Papers are assigned on a first come first serve basis.

The papers list will be published in the course Moodle page after the introductory lectures.

You can only pick one paper of the ones still remaining.

Evaluation

To pass the exam you should:

- Attend all lectures, including workshops
- For each section:
  - Present 1 paper (the presentation slide should be sent in advance)
  - Discuss 1 paper
  - Prepare and present a poster about a paper

Section 1 presentation

Computer Vision for Intelligent Robotics

We will cover different sub-areas of robot vision.

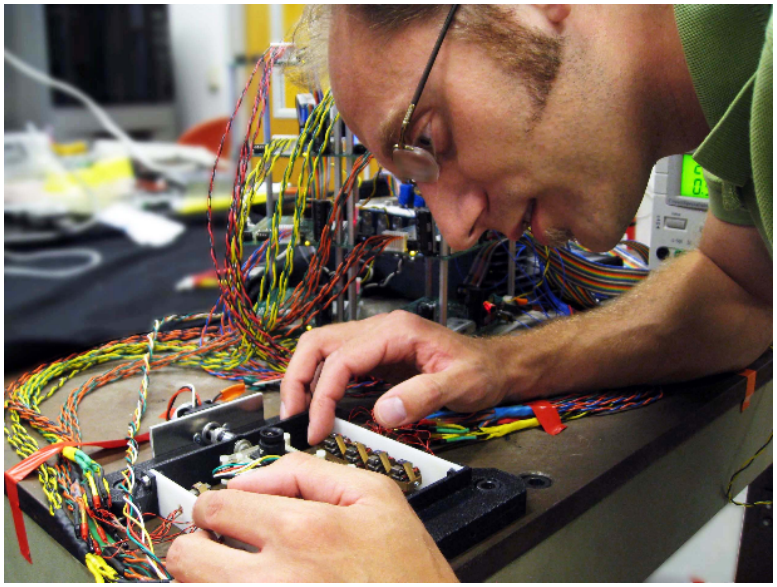
- “Low-level” vision
- Vision based ego-motion estimation and 3D reconstruction
- Visual servoing
- Semantic scene segmentation
- Object detection and localization

The objective of the seminars is to provide an overview of the recent trends in each covered topic.

The sense of vision

Is the main sense in humans and also plays a fundamental role in most living organisms.

Sensing information is processed to infer a **representation of the surrounding world.**



The human visual system measures the **intensity of light incident the retinas** and processes the measurements in the brain to produce an estimate of the 3D layout of the scene, to recognize objects, etc.

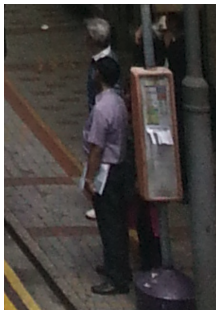
[Pictures: www.getholistichealth.com and gatech.edu]

Computer vision

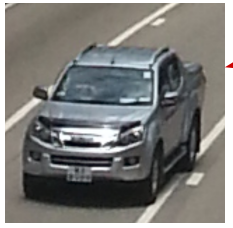
"Teach" a computer to understand an image or a video

- Place recognition
- Compute distances
- 3D reconstruction
- Navigation and localization
- People detection
- Object recognition
- Action recognition
- ...

Two people, they are waiting the bus, ...

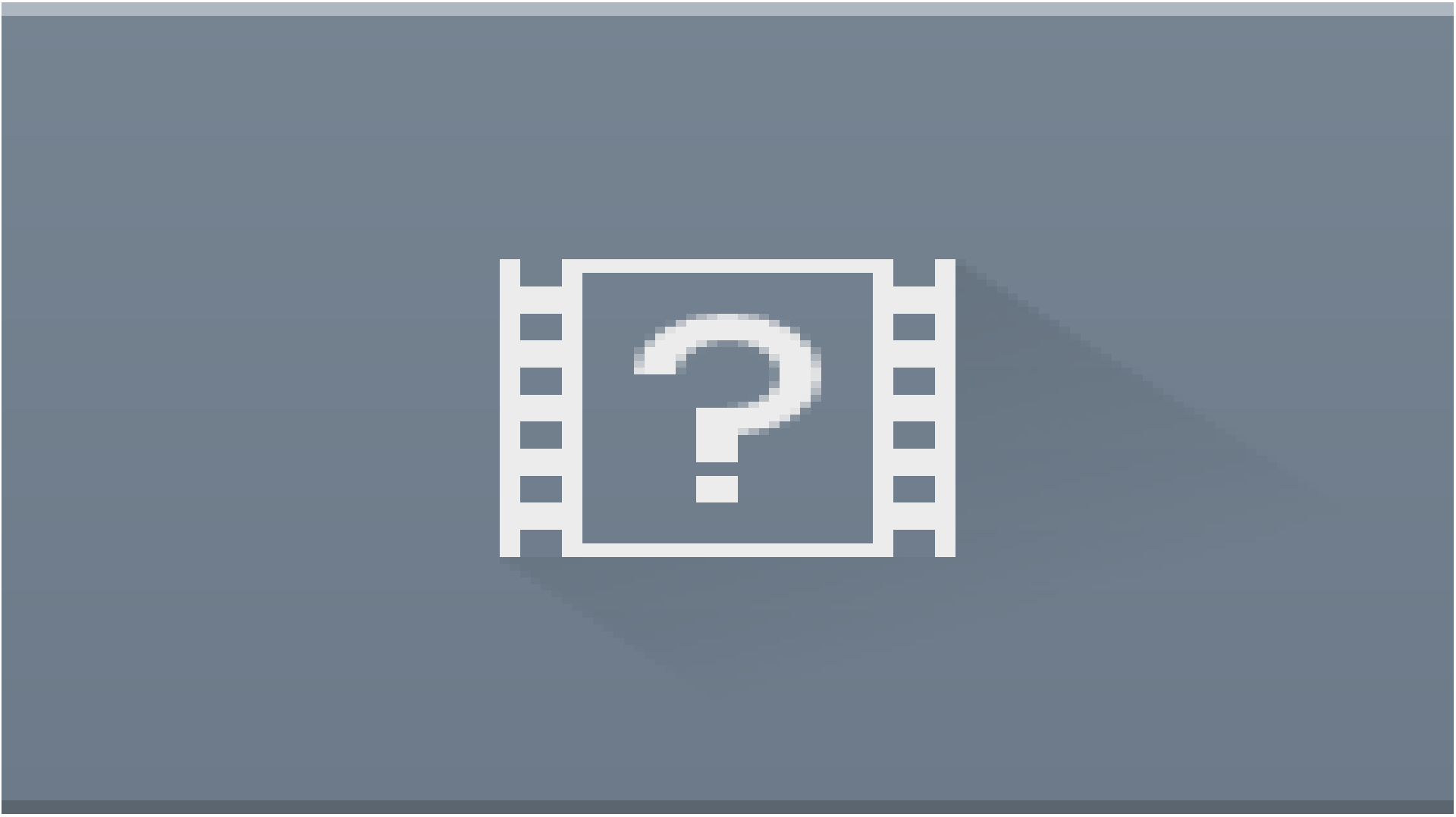


Car, model XXX, it is moving, ...



Car plate number YYY

Images can be tricky!



Computer Vision for Robots

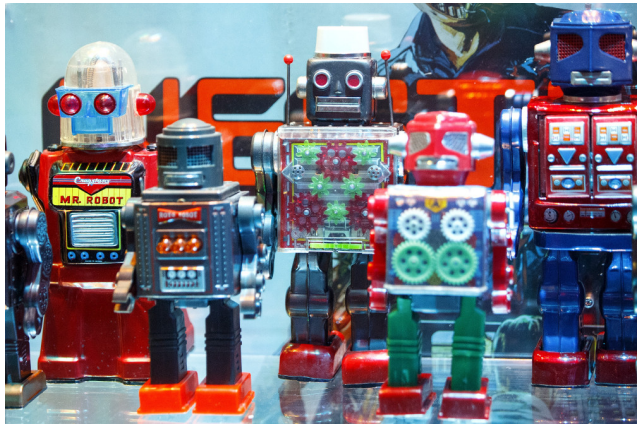
it is well known that **computer vision is hard**

- More human brain devoted to vision than anything else

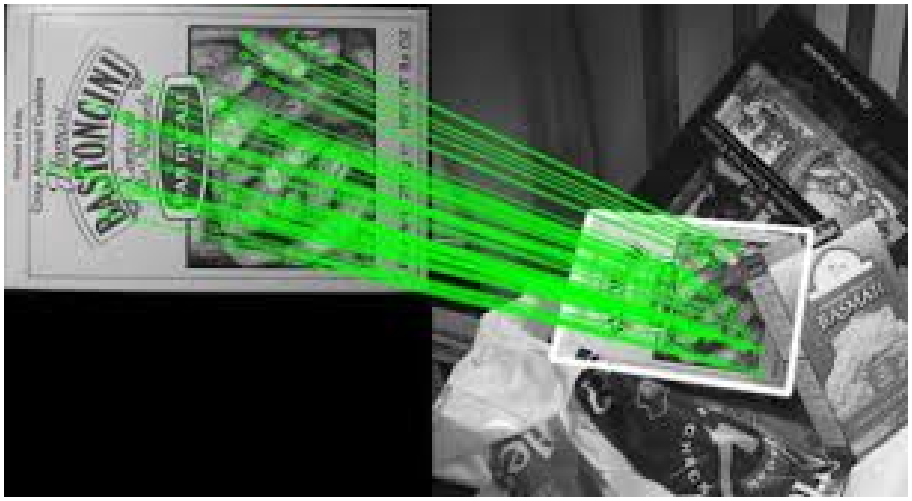
Computer vision for robots challenges:

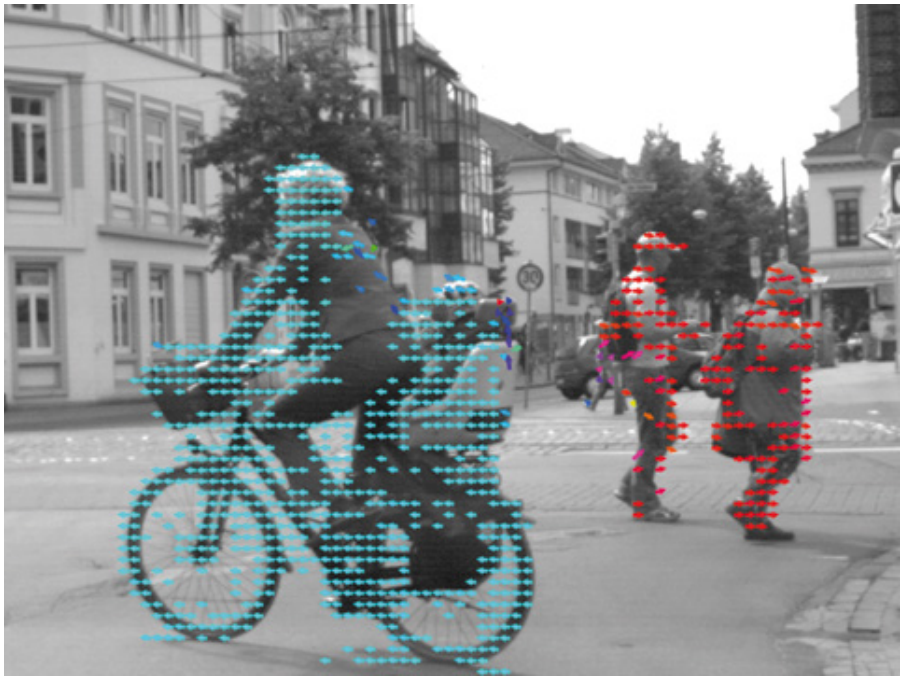
- Unstructured, dynamic world
- Changes in illumination
- Real time constraints
- Clutter
- Limited resources
- Quick motions
- ...

Computer vision for robots is *really* hard



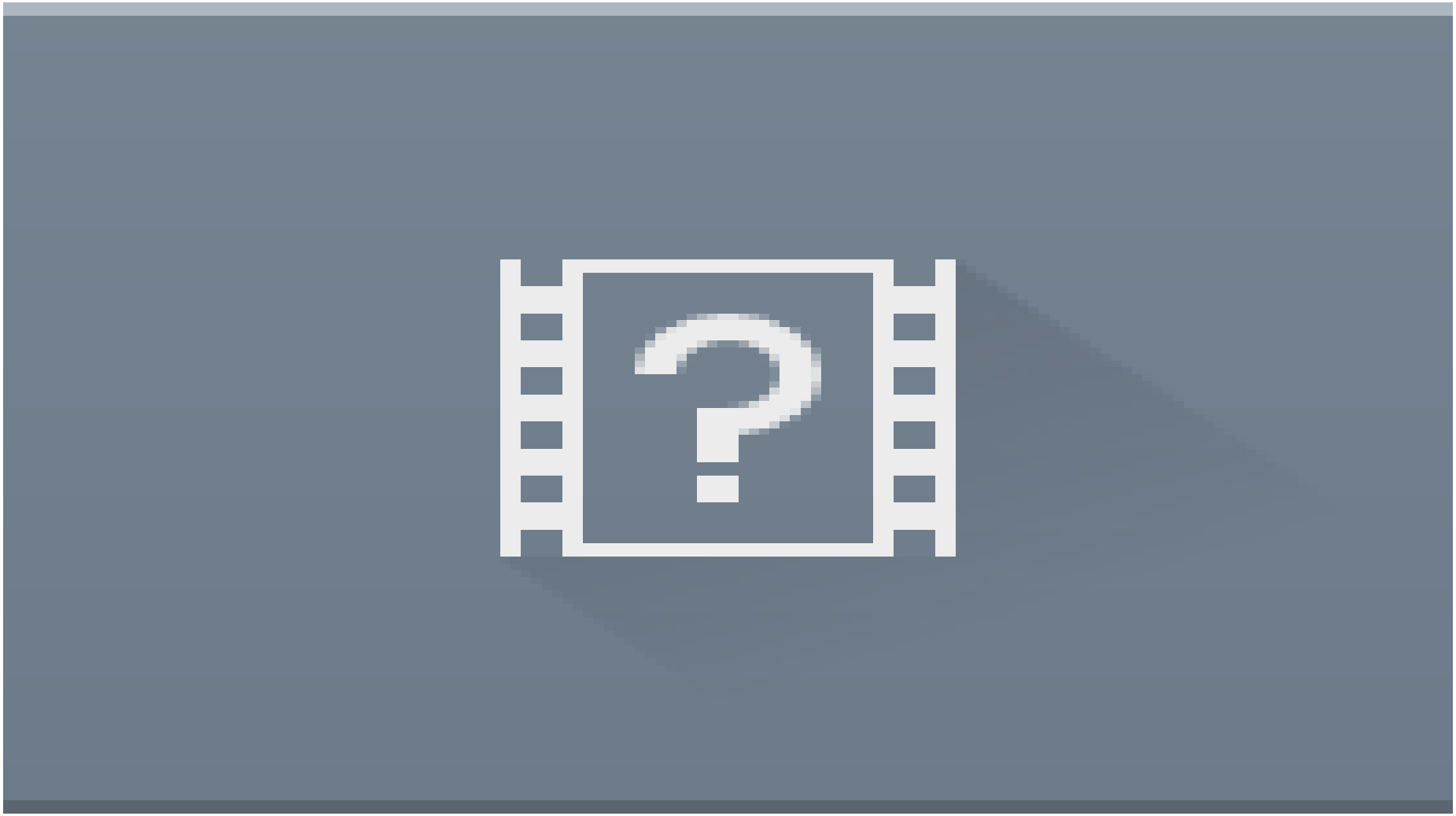
Low level vision





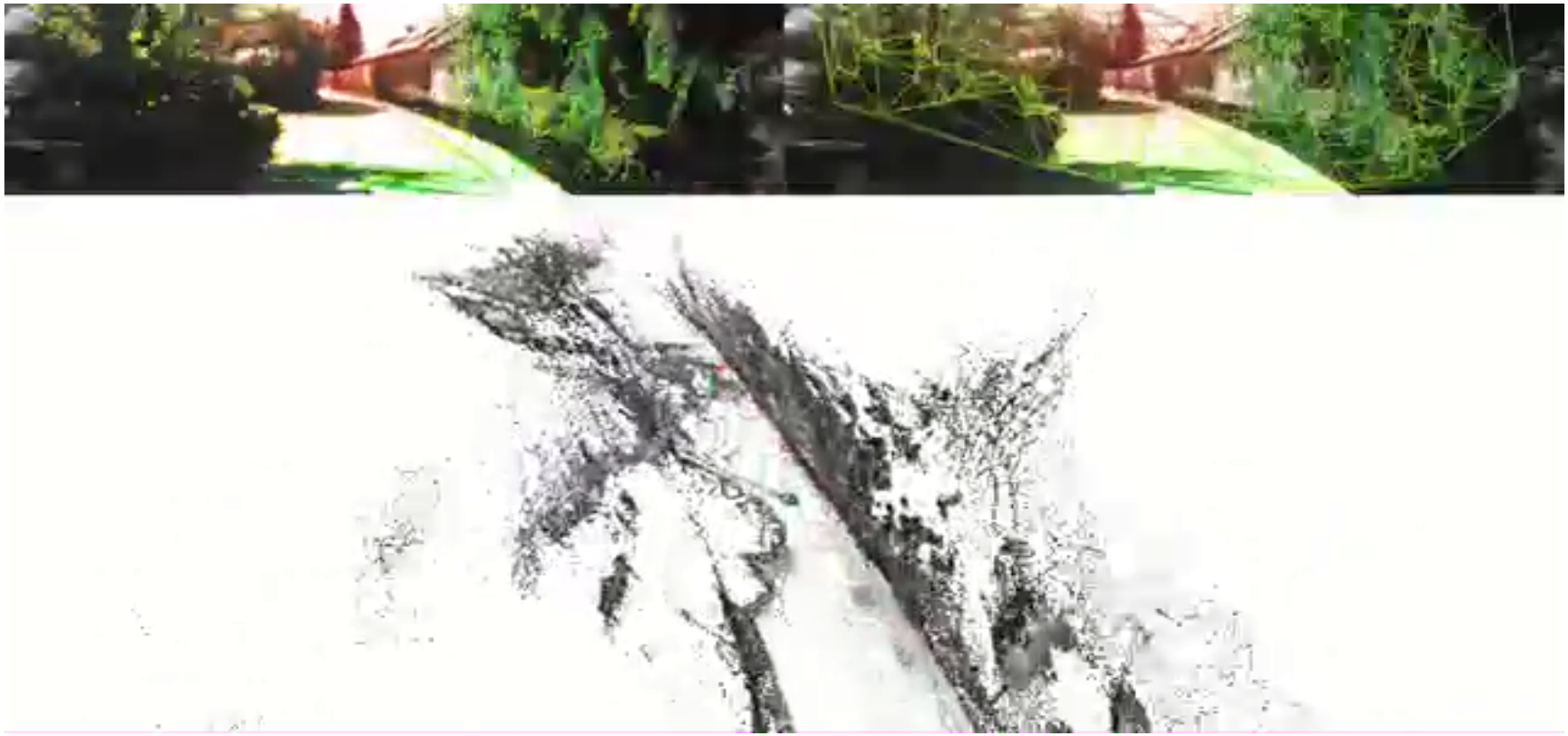
[Pictures: www.commonvisionblox.com, avisingh599.github.io]

Target tracking



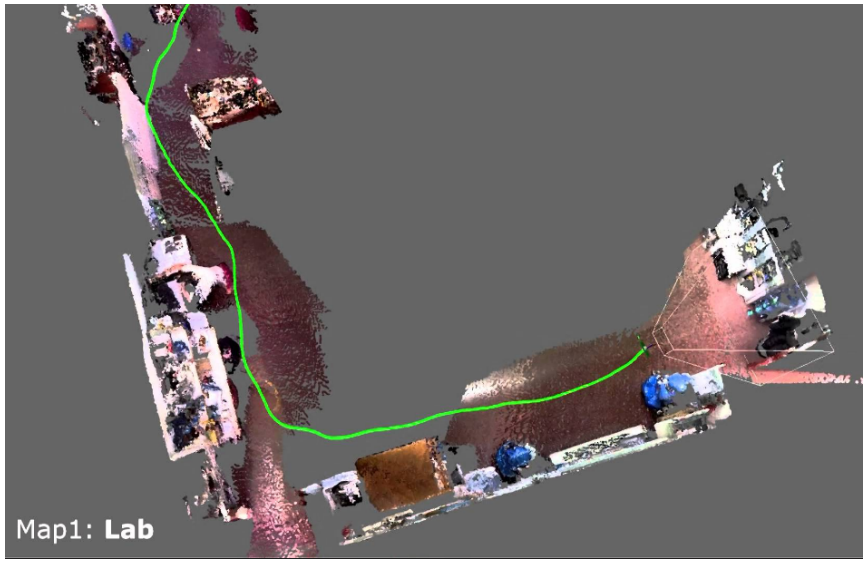
Vertical (Perceptiv Labs Inc.)

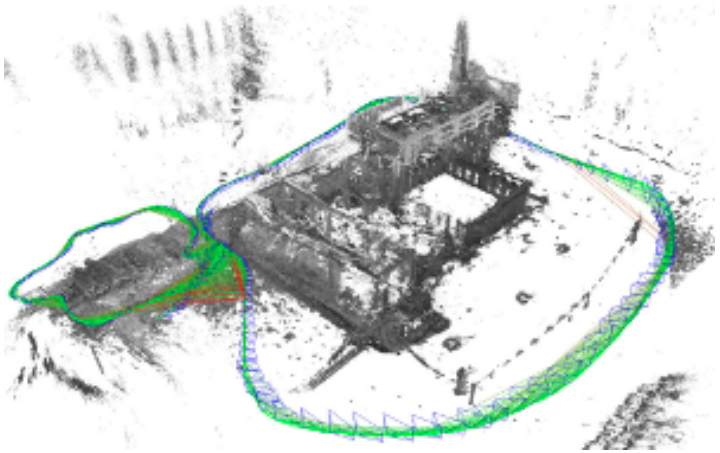
Stereo vision

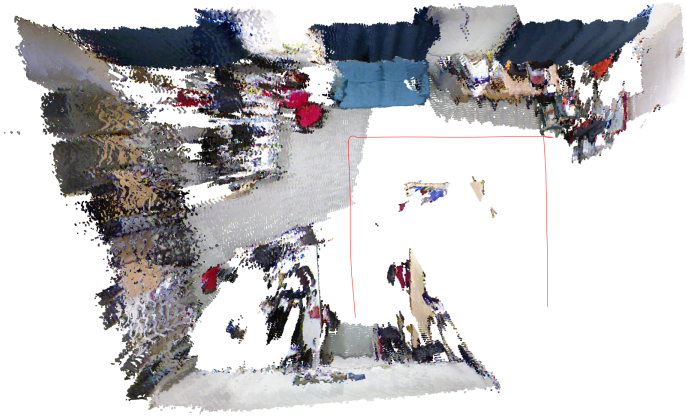


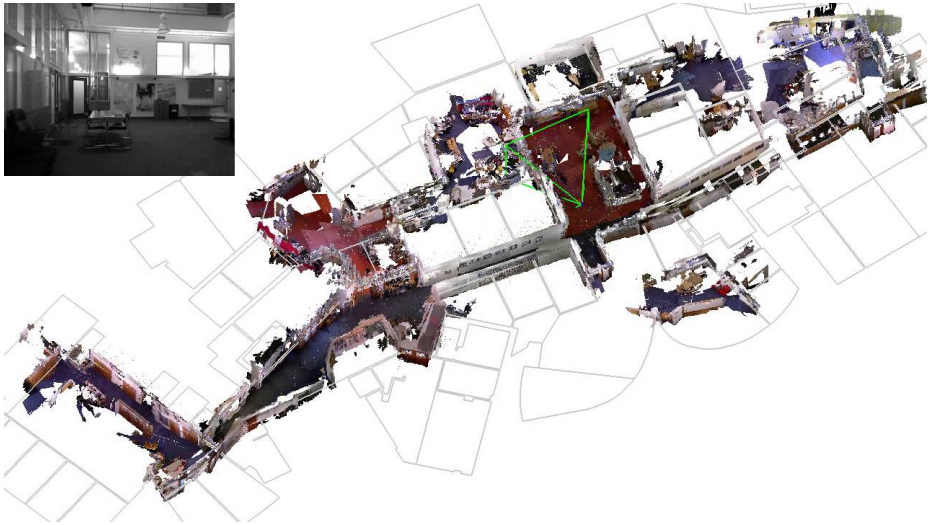
S. Pillai, S. Ramalingam and J. Leonard, “High-Performance and Tunable Stereo Reconstruction”, ICRA, 2016

Visual odometry and 3D mapping



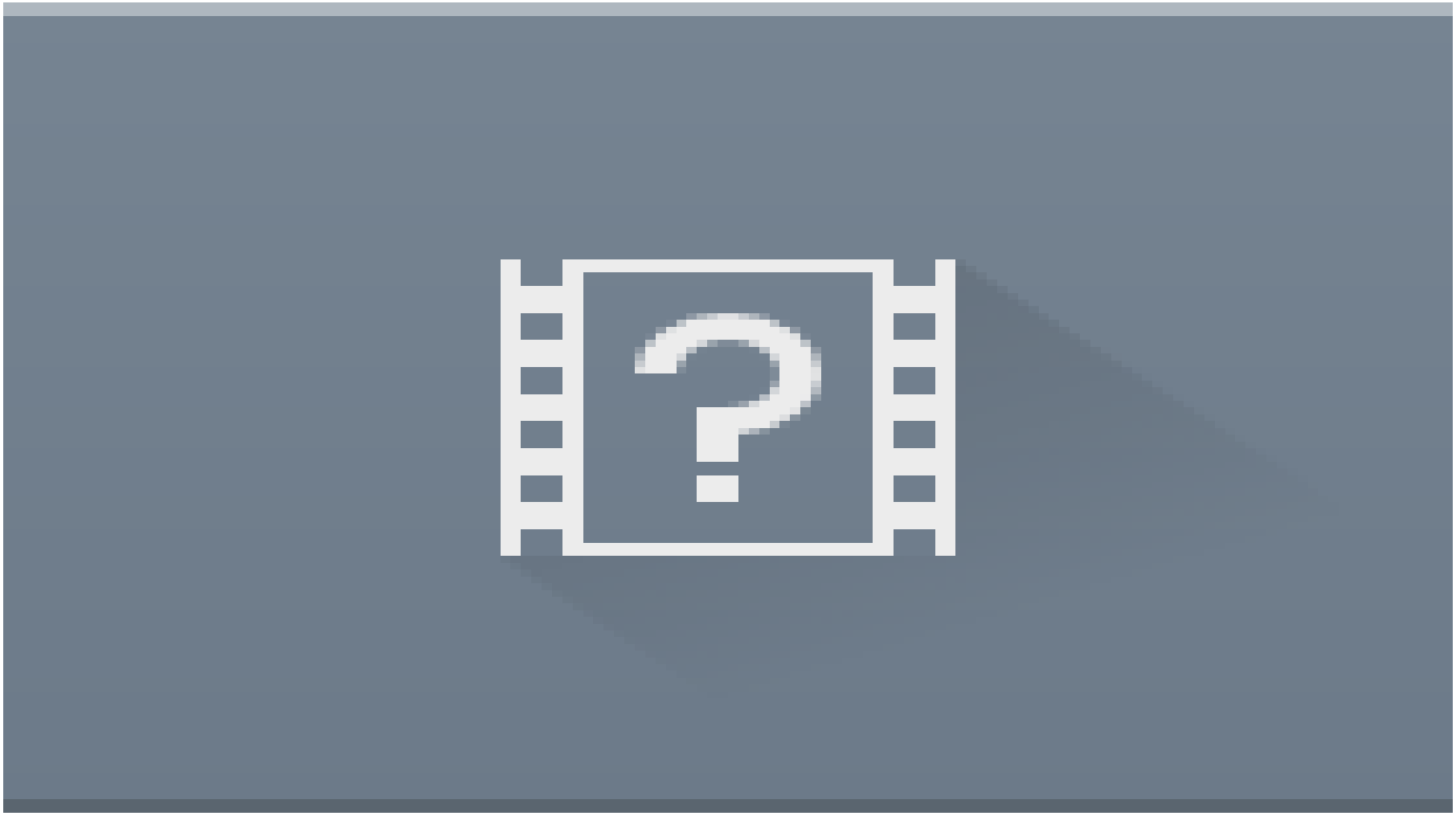






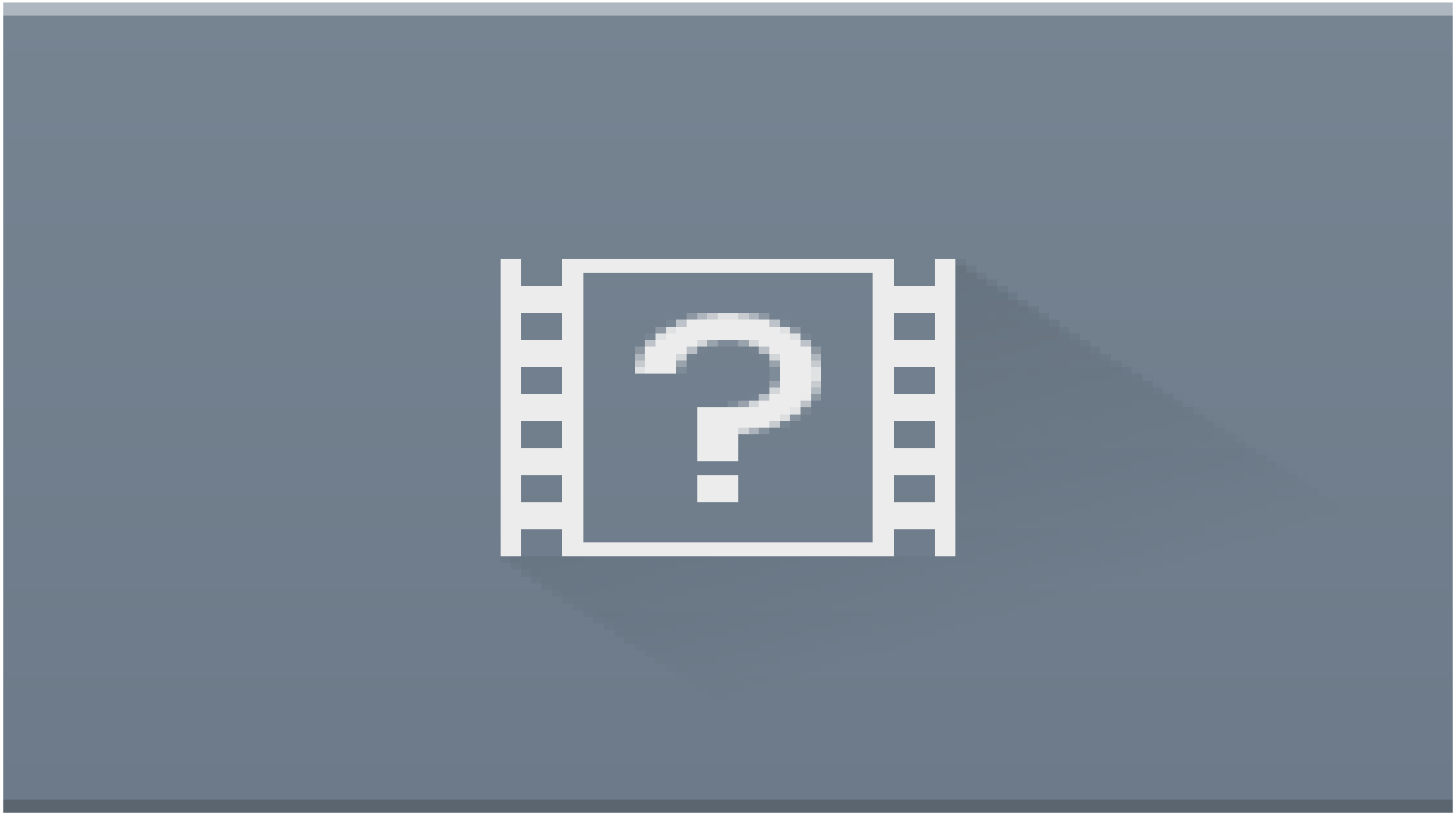
[Pictures: http://mapir.isa.uma.es, http://vision.in.tum.de

Visual odometry



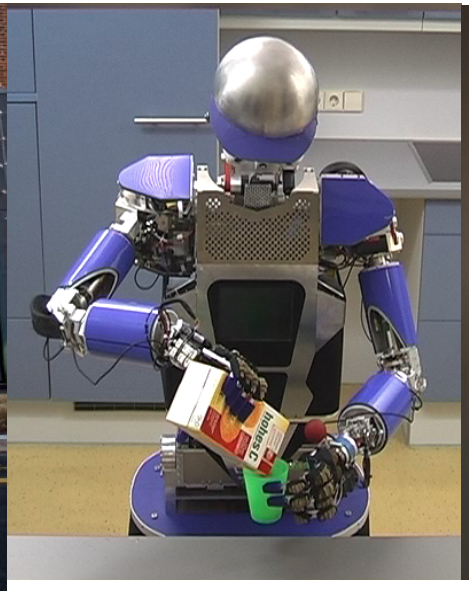
J. Engel, V. Koltun, D. Cremers, “Direct Sparse Odometry”, in arXiv:1607.02565, 2016.

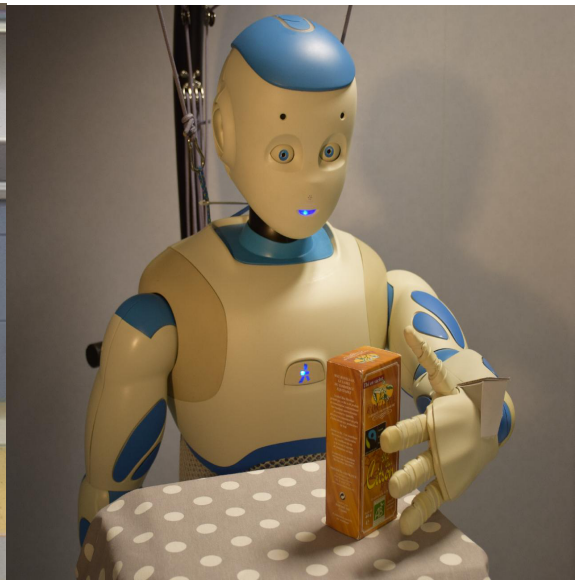
3D reconstruction from images



Qi Shan, Riley Adams, Brian Curless, Yasutaka Furukawa, and Steven M. Seitz
“The Visual Turing Test for Scene Reconstruction”, Proc. Of 3DV13 (2013)

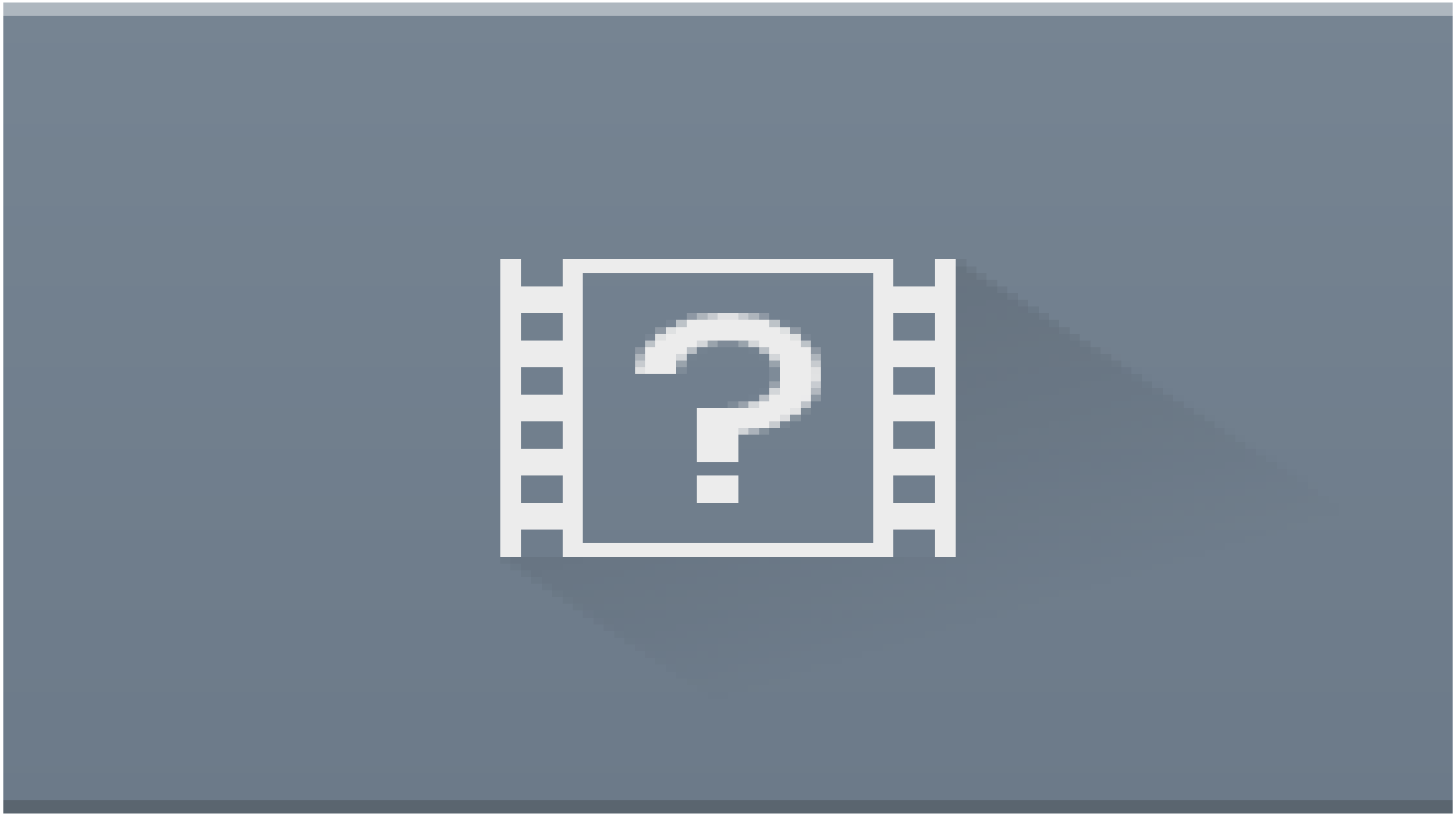
Visual servoing





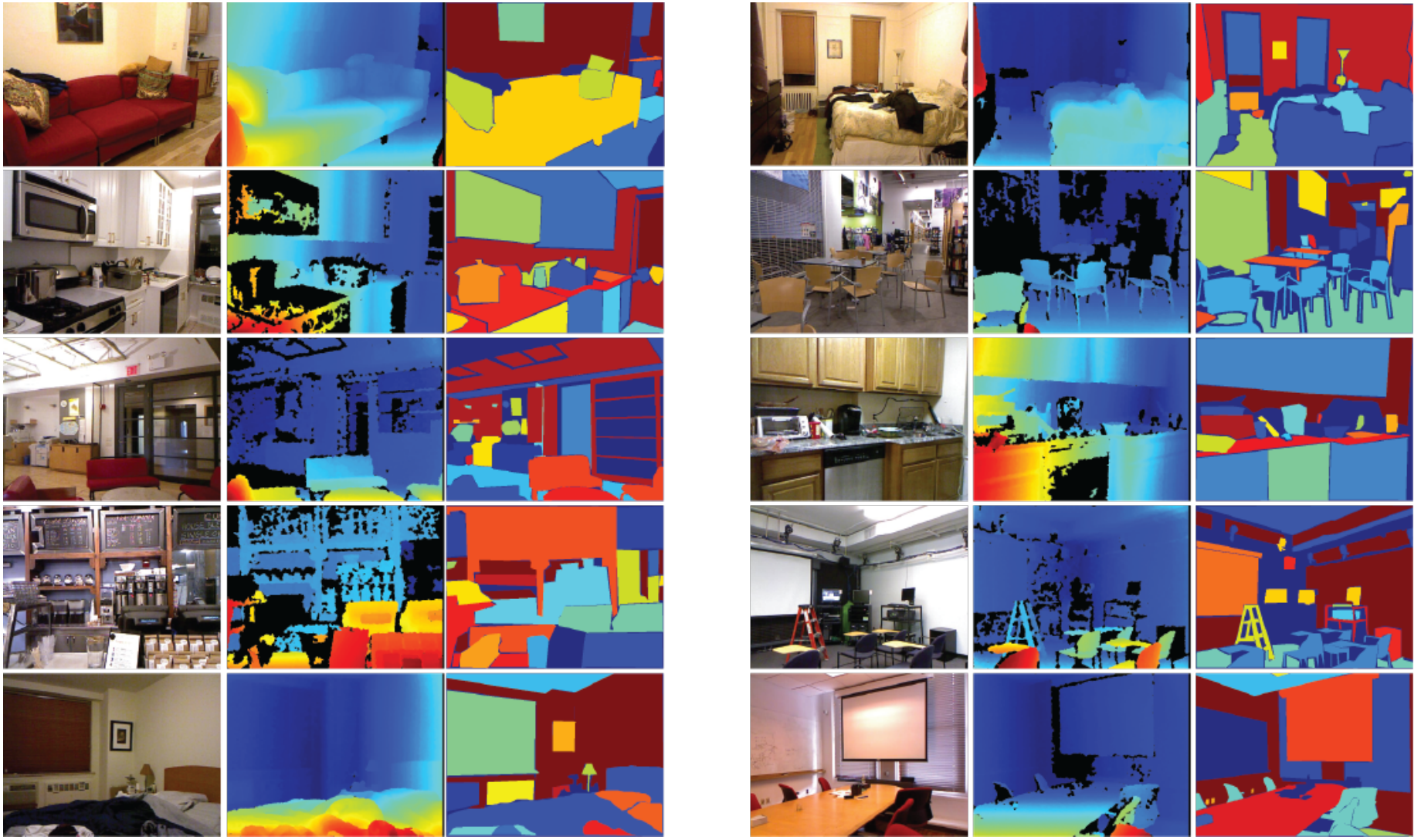
[Pictures: his.anthropomatik.kit.edu, raweb.inria.fr]

Visual aided control



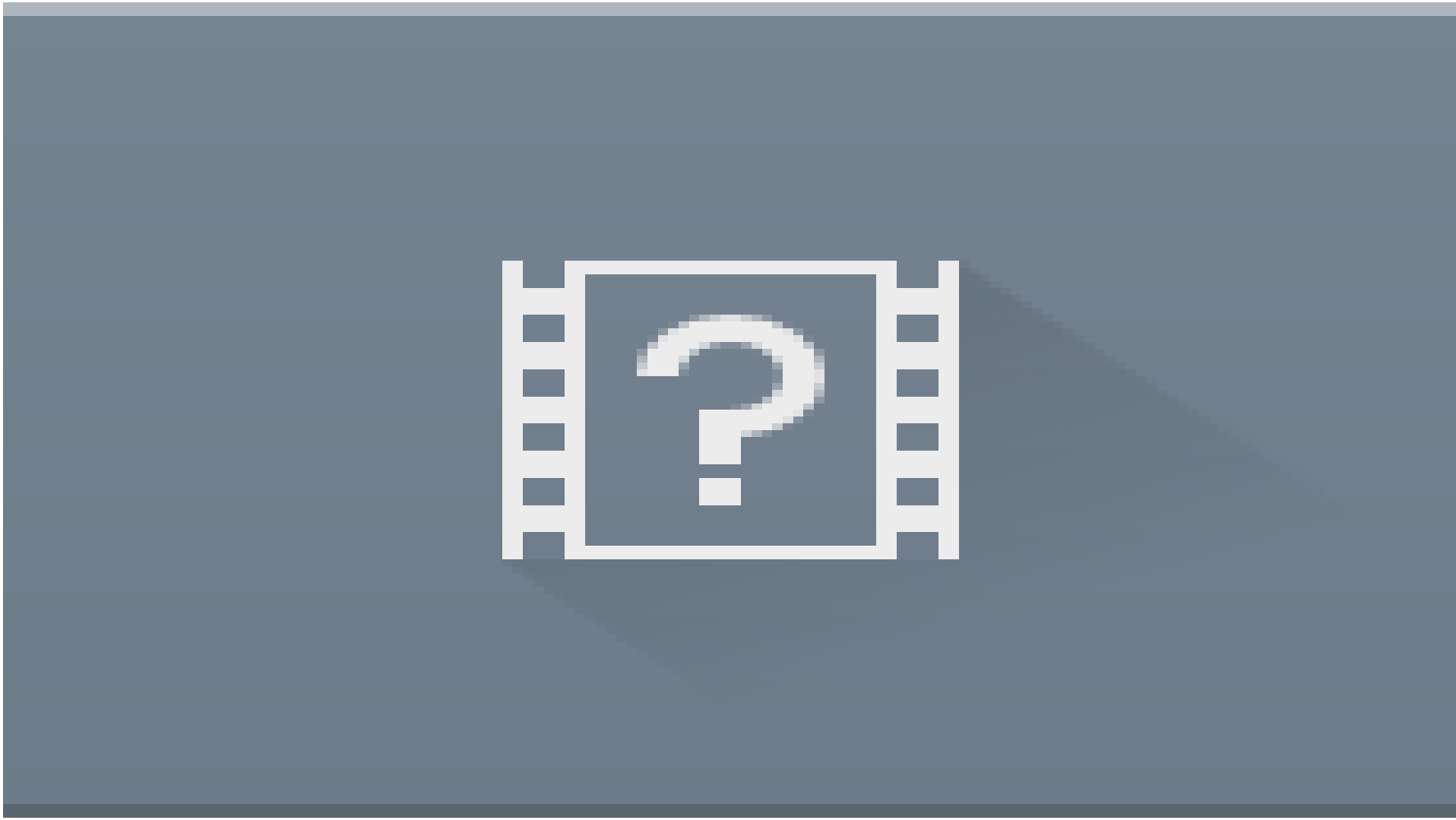
E. Mueggler, B. Huber, D. Scaramuzza, “Event-based, 6-DOF Pose Tracking for High-Speed Maneuvers", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Chicago, 2014.

Semantic scene segmentation

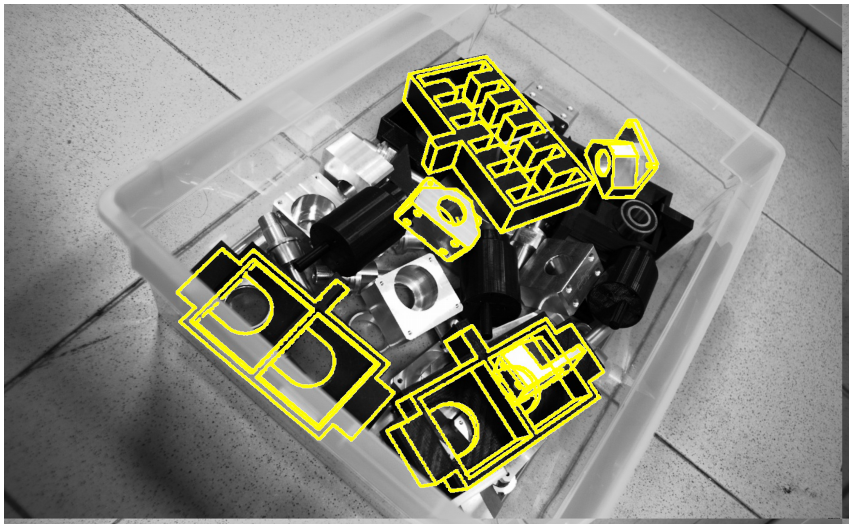


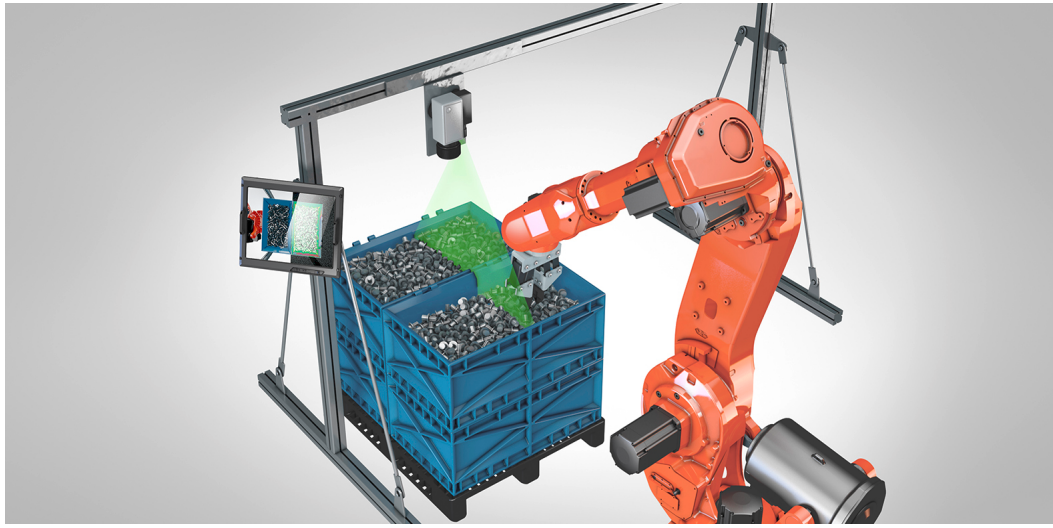
[Pictures: http://cs.nyu.edu/~silberman/

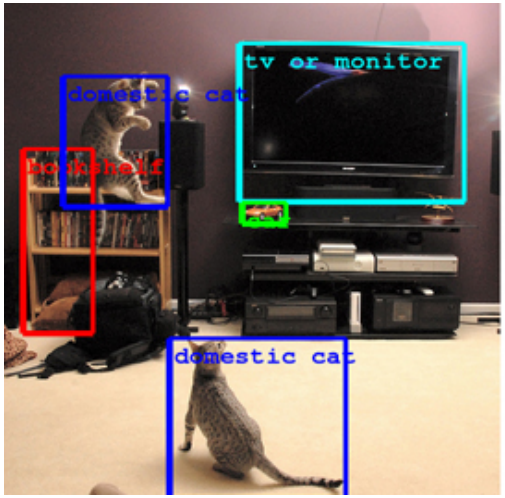
Road scene segmentation

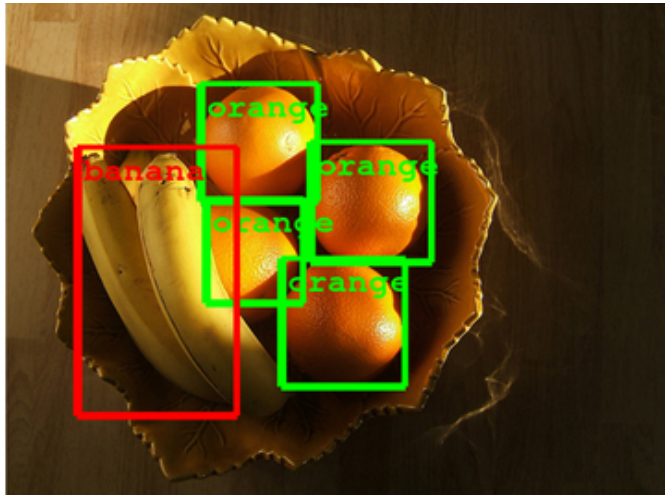


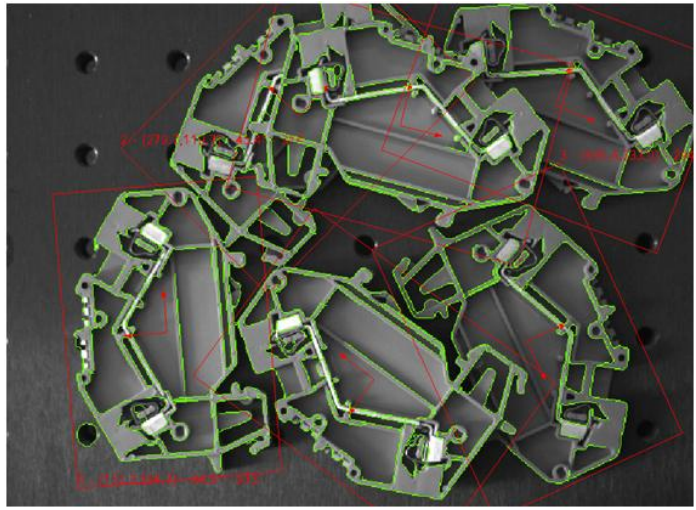
Object detection and localization





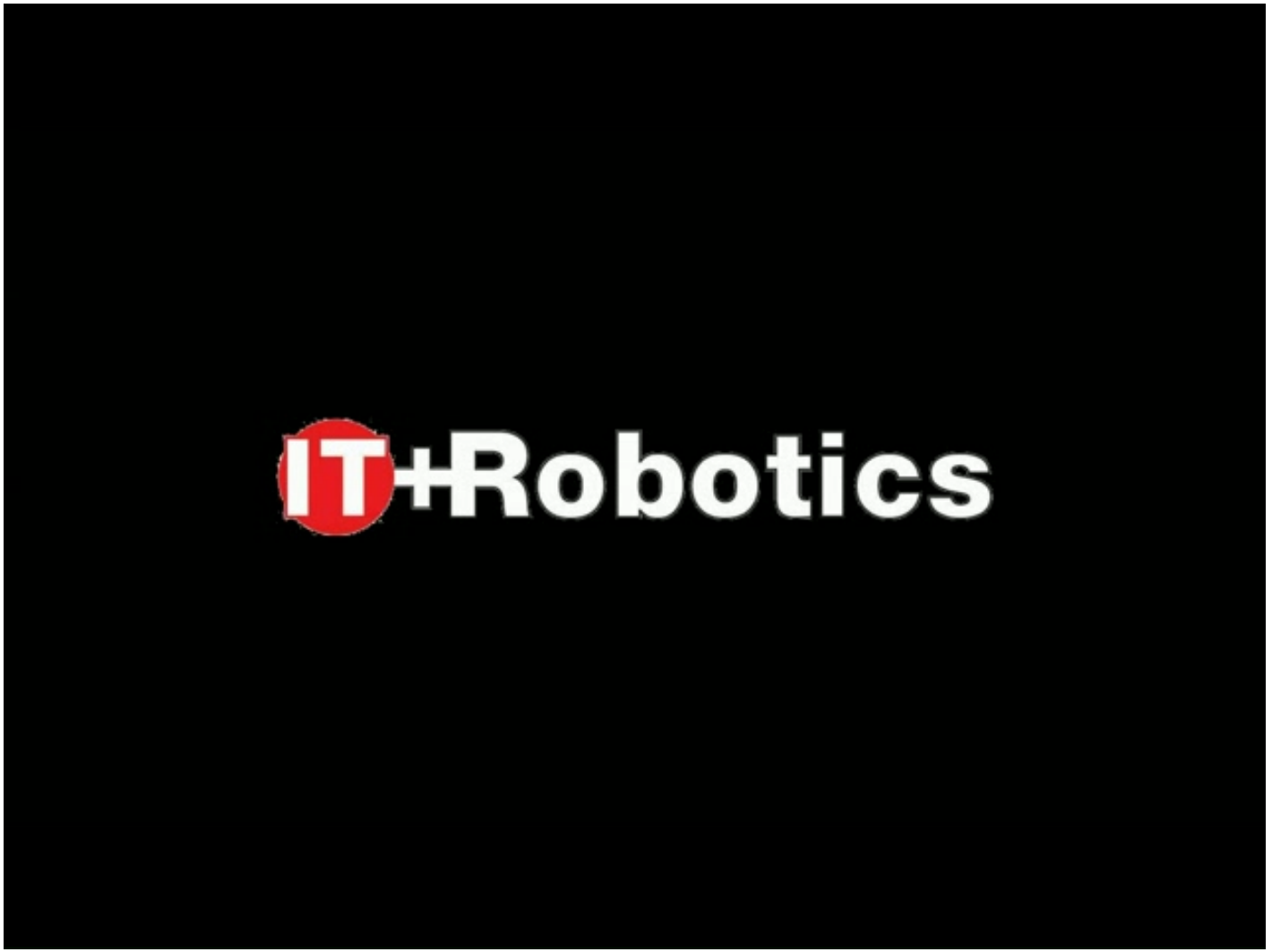




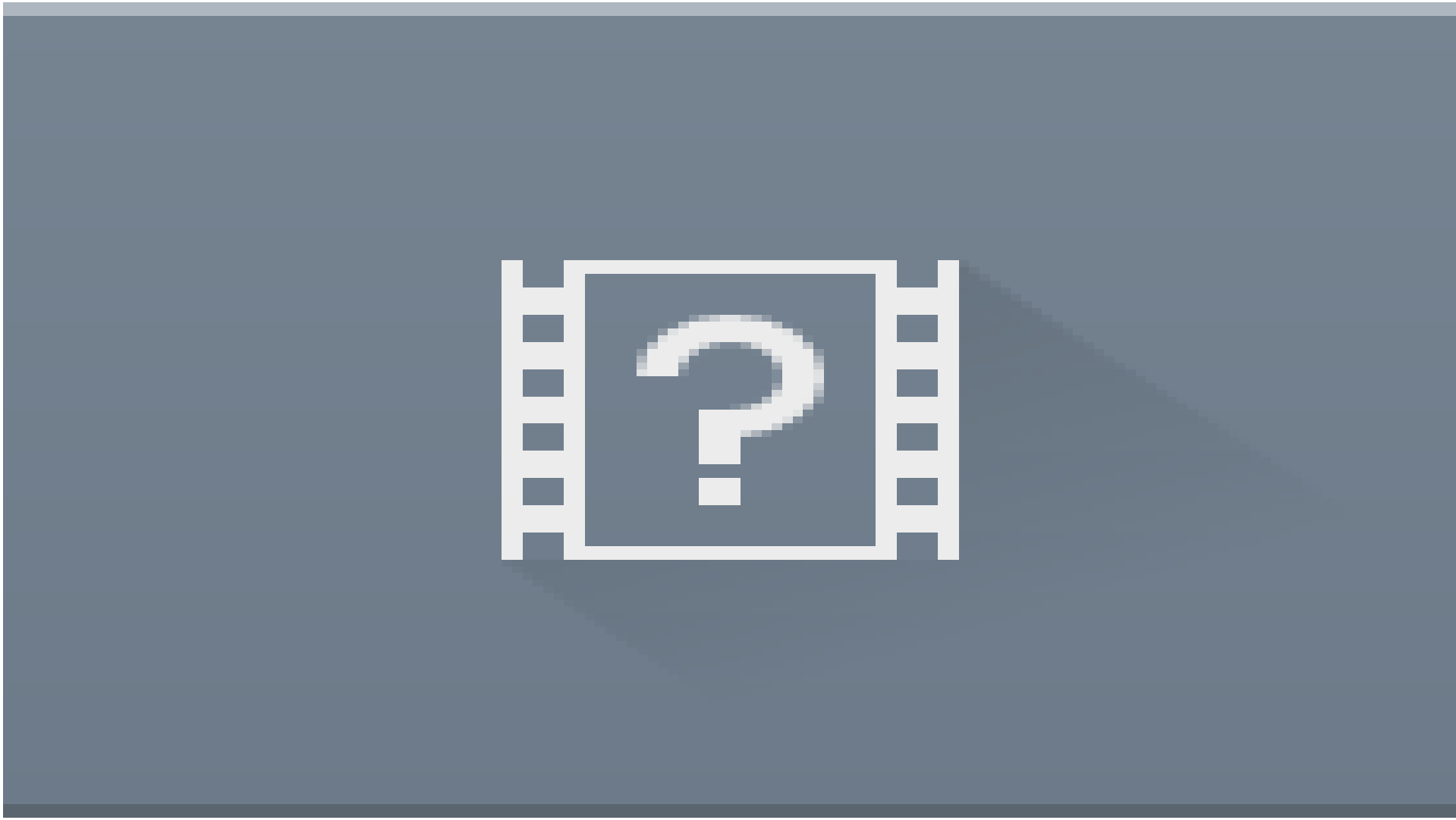


[Pictures: www.robotics.blumenbecker.com, www.engadget.com]

Bin picking



Amazon picking challenge 2016



Use case 1: the Flourish project

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

Sapienza Università di Roma

Research and Innovation Action

Funded by the European Union

Horizon 2020

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

universitätbonn Rheinische Friedrich-Wilhelms-Universität Bonn

BOSCH

cnrs

Sapienza Università di Roma

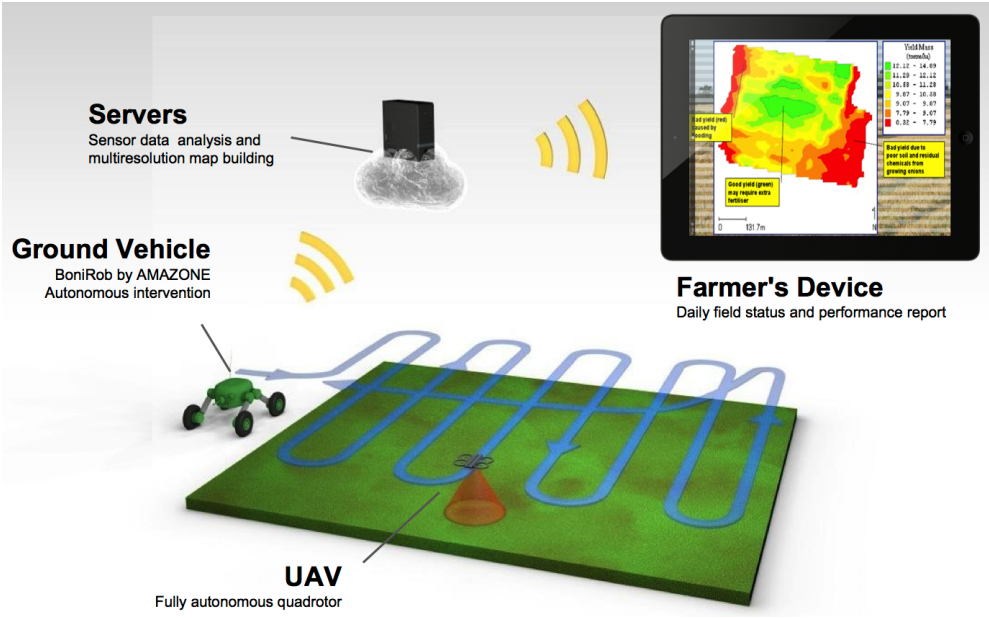
Assam

Goal: Build a robotic agricultural system that is able to achieve high yields while minimizing or eliminating the application of chemicals to the field.

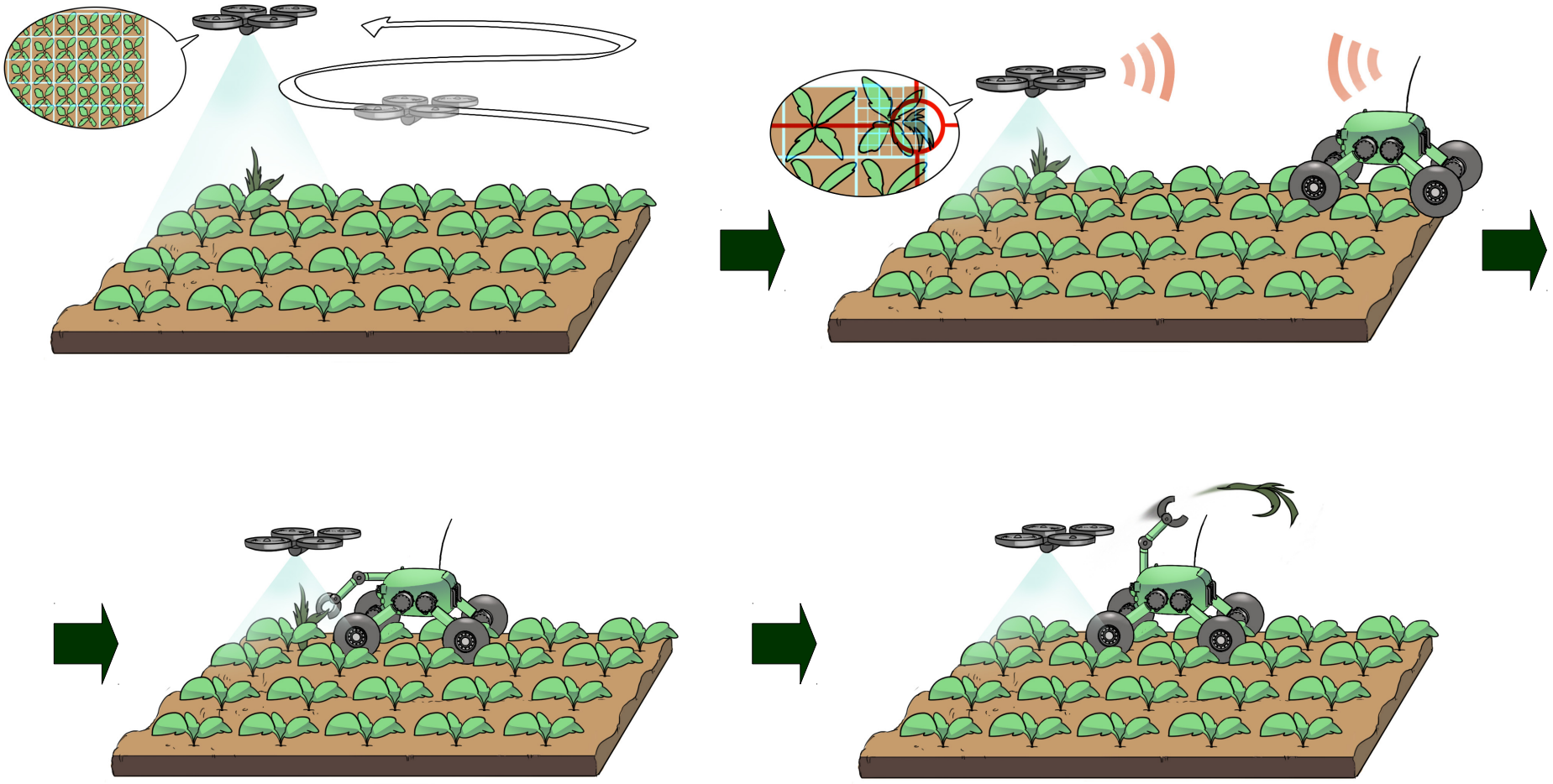
Project concept

A **UAV** continuously surveys a field over the growing season

A **UGV** is used for targeted intervention in the field, and data analysis is delivered to farm operators for high-level decision making.

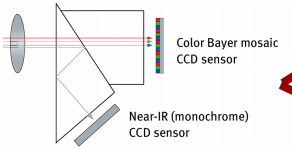


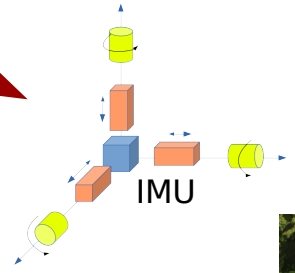
Project concept

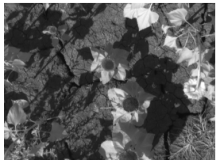


The UAV

ASCENDING TECHNOLOGIES NEO





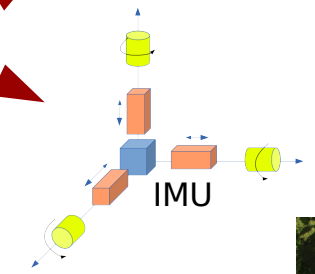


GPS

Depth sensor

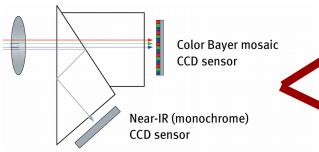
The UGV

BOSCH BoniRob



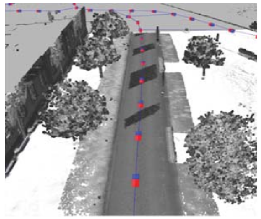
BoniRob

2 X



2 X GPS

2 X

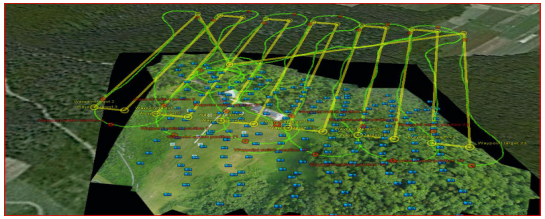


Challenges

State estimation

Robot ego-motion estimation

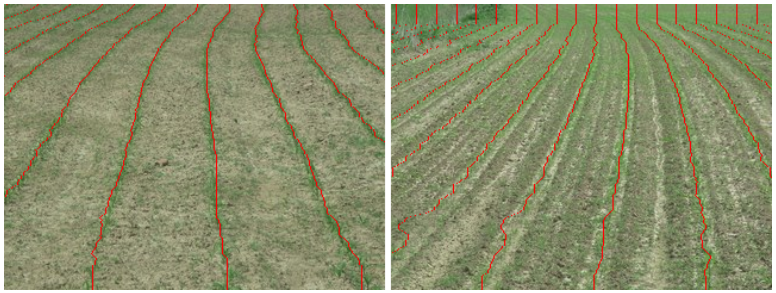
Sensor fusion



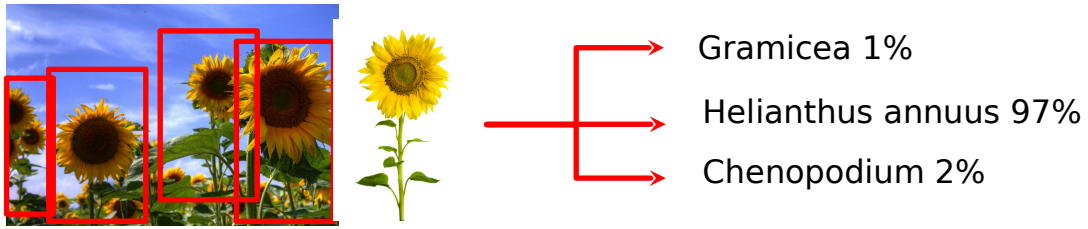
Cooperative Mapping

Pattern recognition

Vegetation detection



Plant classification



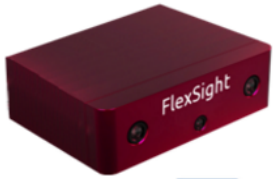
Use case 2: the FlexSight project

Goal: design a perception system based on an integrated smart camera that is able to recognize and localize several types of deformable objects that can be commonly found in many industrial and logistic

CAD model + deformation parameters

Upload

The FlexSight smart camera

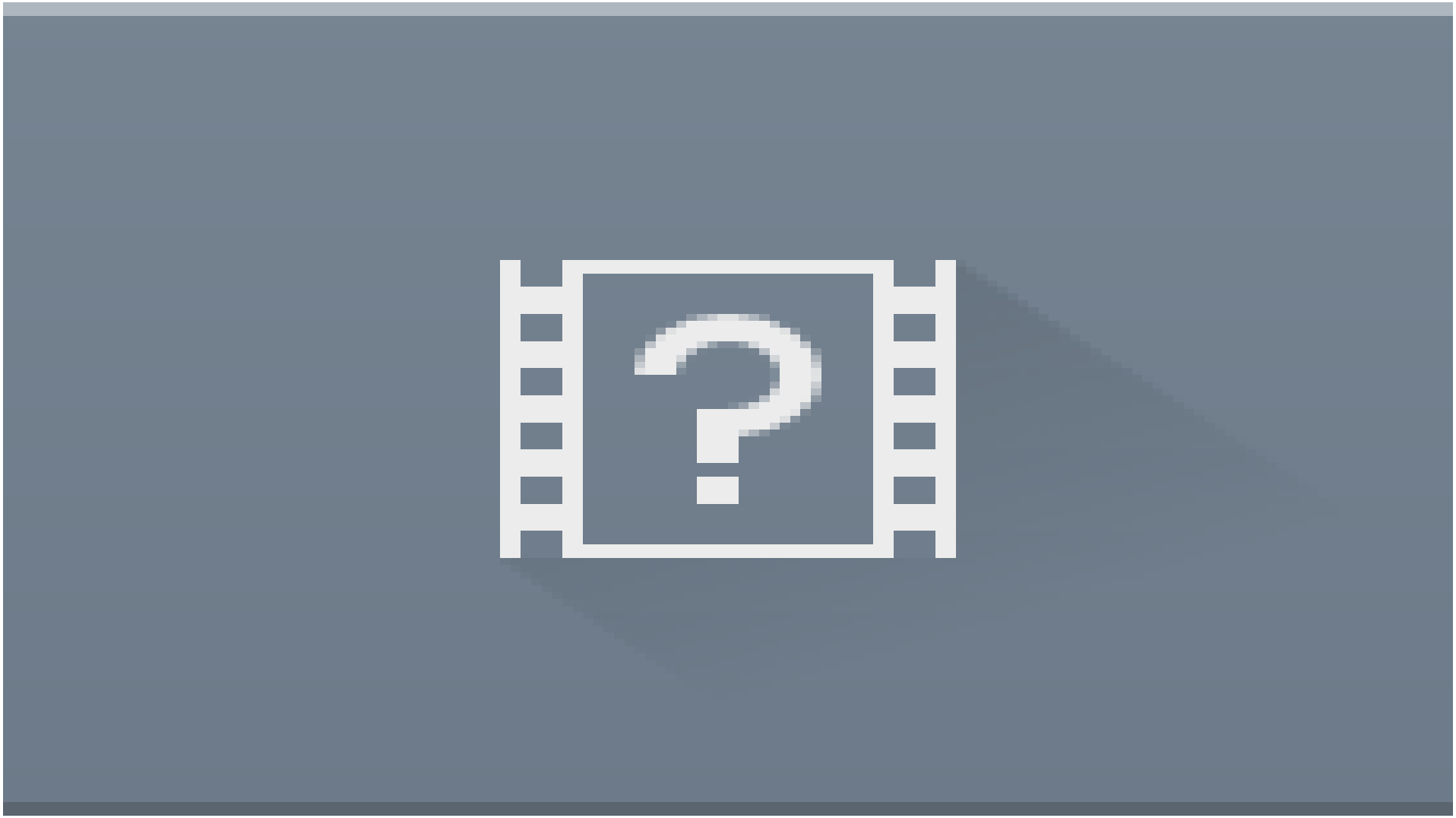


FlexSight

Guide

Pick&Place

FlexSight: State of the art



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Computer Vision for Intelligent Robotics

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Alberto Pretto