Omnidirectional Distributed Vision for Multi-Robot Mapping

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Introduction

Robots' task:

Building a map of an unknown indoor environment with a team of heterogeneous robots.

Sensors:

Omnidirectional Vision systems

Work's aim:

To prove scalability of the Spatial Semantic Hierarchy approach to a multi-robot system

Outline of the Talk

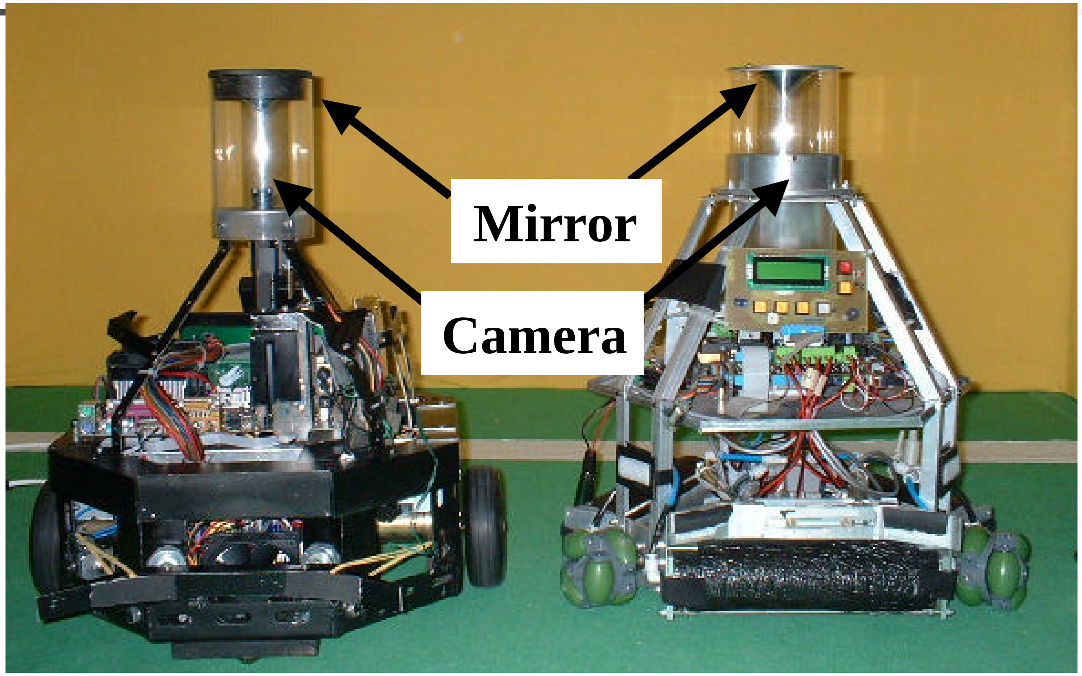
- Single Robot Mapping Strategy
  - Robots' sensor
  - Spatial Semantic Hierarchy and Omnidirectional Vision
- Multi-Robot Mapping Strategy
  - Local Maps construction
  - Map Sharing
- Heterogeneous Vision Systems

Single Robot Mapping Strategy

- Use omnidirectional vision sensor
- Detect topologically meaningful features in the environment
- Use Spatial Semantic Hierarchy of Kuipers (SSH)
- Build a topological map
- Use the map to explore the environment

E. Menegatti, E. Pagello, M. Write
Using Omnidirectional Vision within the Spatial Semantic Hierarchy
IEEE Intern. Conf. on Robotics and Automation,
(ICRA2002) Washington , May 2002

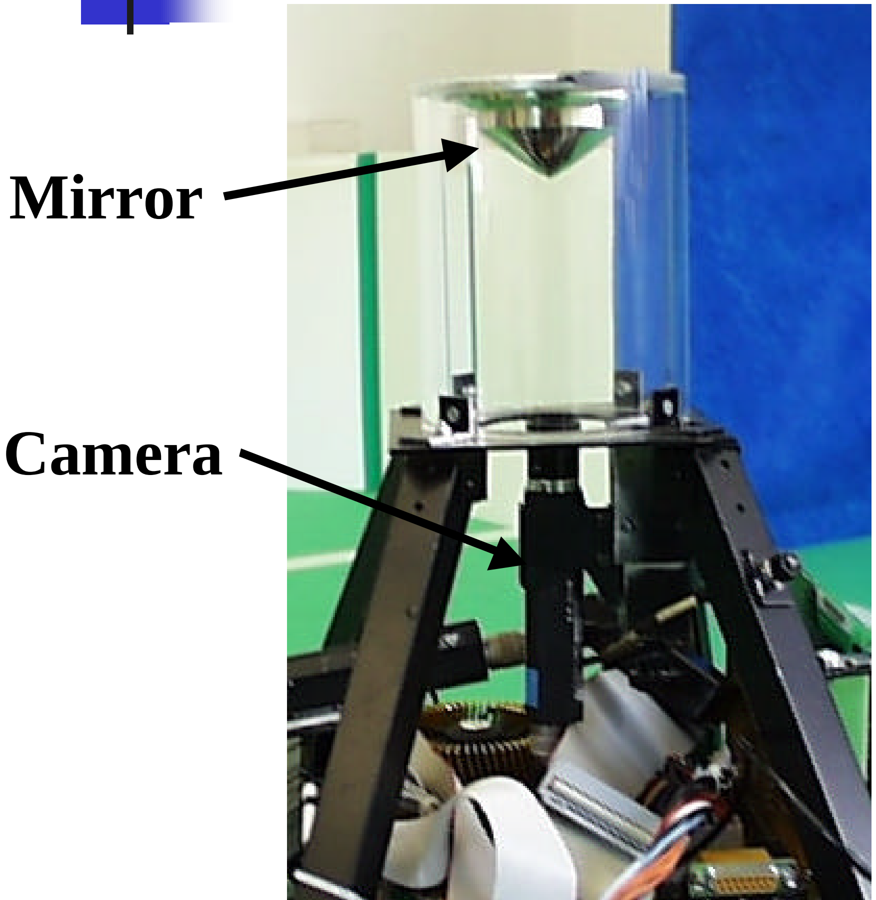
Heterogeneous Robots



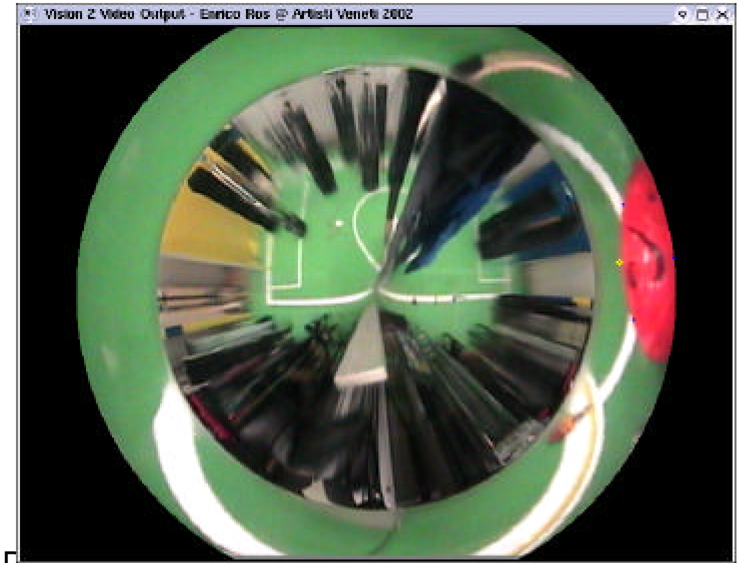
Characteristics:

- *Chassis shaped for omnidirectional vision*
- *Mirror profile designed for the robot's task*

Omnidirectional Sensor



- Mirror with *custom* profile
- Maximise resolution in ROIs

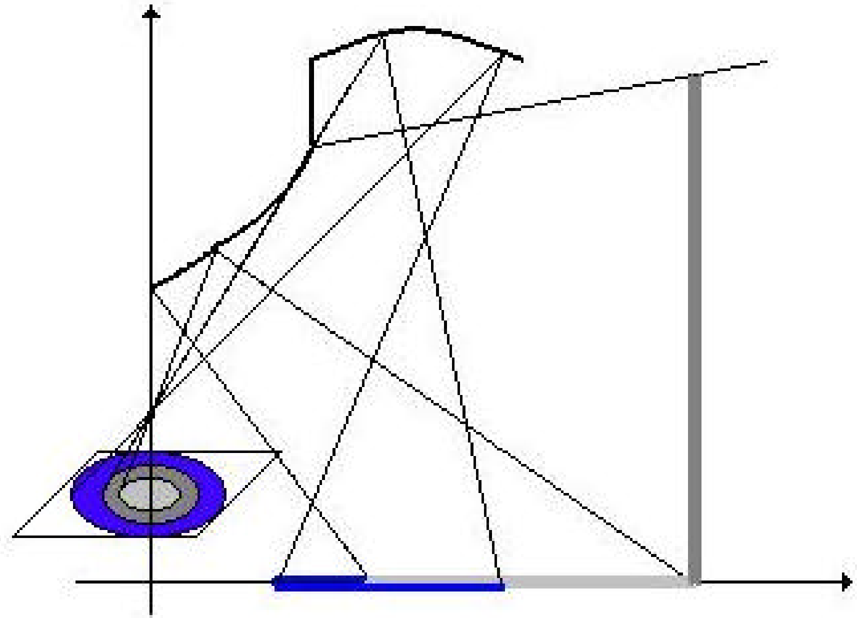


The mirror we designed...

Three parts:

- Measurement Mirr
- Marker Mirror
- Proximity Mirror

The task determines the mirror profile

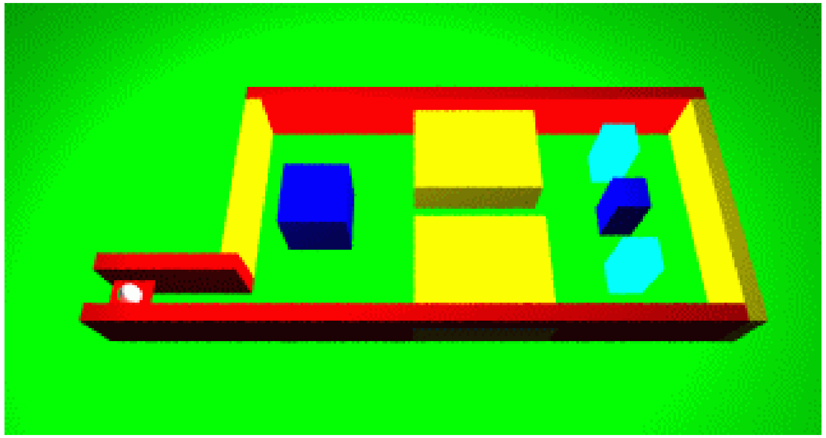


Mirror Profile

E. Menegatti, F. Nori, E. Pagello, C. Pellizzari, D. Spagnoli
Designing an omnidirectional vision system for a goal keeper robot
RoboCup-2001: Robot Soccer World Cup V. (Springer 2001)

Assumptions

- Man-made environment
- Floor flat and horizontal
- Wall and objects surfaces are vertical
- Static objects
- Constant Lighting
- Robot translates or rotates
- No encoders



The virtual environment

Spatial Semantic Hierarchy...

... A model for the human knowledge of large spaces

Layers:

- Sensory Level
- Control Level
- Causal Level
- Topological Level
- Metrical Level

Control Laws, Transition of

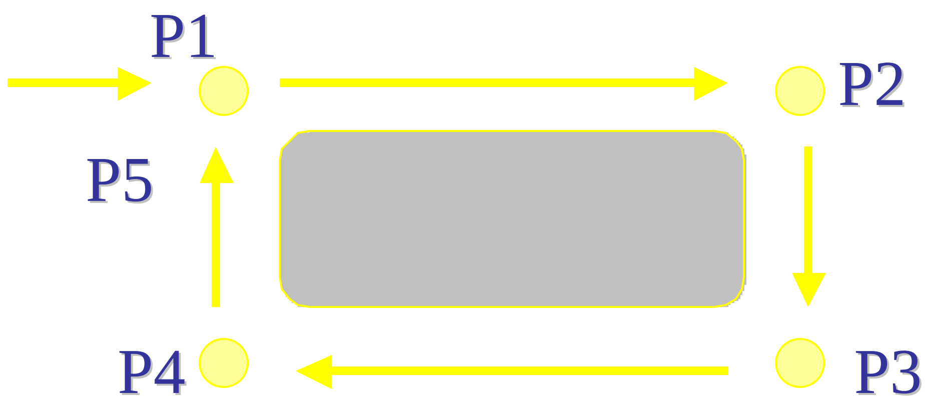
Distance, Direction, Shape

Omnidir. Vision and SSH

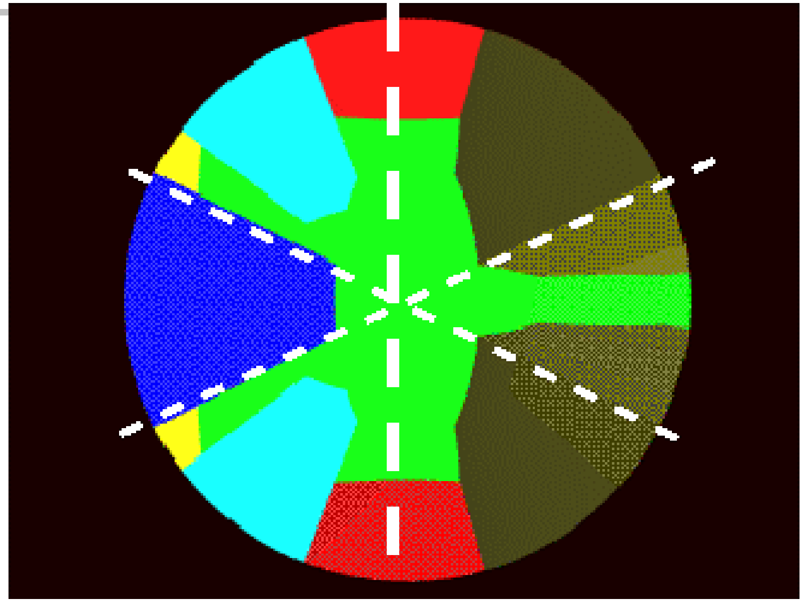
View ⟺ Omnidirectional image

This simplifies data interpretation:

- Discriminate b/t "*turns*" and "*travels*"
- Simplify "Exploring around the block"



Features and Events



Feature:

- Vertical Edges

Events:

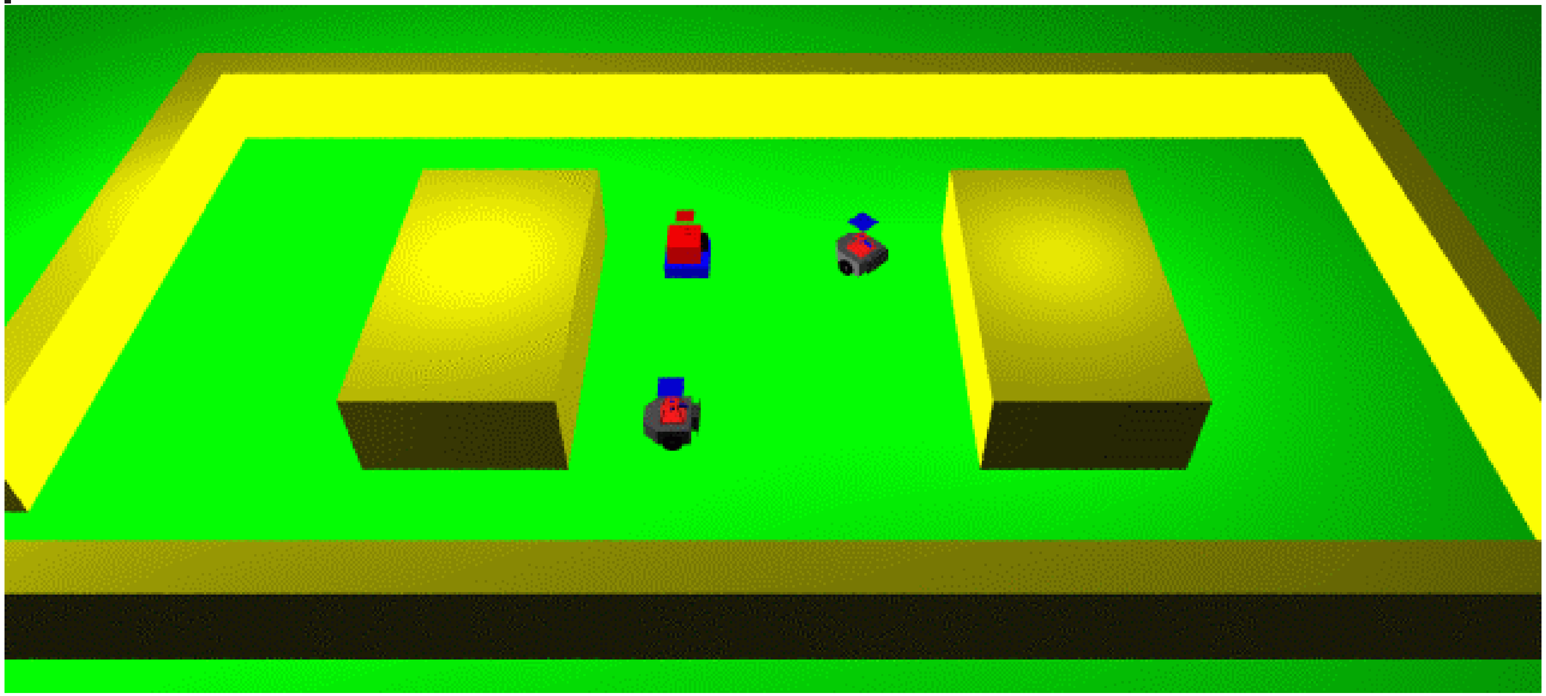
- –A new edge
- –An edge disappears
- –Two edges 180° apart
- –Two pairs of edges 180° apart

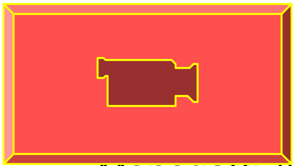
Multi-robot mapping strategy

"*We do not focus on coordination issue* "

- Every robot carries on an independent exploration
- Robots use a *mis-robot* strategy (from "*mis-anthropy*") i.e.
  - Follow the direction of exploration that encreases the distance from the visible teammates
- Every robot builds its own *local map*
- When two robots can see each other, they *share their local maps*

Multi-robot mapping strategy (2)

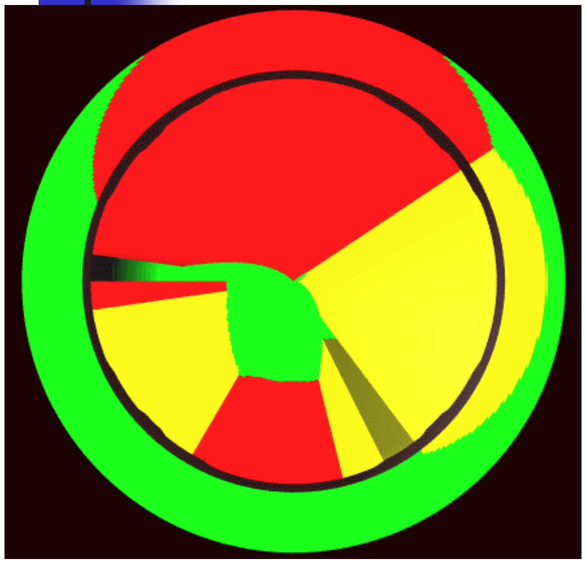




Map Sharing

- When two robots *can see each other*
- They try to *match their current views*:
  - Identifying the objects seen by both robots
  - Estimating their relative distance and orientation
- If the match is successful, *they knows how to connect* their local maps
- They *transmit their own local map* to the teammate
- Each robot *connects* this new local map to its local map

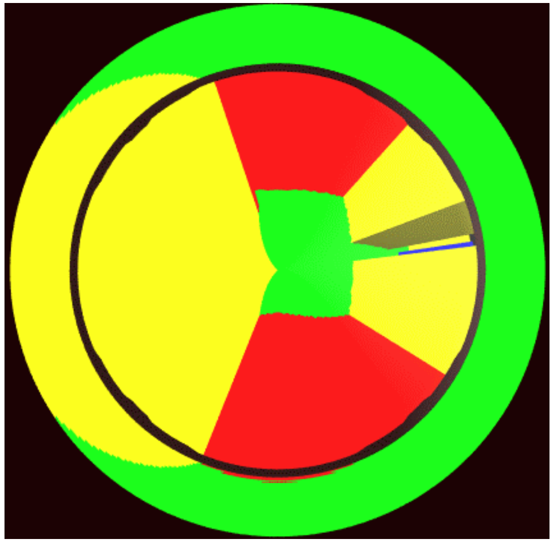
Map sharing (2)



View of Robot #1

Matching

(by seeing the same objects)



View of Robot #2

Relative orientation and pose extimation of the two robots

Heterogeneous Vision Systems

Omnidirectional Vision

Pros

- Wide field of view
- High speed
- Vertical Lines
- Rotational Invariance

Cons

- Low Resolution
- Distortions
- Low readability

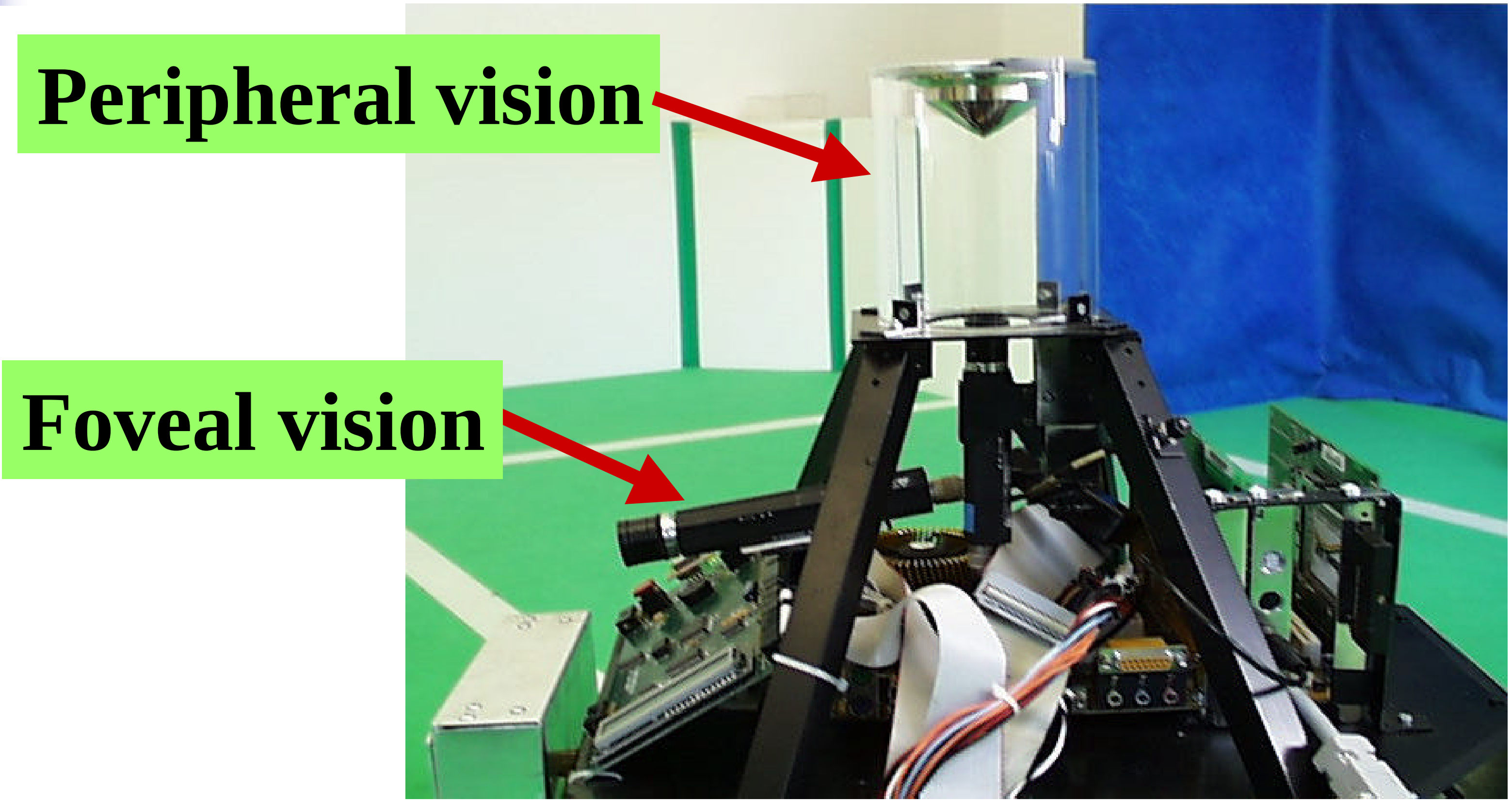
Heterogeneous Vision Systems (2)

- Omnidirectional vision + perspective vision on a *single robot*
- Omnidirectional vision + perspective vision on *different robots*

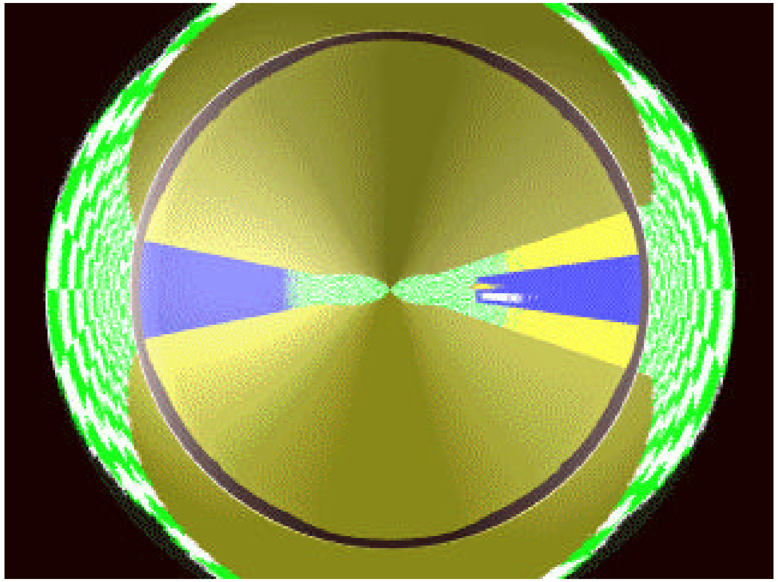
•Agents autonomously elaborate and interprete grabbed images

•Agents communicate and cooperate to increase the system performances

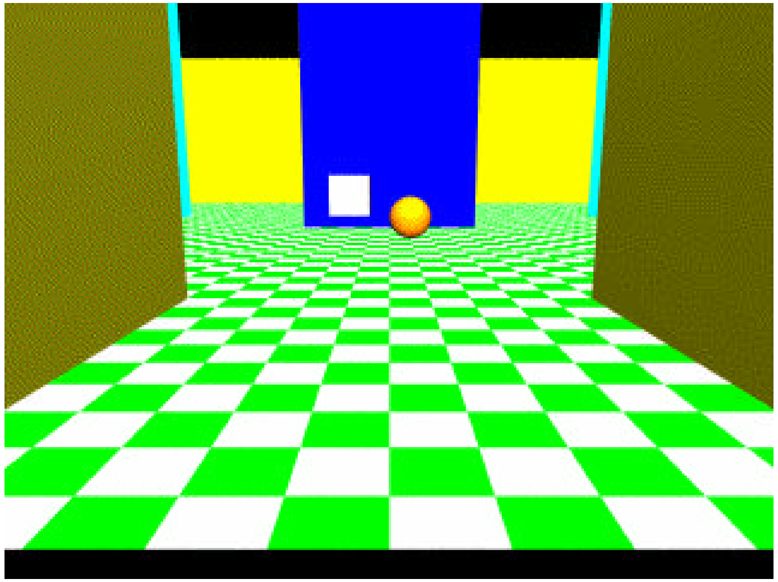
Heterogeneous Vision Systems (3)



Heterogeneous Vision Systems (4)



OVA's view

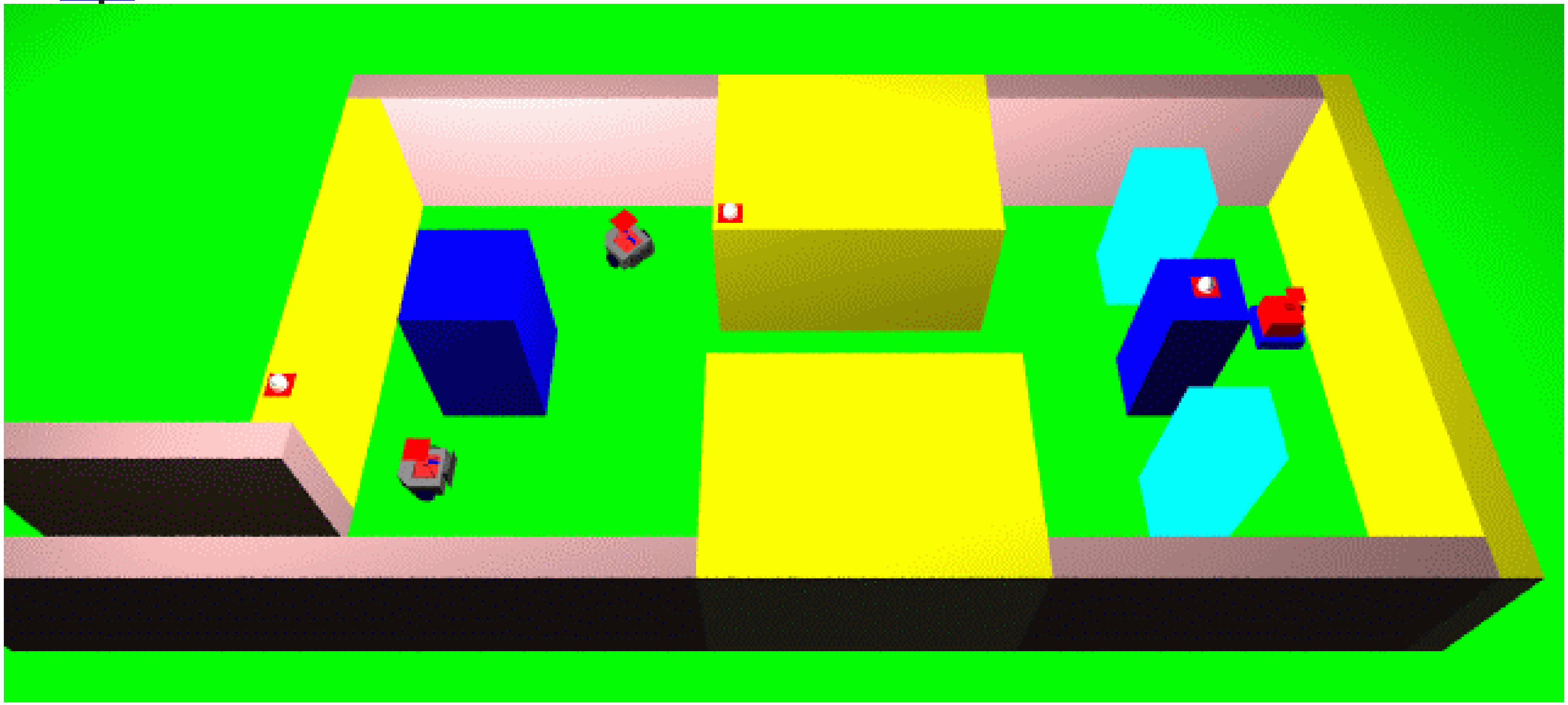


PVA's view

Future Works

- Use *redundacy* of the observers and observation to improve the map
- Exploit the *heterogeneity* of the robots more deeply in tasks too expensive (or not achievable) for omogeneous robots
- Use maps of *non previoulsy met* robots to navigate. The bridge is the common starting location.

Future Works: *Surveillance*



Conclusions

- We presented a mapping strategy for a single robot:
  - SSH + omnidirectional vision
- We proposed how to scale it to a heterogeneous multi-robot team:
  - Merge local maps via matching of current image
- We highlight the need for heterogeneous vision

For further Information:

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