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Cooperation between Omnidirectional Vision Agents and Perspective Vision Agents for Mobile Robots

Intelligent Autonomous Systems - Lab

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Presentation's Outline

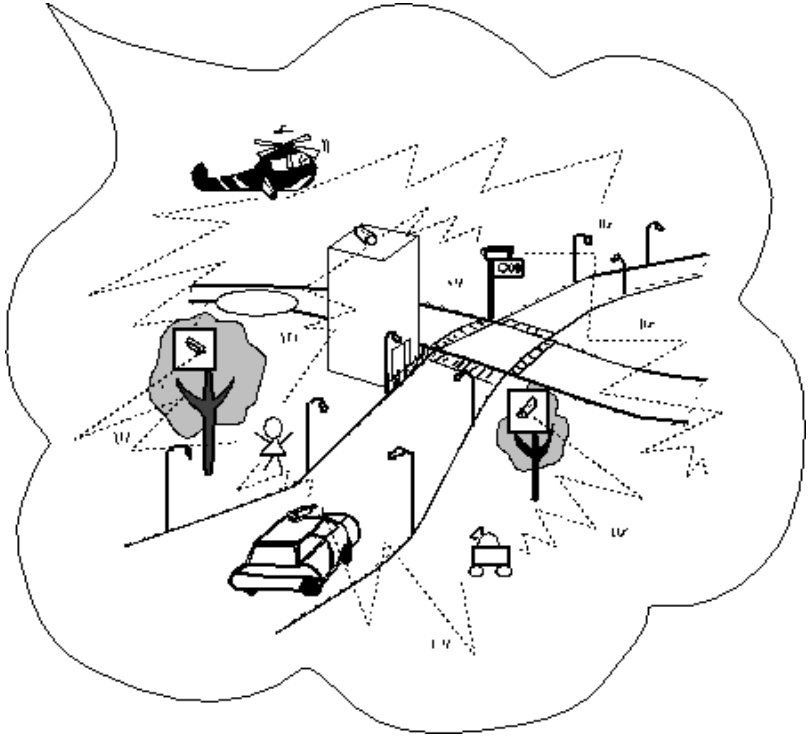
- What is a Distributed Vision System
- Previous work on Omnidirectional Vision
- Our projects:
  - Heterogeneous Vision Agents
  - Designing Omnidirectional Mirrors
  - Cooperative Object Tracking with Mobile Robots

Distributed Vision

- What is it?

  a set of vision systems embedded in the environment and connected by a network

- DV tasks?
  - Real time wide area surveillance
  - Cooperative tracking of objects



(courtesy of Prof. Matsuyama)

Previous Works

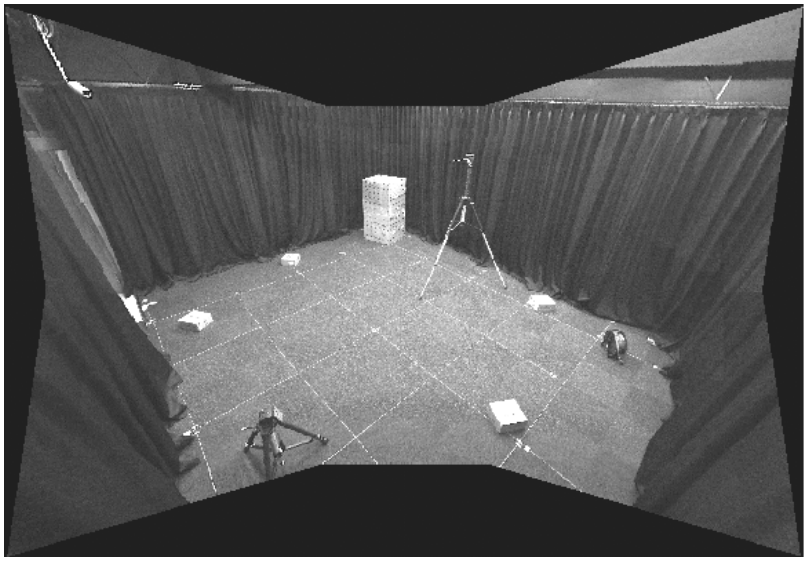
- Cooperative Distributed Vision (CDV) [1999]
  - T. Matsuyama at Kyoto University (Japan)
- Distributed Vision System (DVS) [1997]
  - H. Ishiguro at Wakayama University (Japan)

The CDV testbed [Matsuyama]

- A simple room
- Uniform background
- A big box
- 4 Fixed Viewpoint PTZ cameras

Task:

Track a radio controlled car or two people



CDV limitations

- Expensive hardware for Fixed Viewpoint camera
- Appearance Plane
- Active cameras but static image processing
- Very simple vision algorithm
- No implementation for mobile robots

The DVS testbed [Ishiguro]

- A toy town
- Outdoor-like lighting
- 2 non-autonomous robots
- 16 VAs

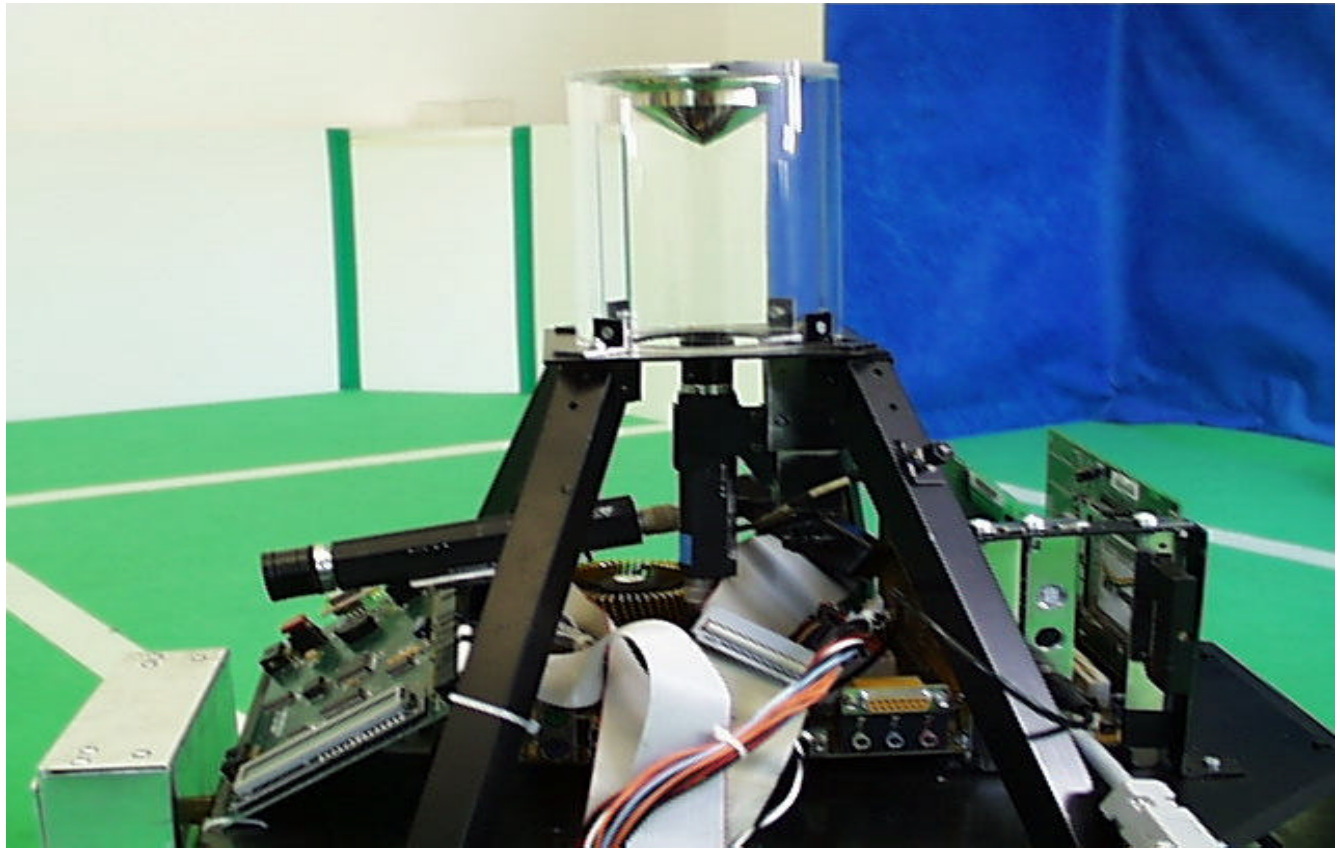
Task:

Navigate two mobile robots in the town

DVS limitations

- No moving cameras
- Need teaching phase
- Robot is not autonomous
- Very simple vision algorithm

Two Vision Agents on a Robot



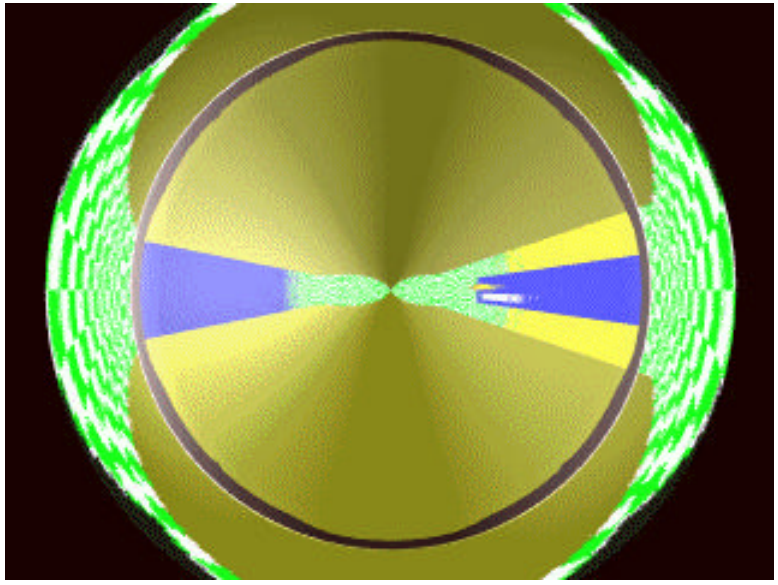
Two Vision Agents on a Robot

- Vision Agent
  - This term emphasizes the fact that the vision system is not just anyone of the sensors, but it must interact with the other vision system to create an intelligent distributed system
- Omnidirectional Vision Agent (OVA)
  - It is used as a peripherical vision, and gives a less accurate information on what is going around the observer
- Perspective Vision Agent (PVA)
  - It is used as a foveal vision, and determines the *focus of attention* and provides accurate information on a narrow field of view
- Task:

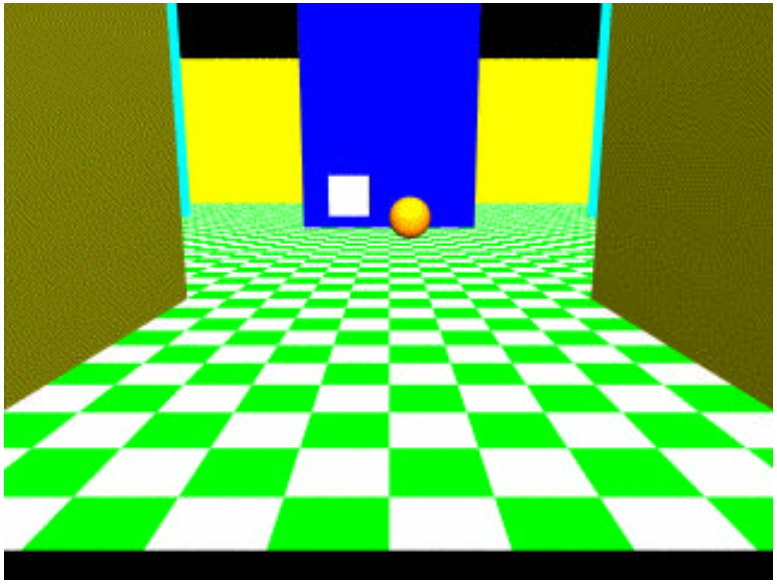
  Detect a moving object and Locate it

  Communicate its position to other agents

Agents' Views



OVA's view



PVA's view

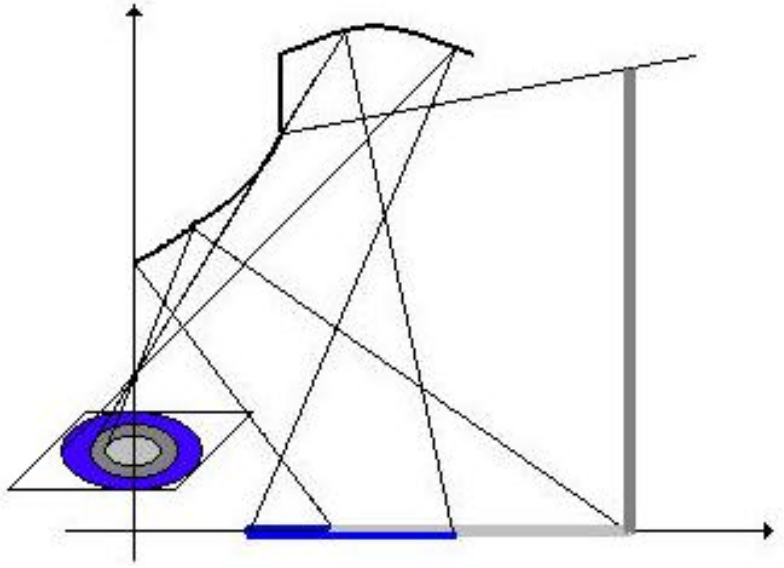
The mirror we designed...

E. Menegatti, F. Nori, E. Pagello, C.Pellizzari, D.Spagnoli
Designing an omnidirectional vision system for a goalkeeper robot,
In RoboCup-2001: Robot Soccer World Cup V.,
A. Birk, S. Coradeschi, T. Tadokoro (Eds.) L. N. on A. I, Springer 2002

The mirror we designed...

Three parts:

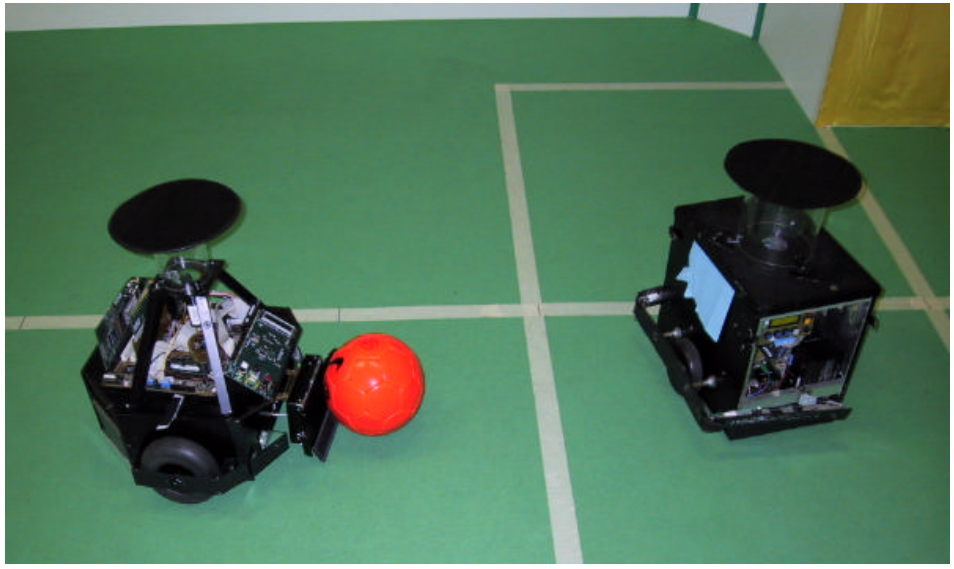
- Measurement Mirror
  (high resolution)
- Marker Mirror
  (low resolution)
- Proximity Mirror
  (medium resolution)

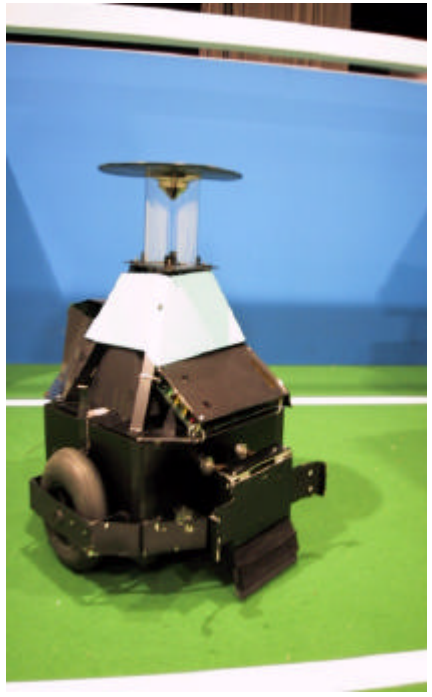


Mirror Profile

The task determines the mirror profile

A Goalie's Mirror versus An Attacker's Mirror





Goalkeeper

Attacker

Requirements

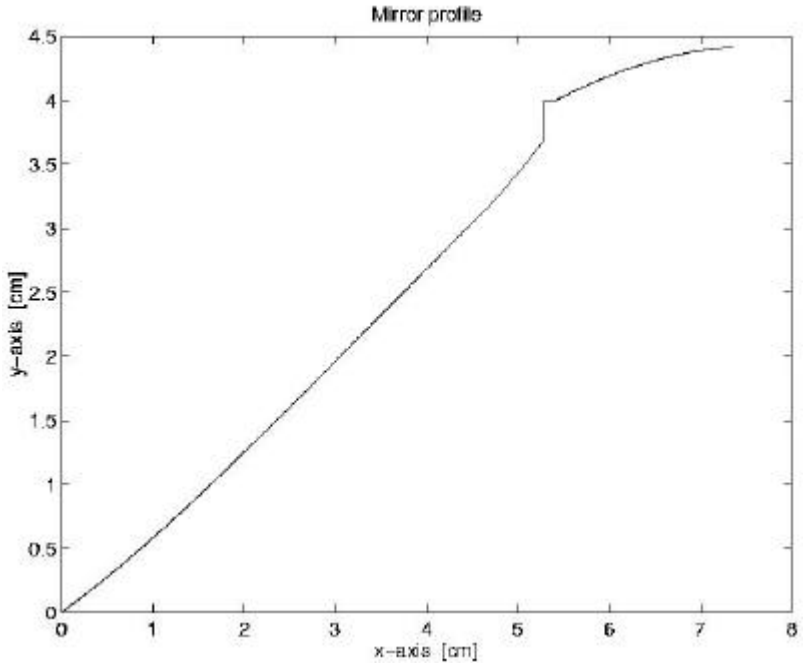
For Goalie:

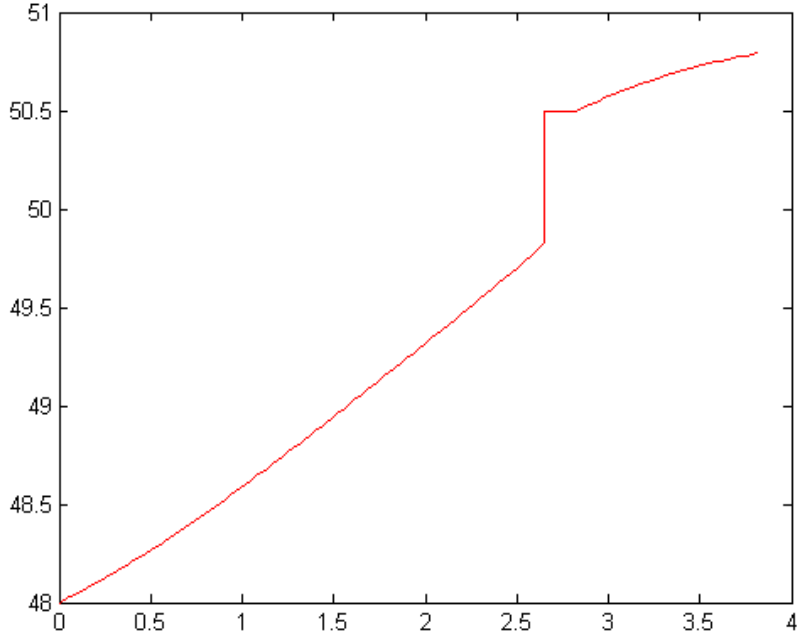
- Locate the ball
- Identify the markers
- See the defended goal

For Attacker:

- Locate the ball
- Identify the markers
- See both goals
- Lighter mirror

Two Mirrors, Two Tasks





The matching algorithm

- In a general application:
  - We use the position, the shape and the colour of the detected objects to create a matching between the two views
- In the RoboCup environment:
  - We have a knowledge base with the description of the properties of the meaningfull objects

    (robots, ball, goals, ...)
  - The calibration of the sensors permits to extract the features of the visible objects and to match them with the descriptions in the knowledge base

Cooperative Object Tracking

- We started from the Cooperative Object Tracking Protocol [Matsuyama 1999] (that has NO Mobile Robots)
- We used
  - Matsuyama's *Agency* and *Agency's Master* concepts
- But, because of the Mobile Vision Agents, the point of view is changing all the time:
  - We need to identify the different objects and estimate their position
  - We need to communicate those information to other Agents
- Thus, our Vision Agents not only do image processing, but also
  - They must *Understand* the Scene, and *Communicate* with other Agents

Agency's Master

- Most critical role:
  - Decide who can enter the agengy
  - Decide which are the reliable positions among the position sent by the other robots
  - Decide the "true" position of the tracked object by merging the reliable information
- The Master role cannot be statically assigned
  - Passed to the robot with the highest value of confidence function

Confidence function

- We introduced a new concept:
  - A Confidence Function:
    It is a measure of the uncertainty associated to the measure of the position of the tracked object.
- Ψ_{abs} , associated to reliability of the absolute object position

$$\psi_{abs} = \psi_{sl} + \psi_{rel}$$

Ψ_{sl} => associated to reliability of self-localisation

(It depends from the type of vision system, estimated error in computing landmarks, time passed from last self-localization process, etc.)

Ψ_{rel} => associated to relative position of the object wrt the robot

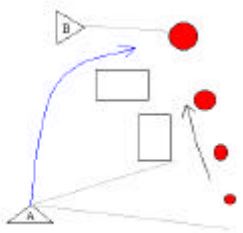
(It depends from the type of vision system, distance from the object, etc.)

- It is used to assign the role of Agency's Master

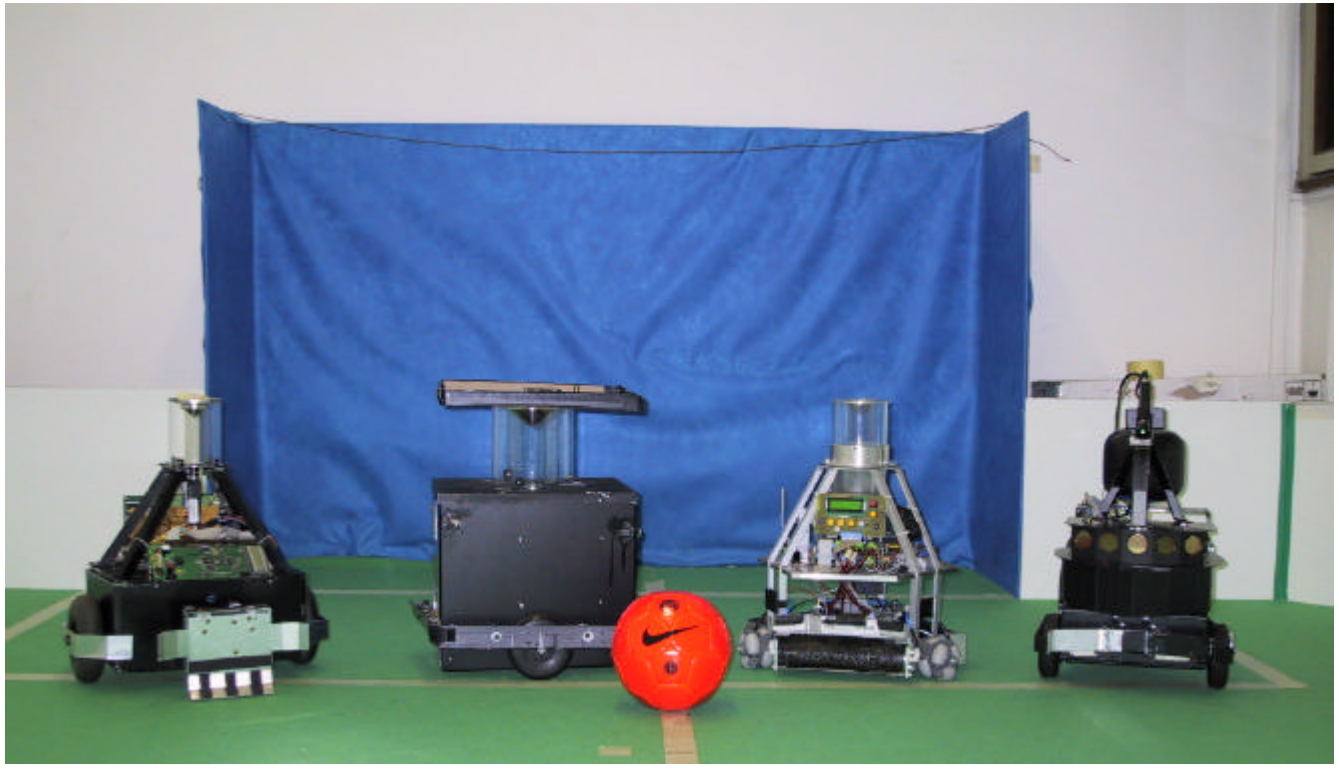
Cooperative Object Tracking in the case of mobile robots

- *We are experimenting these concepts in the RoboCup domain*
  - *Since the ball is continously moving during the game, master role must pass dynamically from robot to robot*
- *The position of the ball in the play field is calculated through the Confidence function as a vectorial sum of*
  - *The absolute position of the robot (the confidence function associated to the self-localization, Ψ_{sl}*
  - *The relative distance of the ball from the robot (the confidence function associated to the estimation of the relative position of the ball wrt the robot, Ψ_{re}*

Three different action play



Cooperative Object Tracking by a 4-Robots Team



The *Artisti Veneti* RoboCup Team

Conclusion

- We discussed the Cooperative Distributed Vision Approach
- We illustrated our actual researches on:
  - How to integrate Heterogeneous Vision Agents both in a Single Robot and in a Multi-robot System
  - How to design Omnidirectional Mirrors for robot tasks
- We outlined our research ideas on:
  - How to develop Cooperative Object Tracking with Mobile Robots