RIMLab

Lessons Learned in a Ball Fetch-And-Carry Robotic Competition

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OUTLINE

- The Team
- Competition rules
- System architecture
- Experiments
- Lessons learned
- The competition: video

RedBeard Button Team

7 students of Master Degree in Computer Engineering

+

Robotics class professor

From left to right:

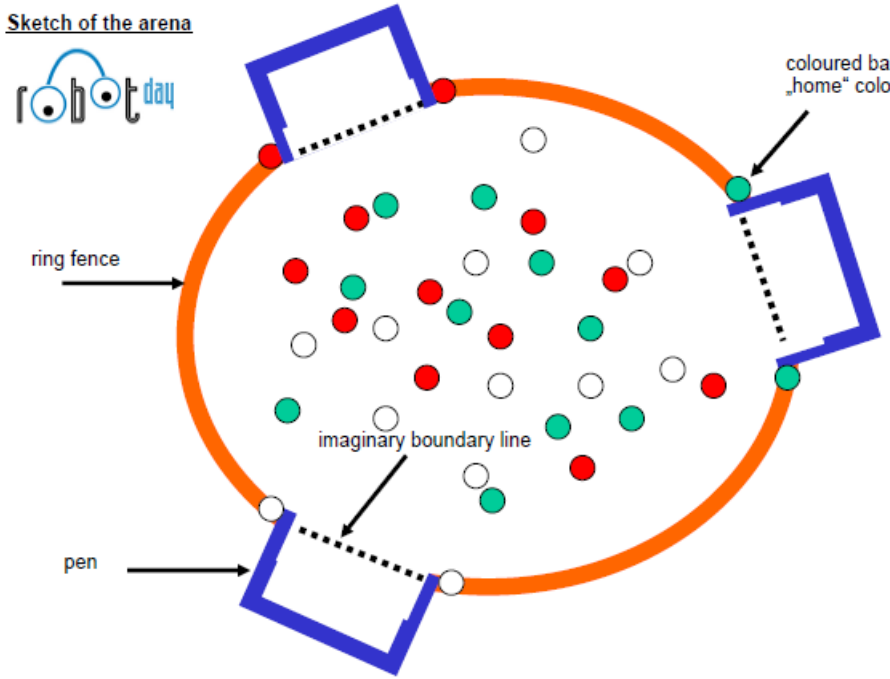
Marco Patander, Marco Cigolini, Federico Parisi, Davide Valeriani, Dr. Eng. Dario Lodi Rizzini, Andrea Signifredi, Alessandro Costalunga, Isabella Salsi

SICK robot day 2012

- Robotic competition open to universities and sponsored by **Sick AG**, leader in sensors
- Past editions: 2007, 2009, 2010 and **2012**
- Autonomous robots must perform preassigned tasks in a limited time

Competition rules

Task: search and take colored balls and carry them to a specific region of the arena (diameter: 15m) termed ***pen***



- Ball moving allowed
- Penalties for fence collision and fetching incorrect balls
- Disqualification for collision with opponents
- 2 rounds available: 10 minutes each

Challenges

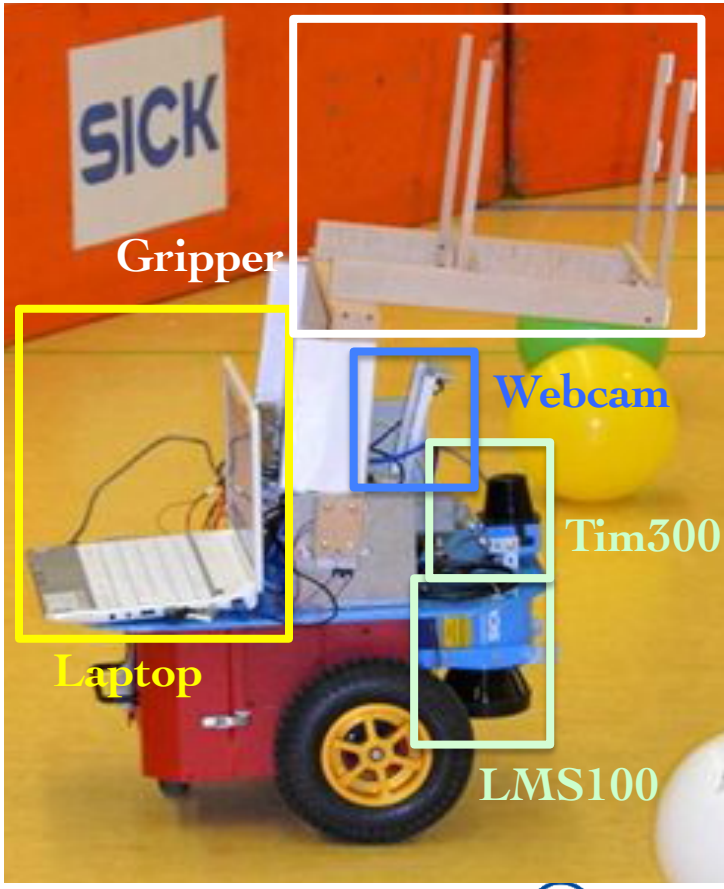
- **Perception**
  - What sensors to use?

  - What characteristics balls have (reflectivity, colors)?
- **Ball Fetch-and-Carry**
  - How to take balls?
  - How to transport them safely?

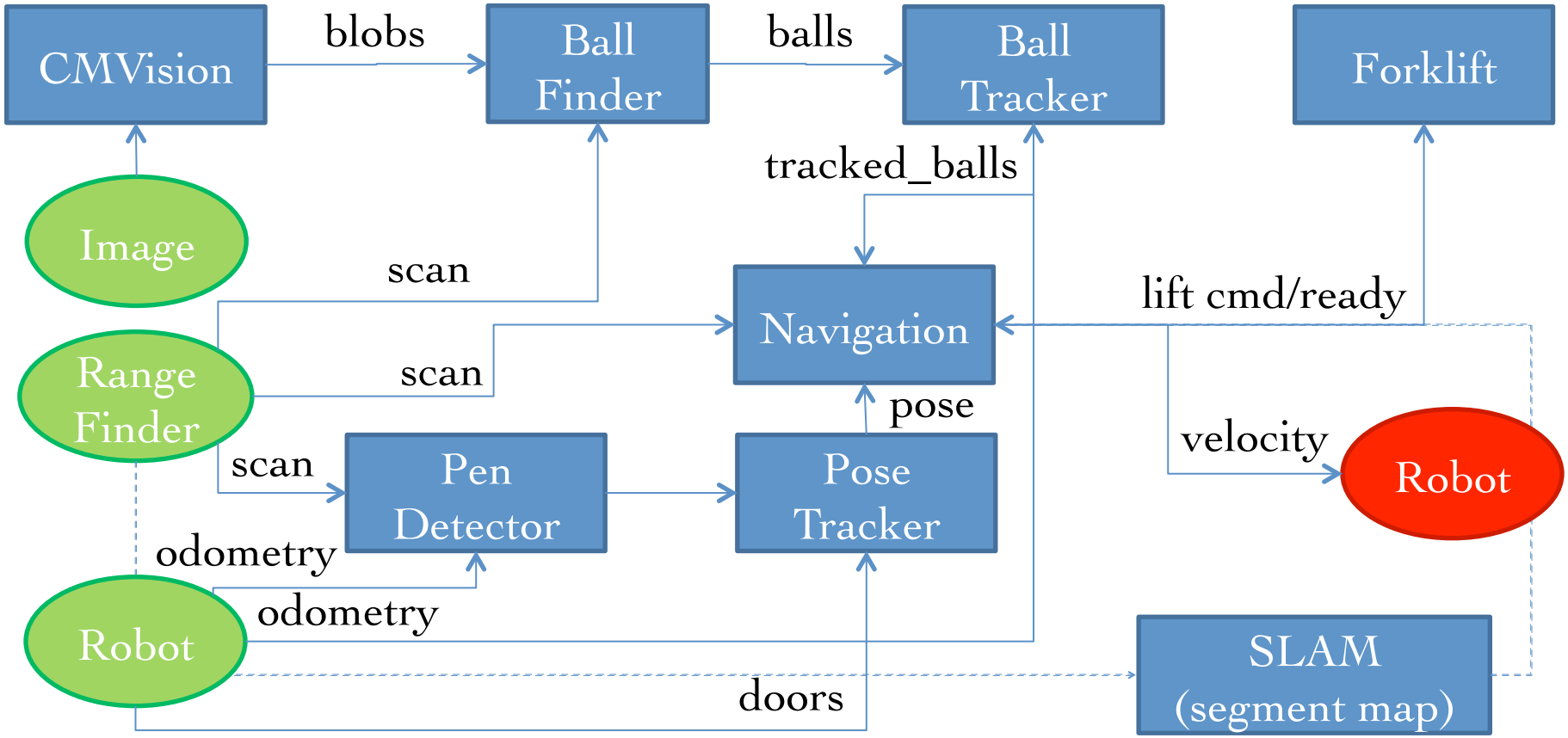
- **Localization**
  - What landmarks to use to identify the pen?

Robot architecture

- MobileRobot Pioneer 3DX
- Environment perception
  - Sick LMS100 laser scanner
  - Sick Tim300 laser scanner
  - Logitech C270 webcam
- Handmade gripper
  - Microchip PICDEM.net 2
  - DC Motor
- Laptop
  - CPU: Core Duo processor SU7300



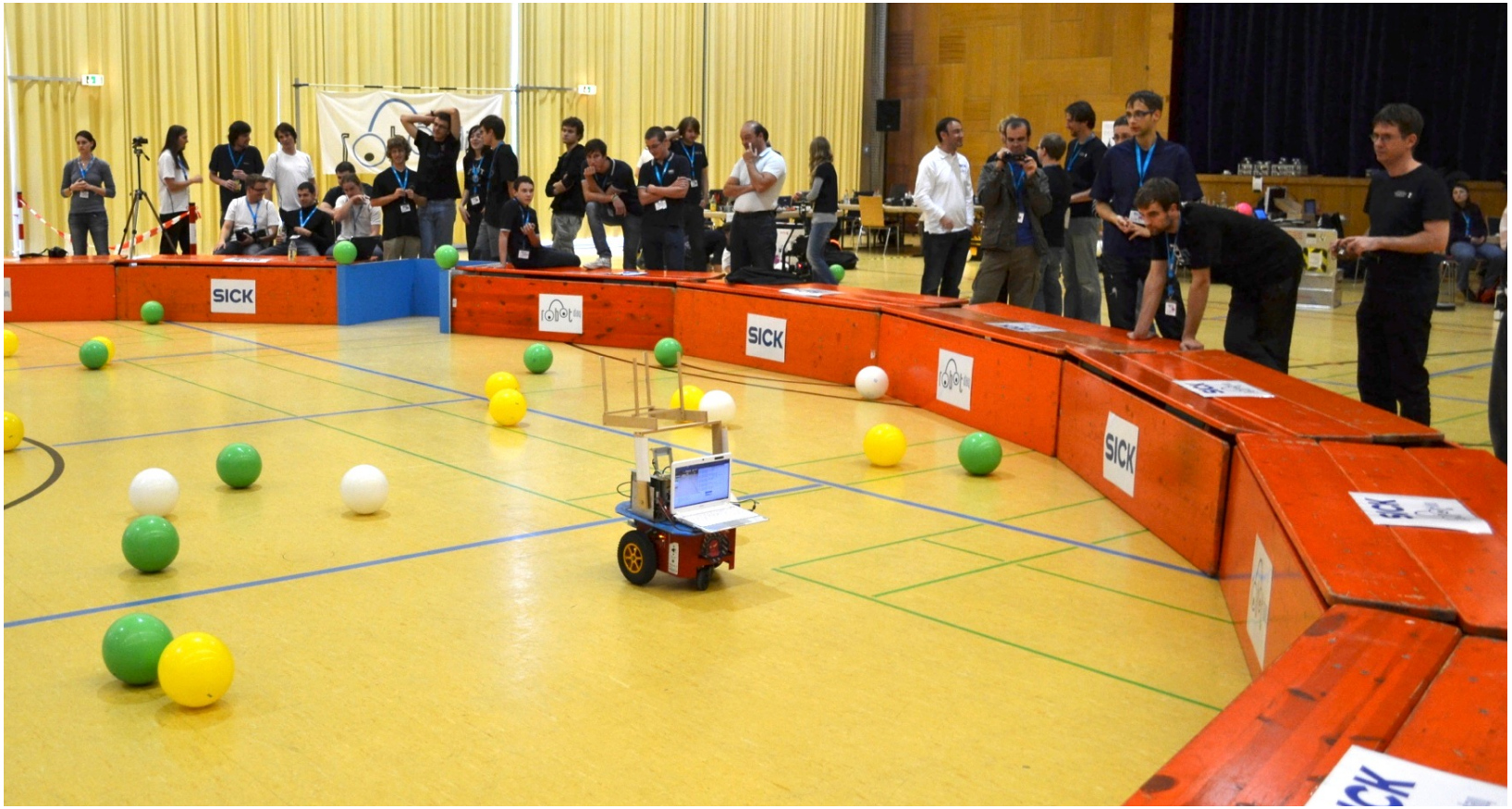
Software architecture



Sub-tasks

- Main task splitted in several **sub-tasks**:
  - **Exploration** of the arena, avoiding collisions
  - **Detection** of a ball of assigned color
  - **Grip and release** of the ball detected
  - **Localization** of the own pen and navigation to it
- Whole system like a **state machine**

Exploration



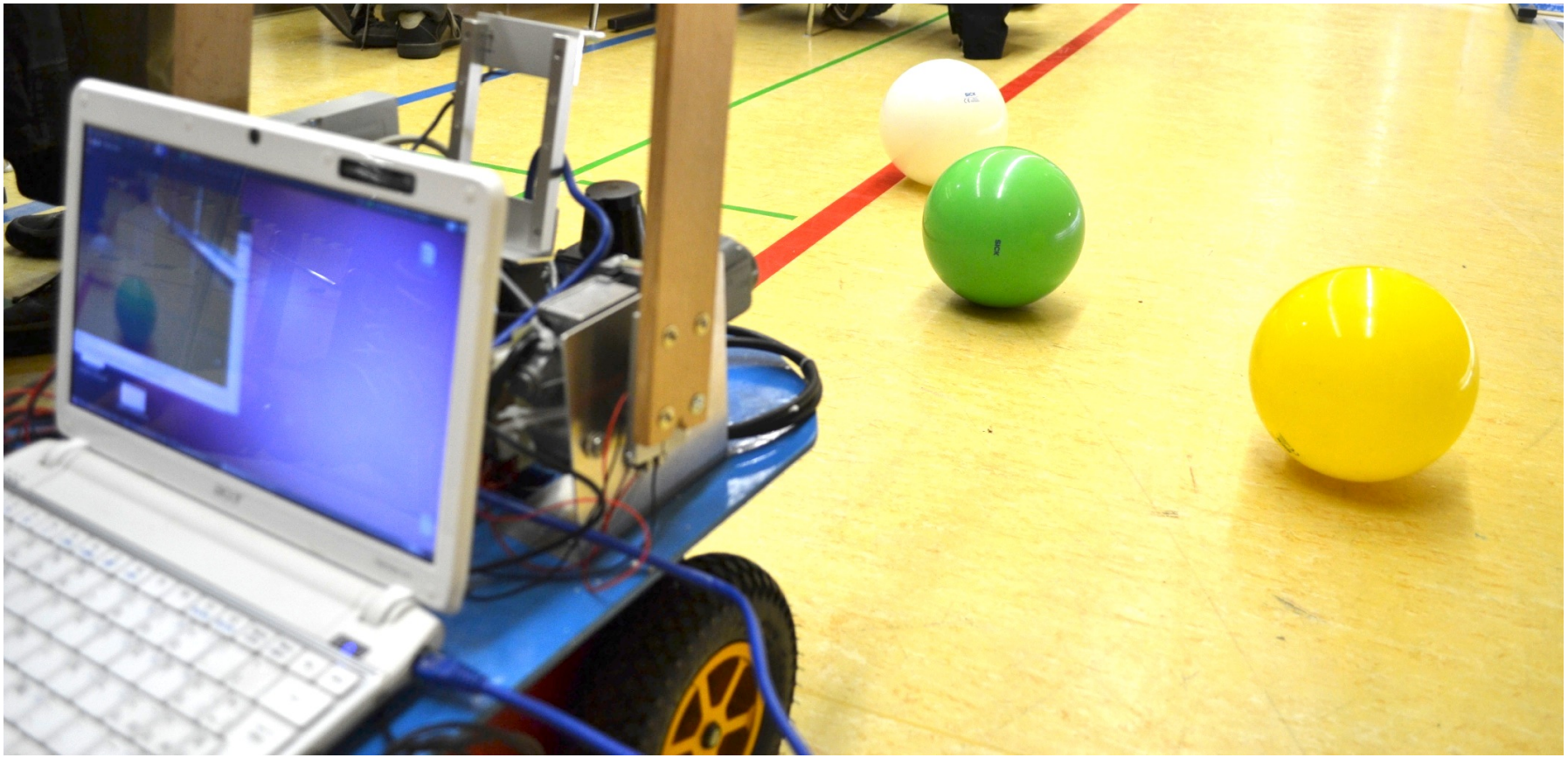
Different kinds of obstacles

- **Static** (fence)
- **Semi-static** (opposite balls)
- **Dynamic** (opposite robots)

Exploration

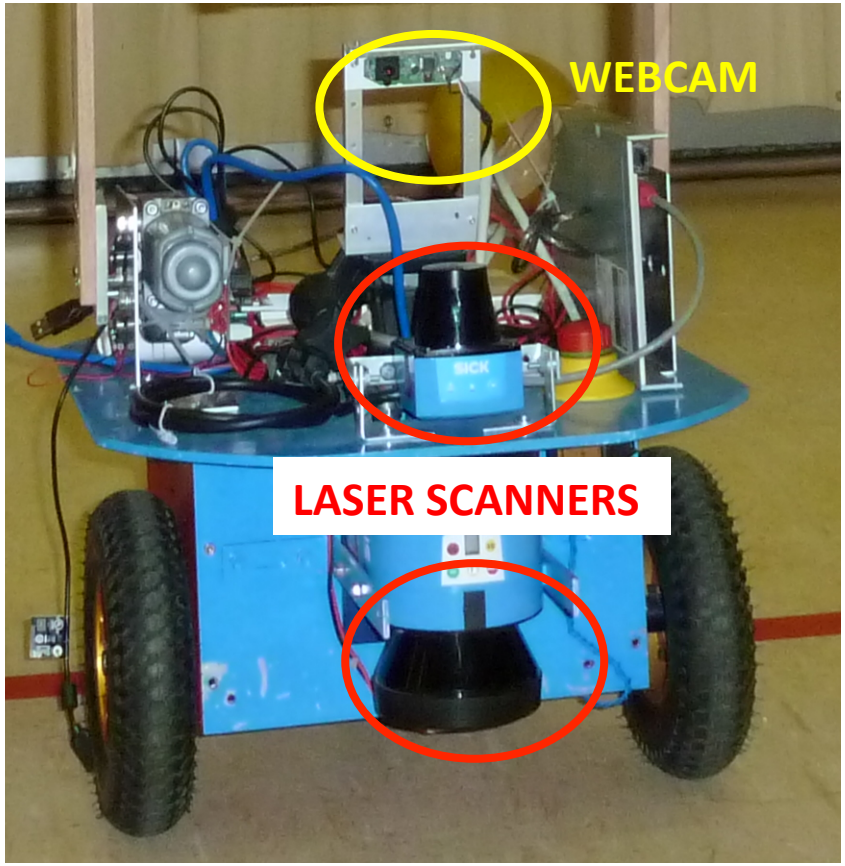
- Several possible approaches:
  - Stay In The Middle
  - Wall Following
  - Robot rotation until ball detection
- Choice:
  - **Mixed approach:** Stay In The Middle + random change of direction every 12 seconds
  - **Wall Avoidance** if an obstacle is closer than **55 cm**

Ball detection



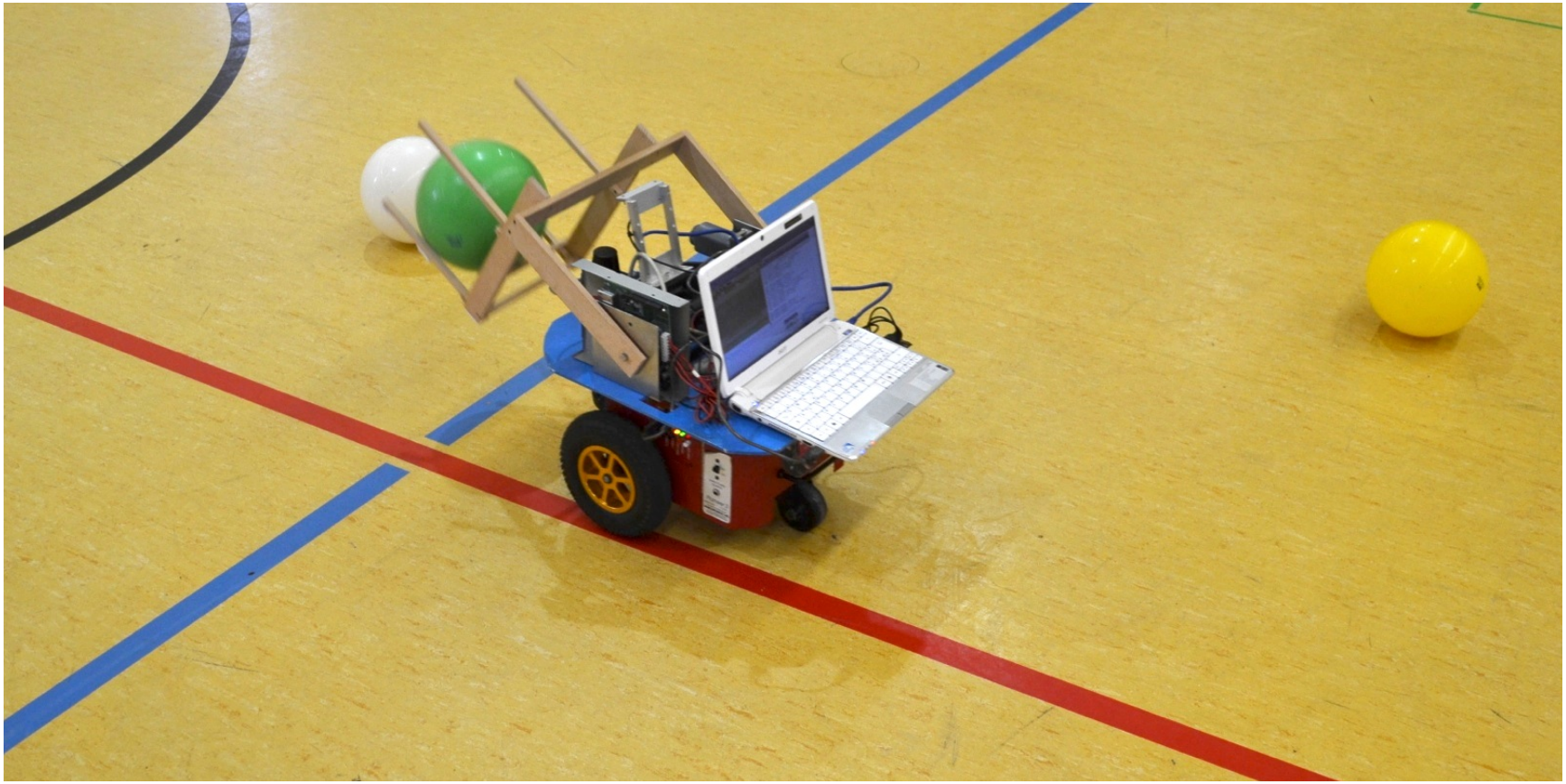
Information available

- Shape
- Aspect ratio
- Size
- Position
- Colour



Detection steps

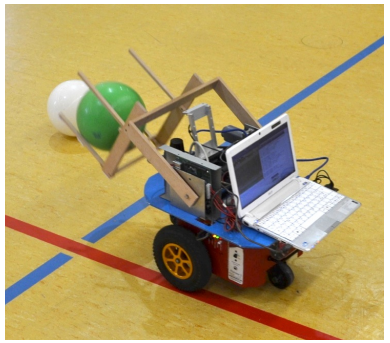
Gripper



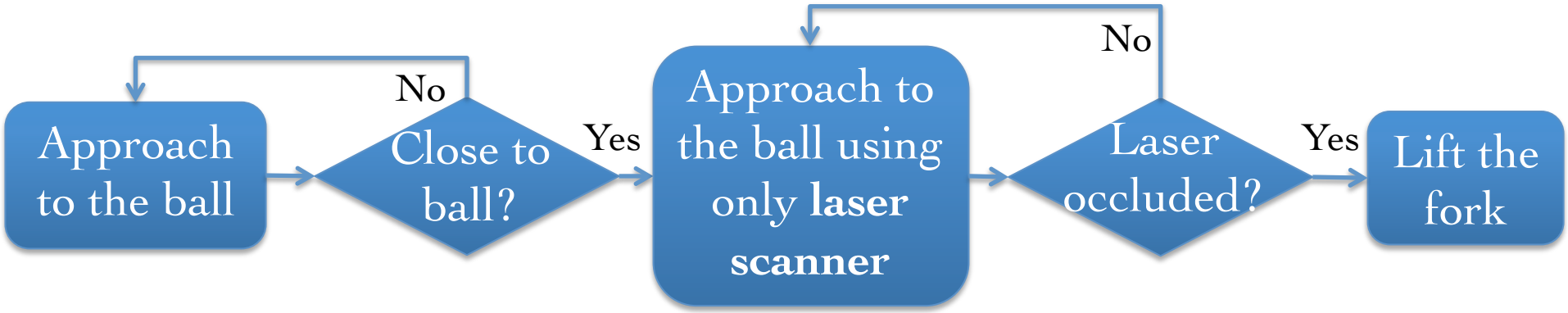
Kind of gripper

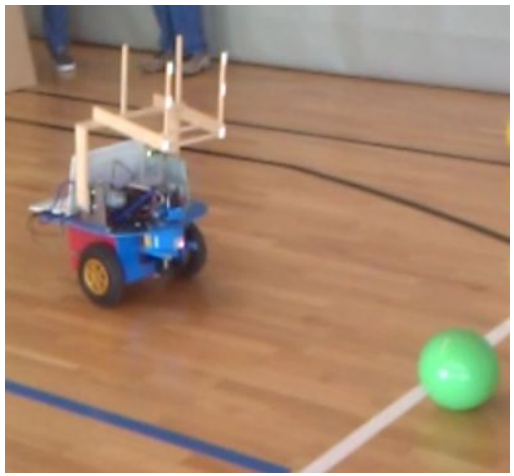
- **Fixed**
  - 👍 : simple, independent from mechanical and electronic parts
  - 👎 : laser occlusion during the navigation toward the pen, hard to maintain the ball

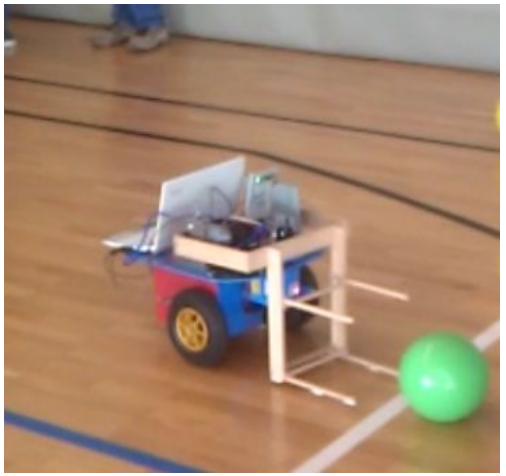
- **Motorized**
  - 👍 : firm grip of the ball, navigation independent from the presence of the ball in the grip
  - 👎 : difficult to design and implement



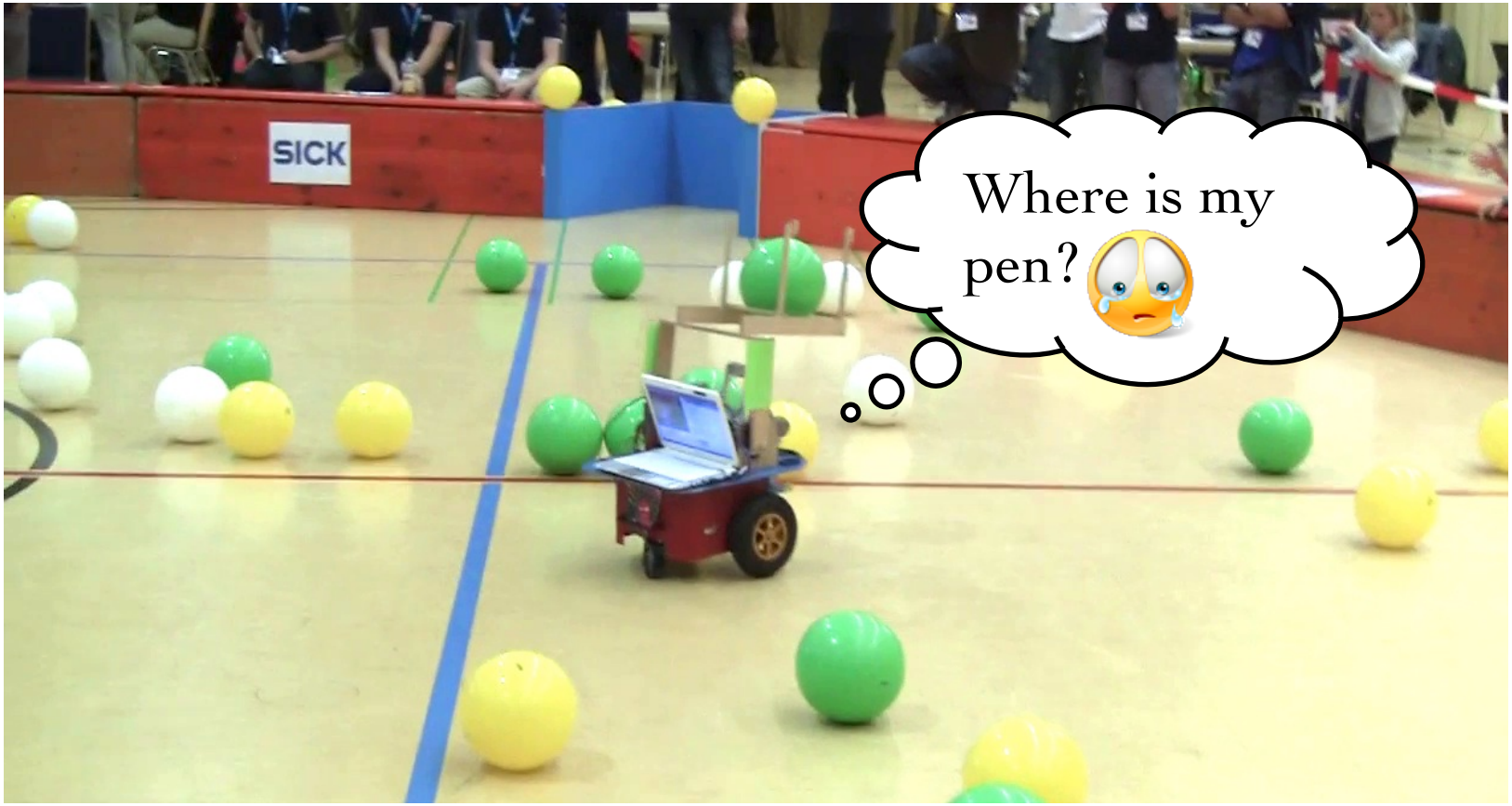
Grip the ball







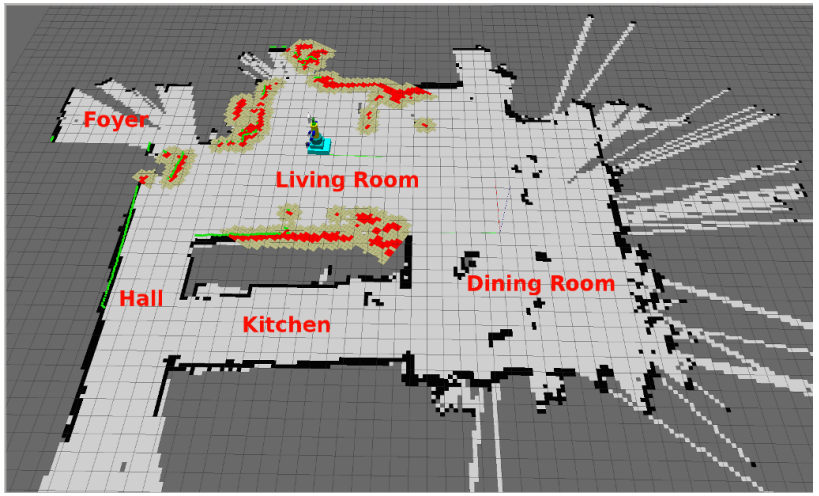
Localization



Different solutions available

✗ **Detailed Map**
precise but expensive

✗ **Odometry**
simple but inaccurate

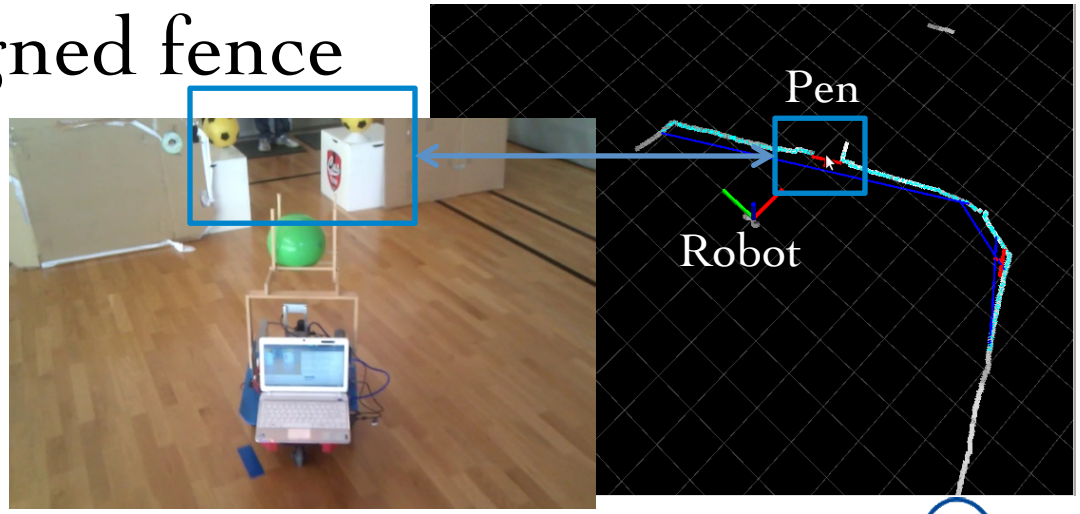


✓ **Odometry + laser scan correction**
good compromise, map with a few landmarks

Mixed approach

Odometry used to identify the **approximate area** of the pen. Initialization when exploration starts.

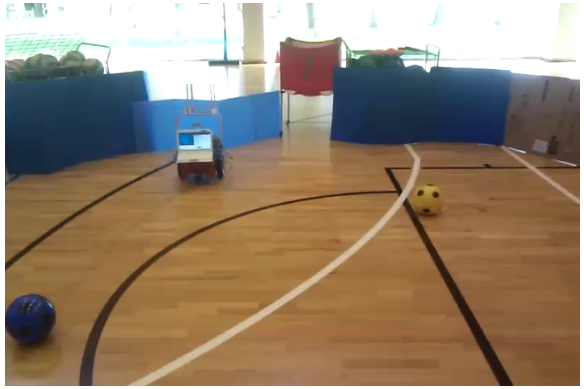
Laser scanner used for a more accurate **pen detection**, using aligned fence discontinuities and Hough transform.

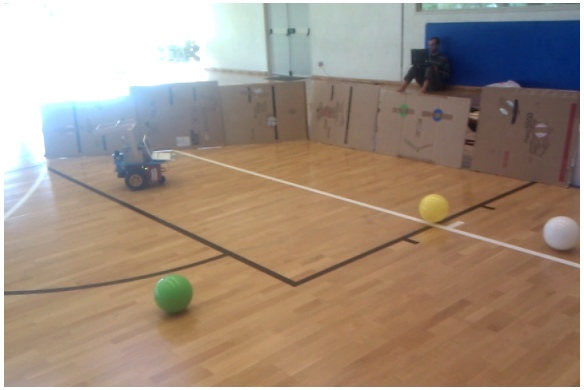


Experiments

Testing environments

- **Robotics Laboratory** of the University of Parma: testing **individual modules**.
- **Gym** of the University of Parma: testing the **whole system** in an environment more similar to the Sick Robot Day arena.



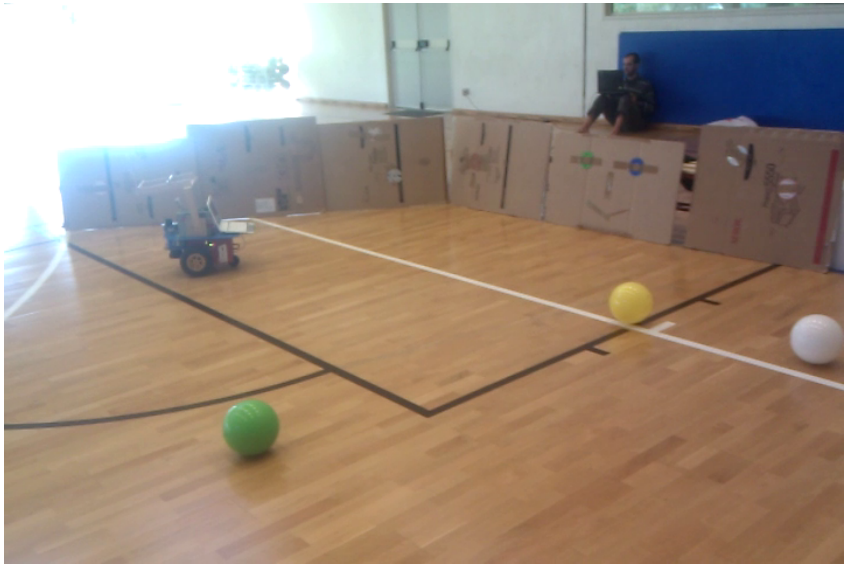


Testing is useful!

- **Deadlock** in the fork module
  - Timeout (10s)
- **Localization**
  - Odometry unreliable
  - Added **pen detector** module
- **Tuning** parameters
  - Color segmentation
  - Pen detector

But doesn't solve all problems!

- Perception depends on **lighting conditions**
  - White ball detection unreliable
- Alternative solution
  - Laser-driven approach
- Team decision:
  - Change of approach for ball detection?
  - **No time available** to do it!



Lessons learned

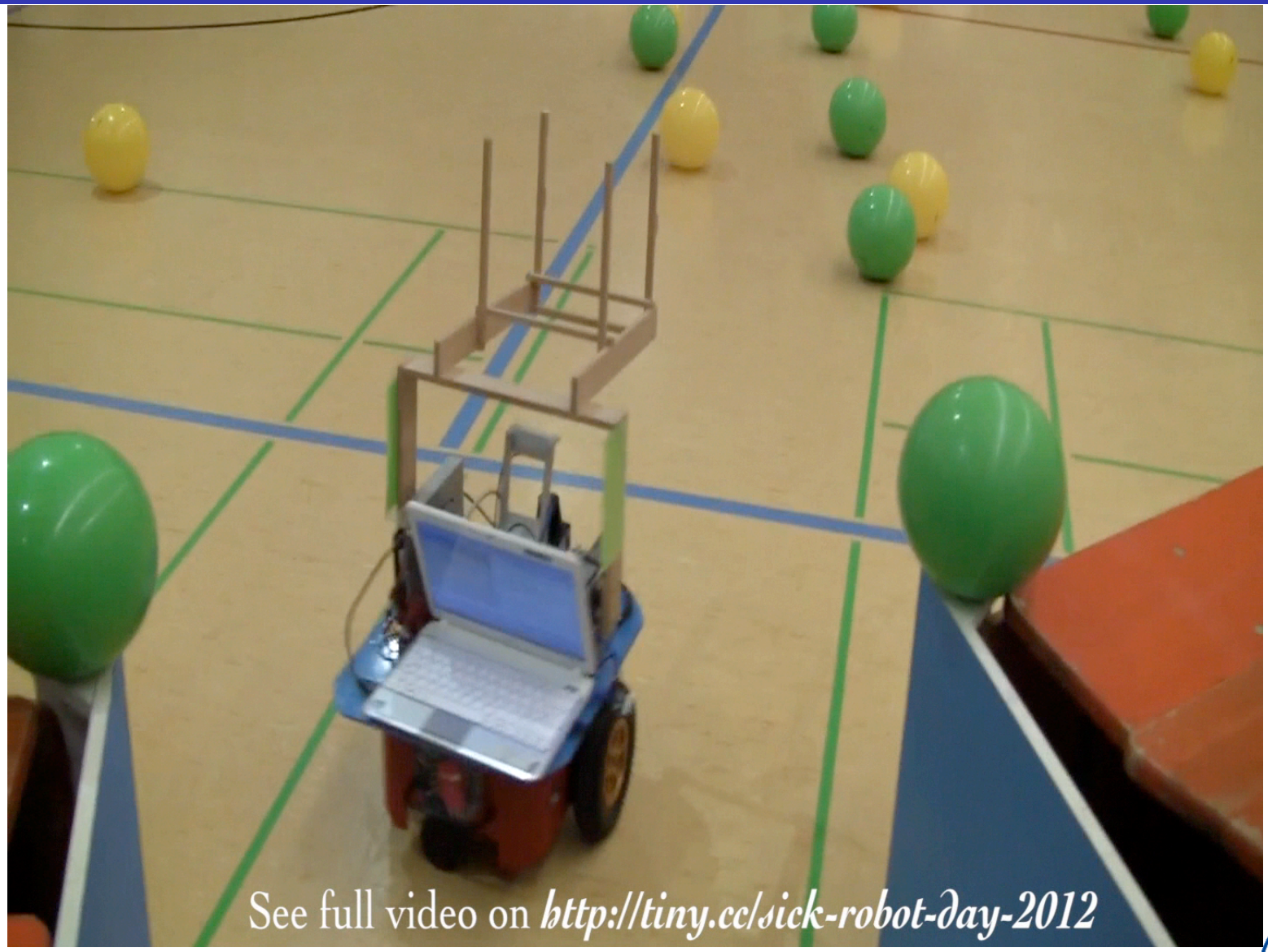
Lessons learned

- **Perception** is the **most important** reason for the success or failure in accomplishing a given task.
- The **complexity** of the solution should be **proportional** to the complexity of the problem.
- **Testing** both single modules and whole system is necessary to get the result.
- **Manage uncertainty**, also with experiments.
- *Simple* not always equal to *Efficient*

Competitions and RiE

- Very useful to learn to **work in team** and promote **social skills**.
- Motivate learning of extra skills (electronics, geometry, mechanics) due to the **multidisciplinarity** of robotics.
- Complex problems must be faced and split in smaller problems, → competitions promote problem solving skills required in real life

Sick Robot Day 2012


See full video on http://tiny.cc/sick-robot-day-2012

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