

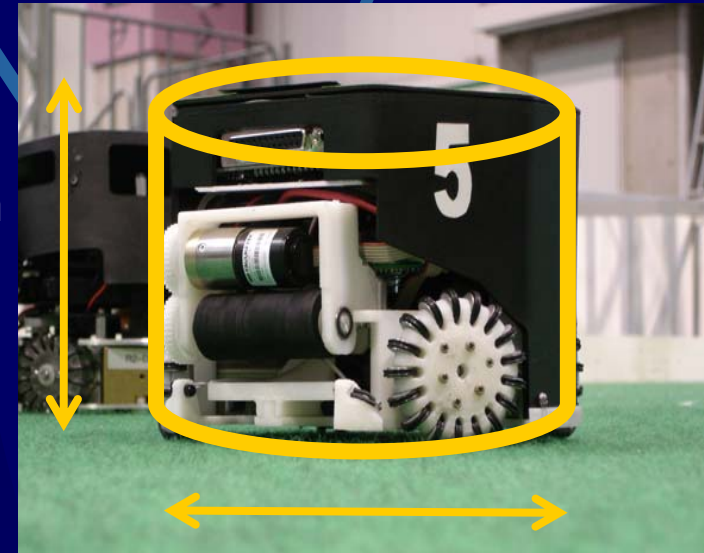
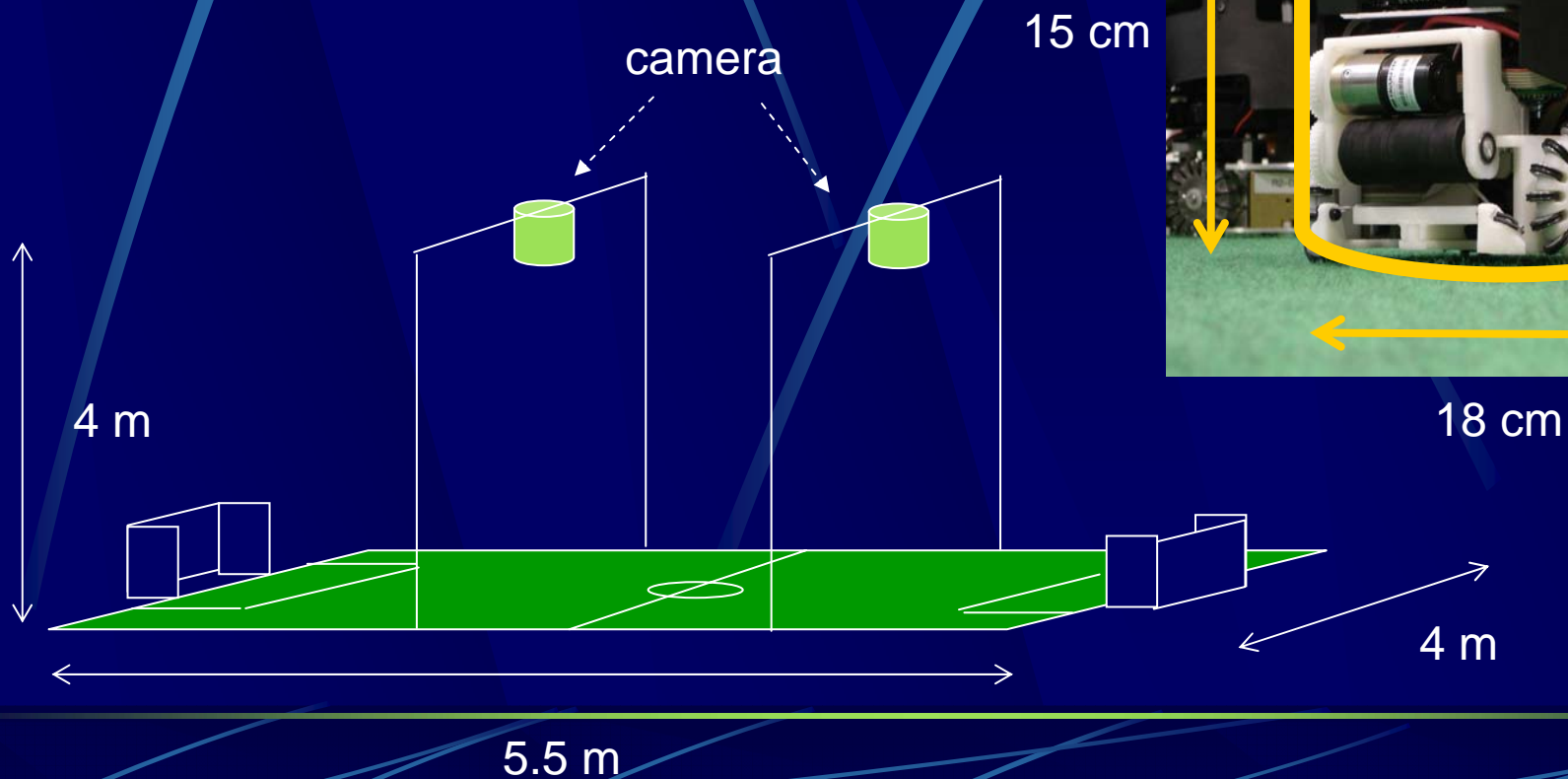


Eagle Knights: RoboCup Small Size League

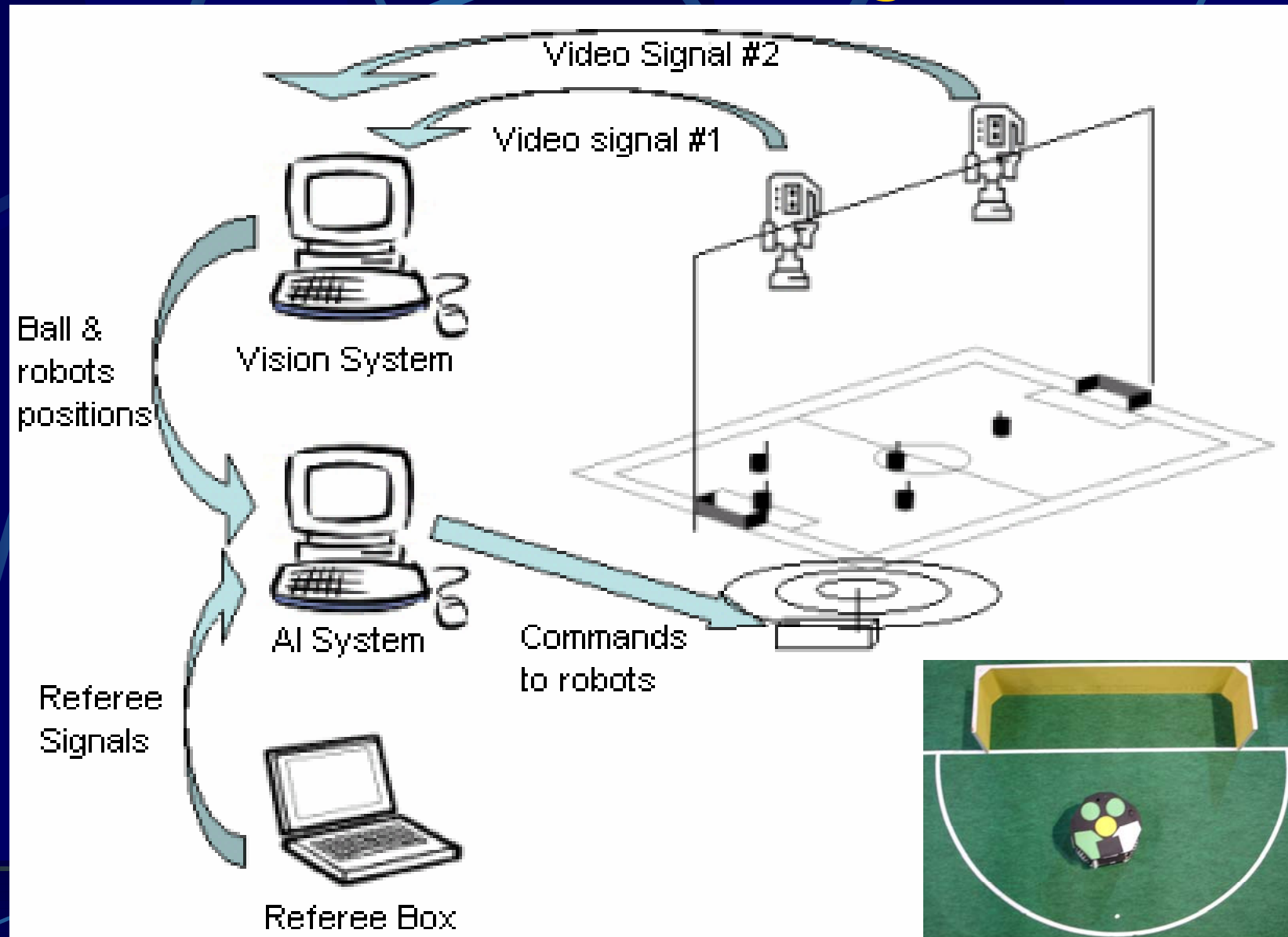
Dr. Alfredo Weitzenfeld
ITAM - Mexico



Playing Field and Robot Size Small-size League



Distributed Robot Control Small-size League

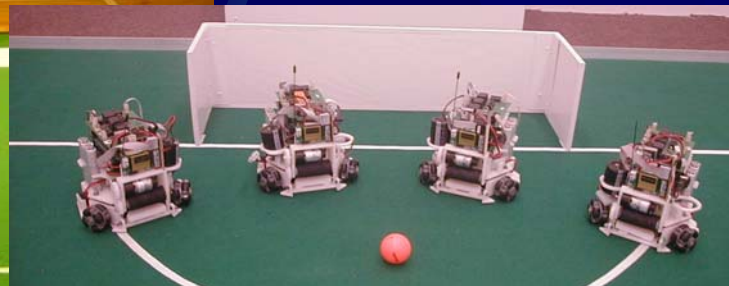
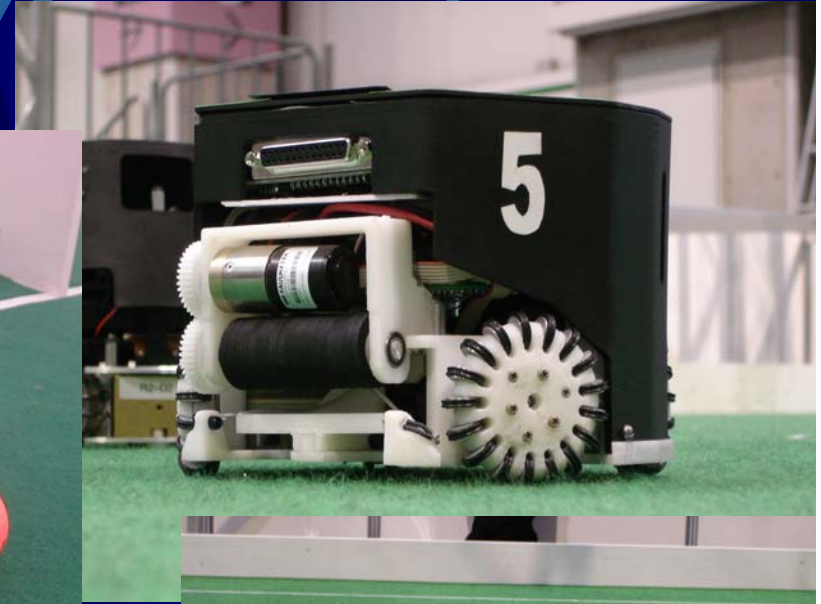
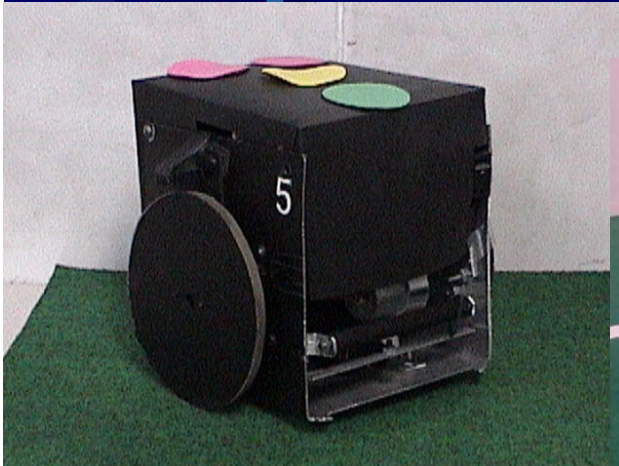


Eagle Knights (2003-2006) Small-size League

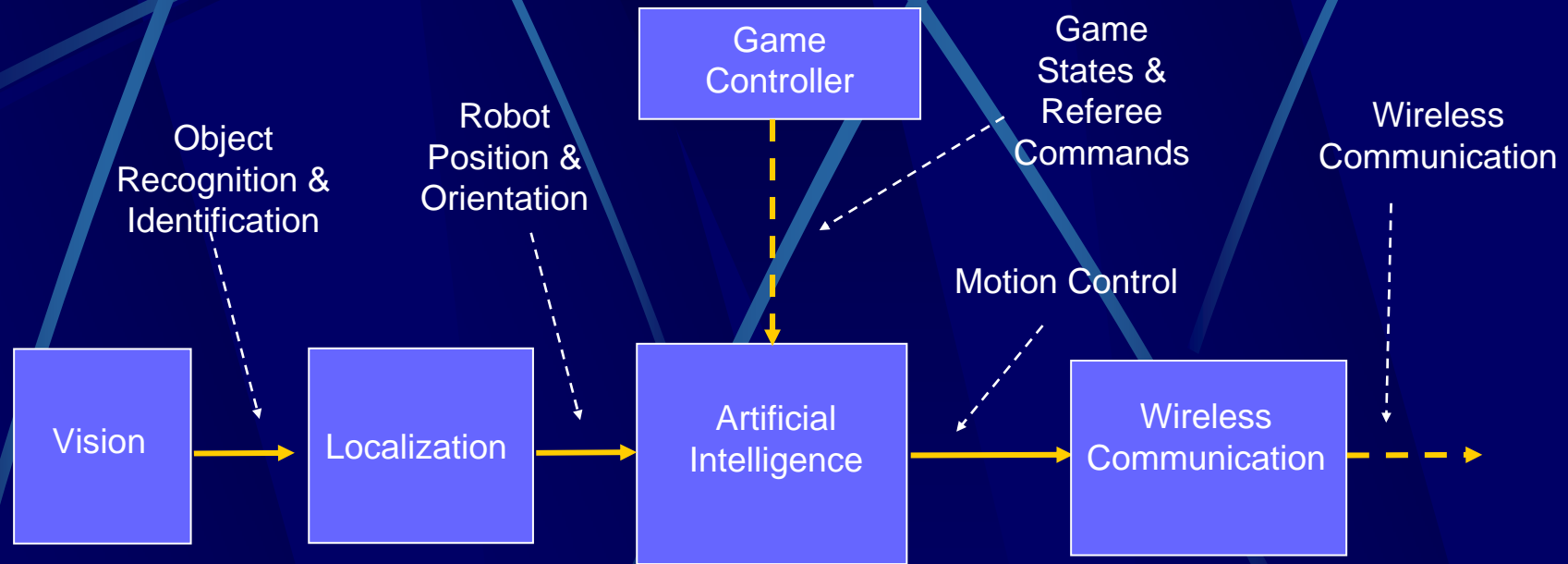
2003

2004

2005



Robot System



Small-size League: Global Vision (multiple cameras), remote processing

Vision

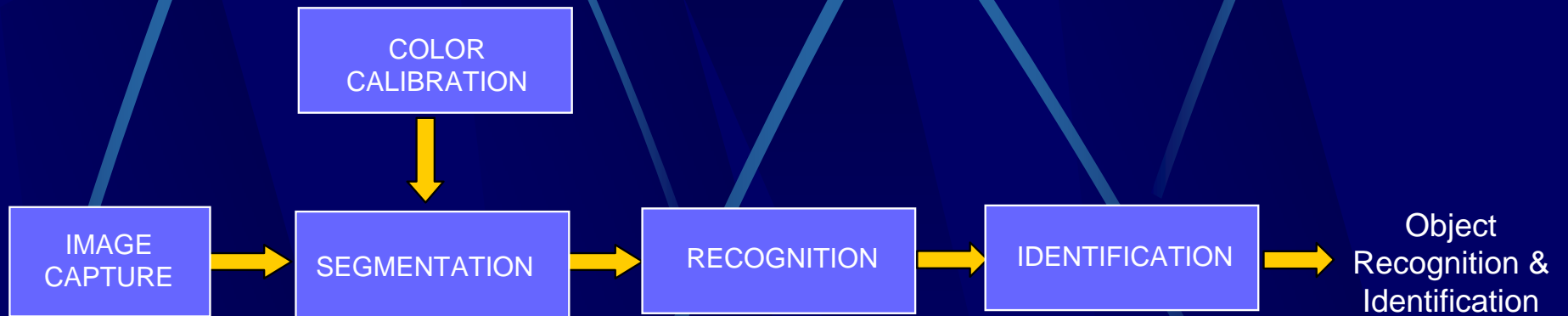
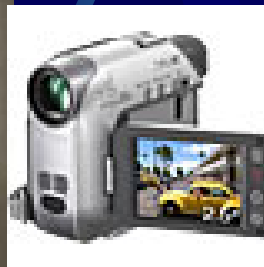
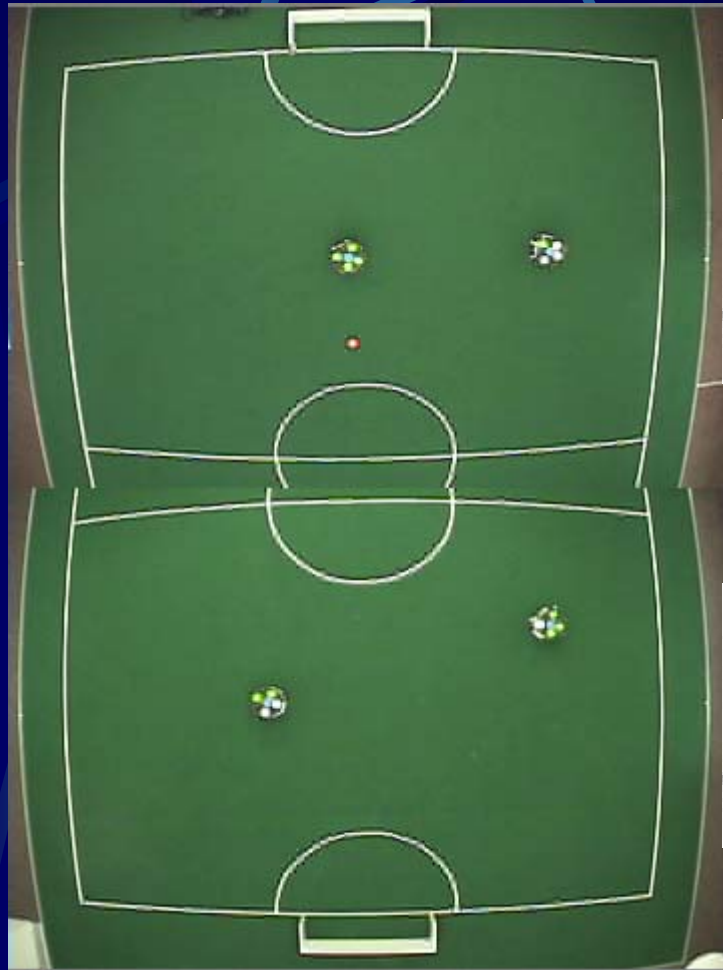


Image Capture Small-size League

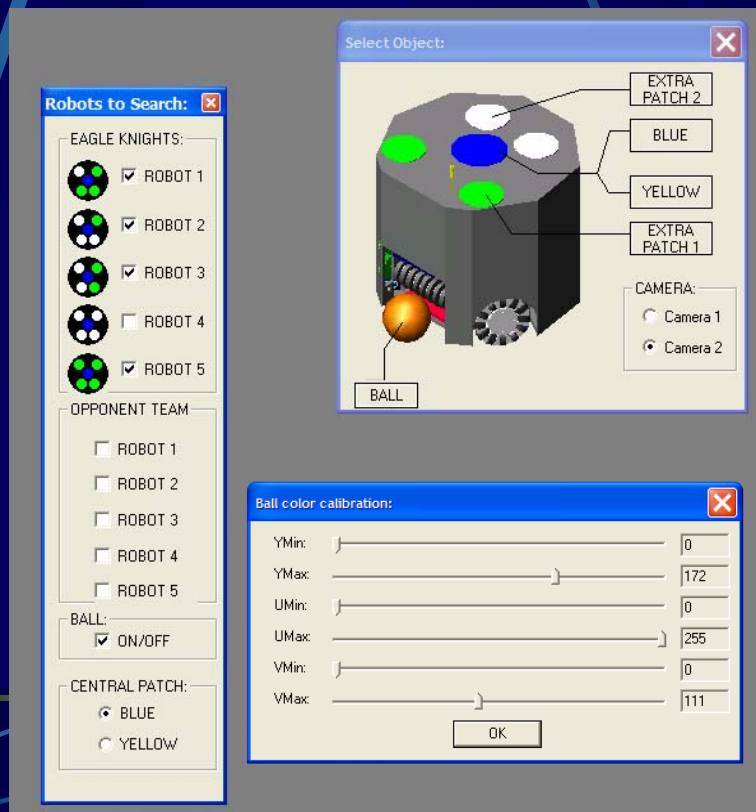


- Two color digital video cameras with IEEE1394/FireWire (previously analog cameras and PC video board with SVideo)
- Frequency (30 fps - frames per second)
- Resolution (320 x 240 pixels)

Color Calibration

Small-size League

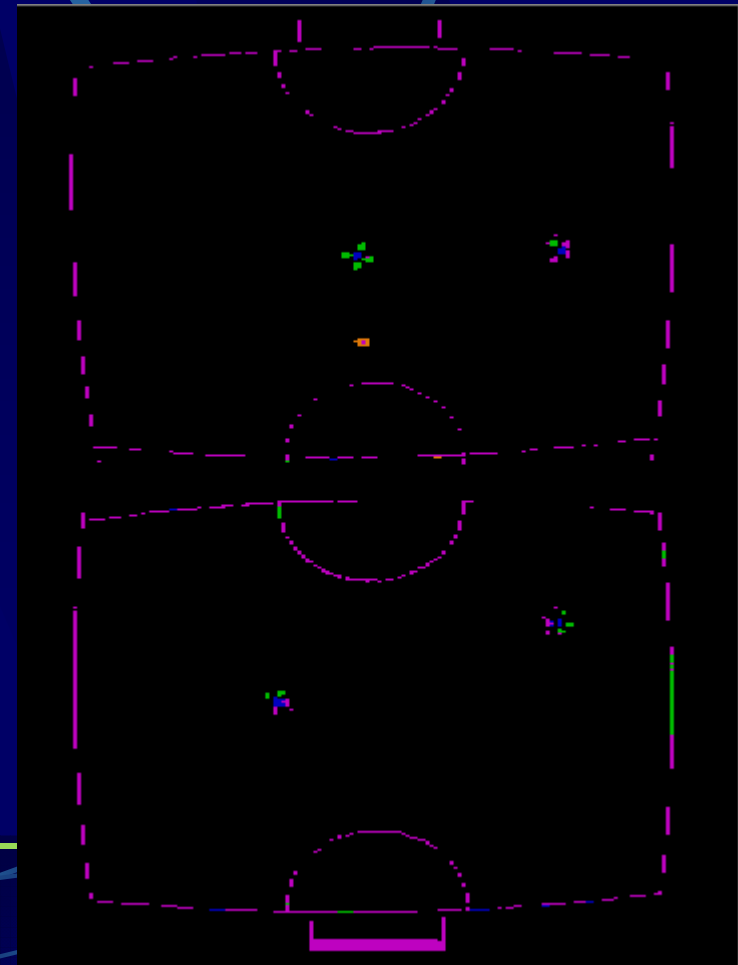
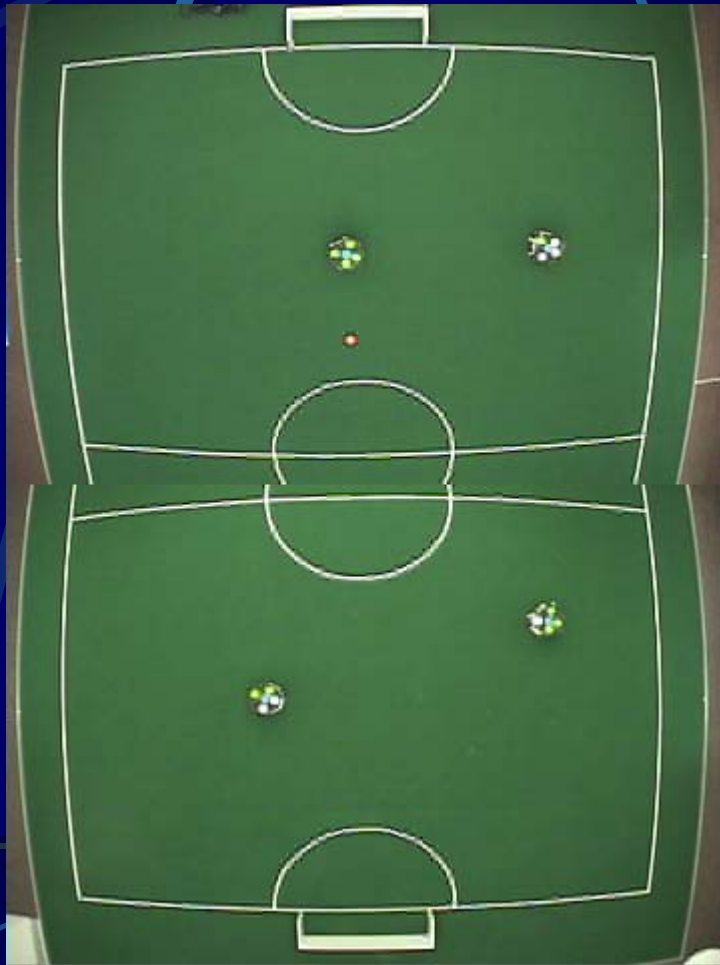
- YUV – luminosity (Y), chromaticity (UV)
- 5 colors: ball (orange) and markers/patches (yellow, blue, light green, white)



Segmentation

Small-size League

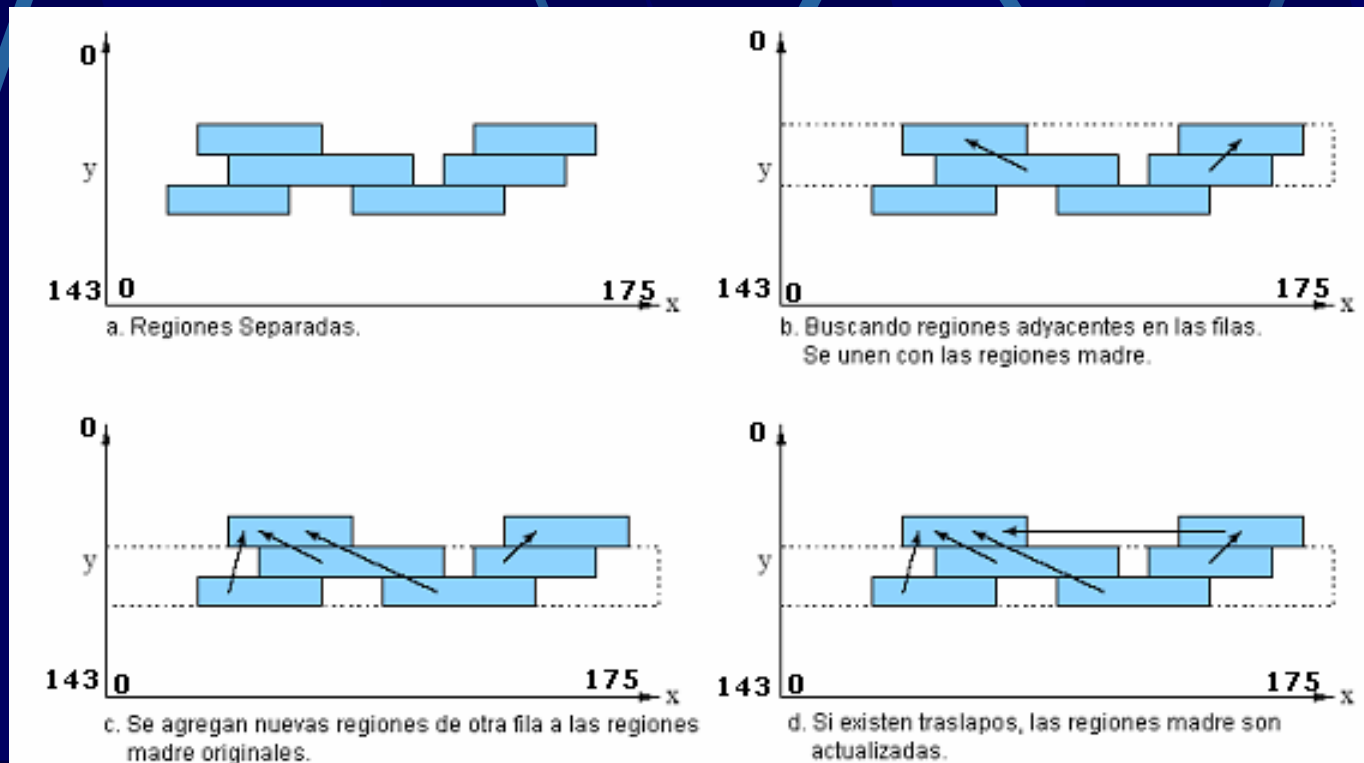
- Classify and filter 5 colors
 - orange, yellow, blue, light green, white



Segmentation

Blob Formation

- RLE - Run Length Encoding*
 - Color region compression algorithm
 - Pixel lines, y: 0-143, x: 0-175

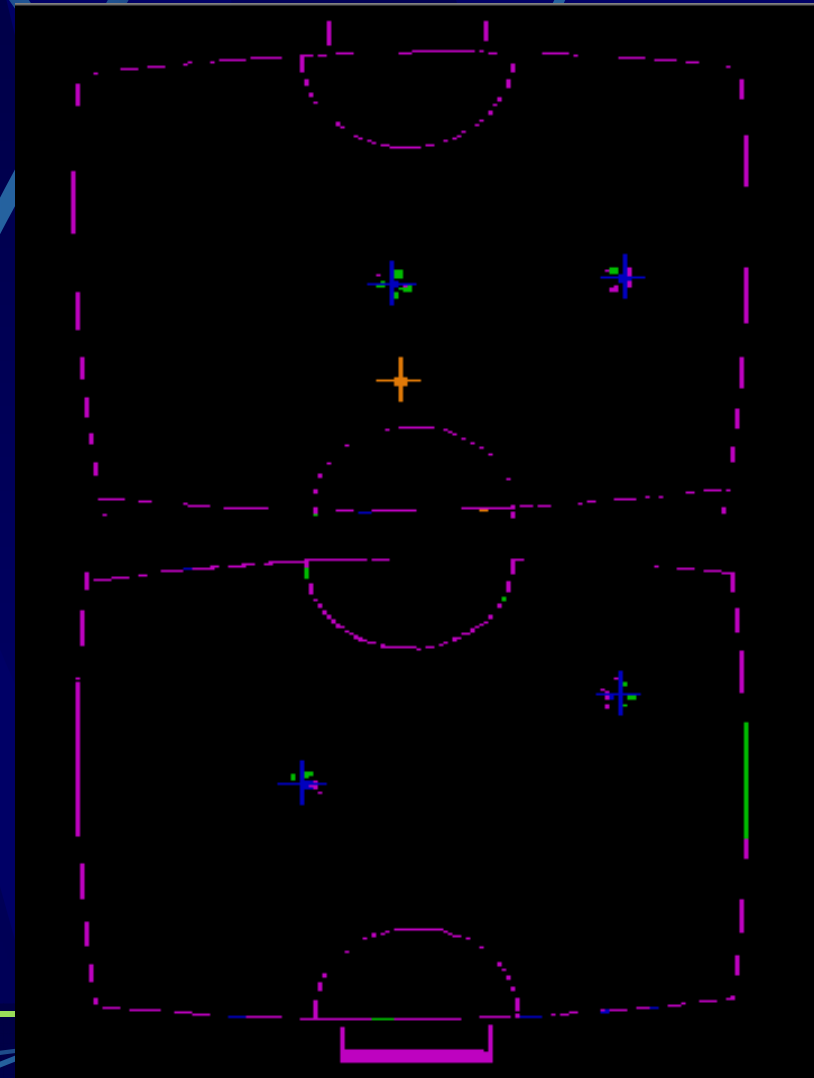
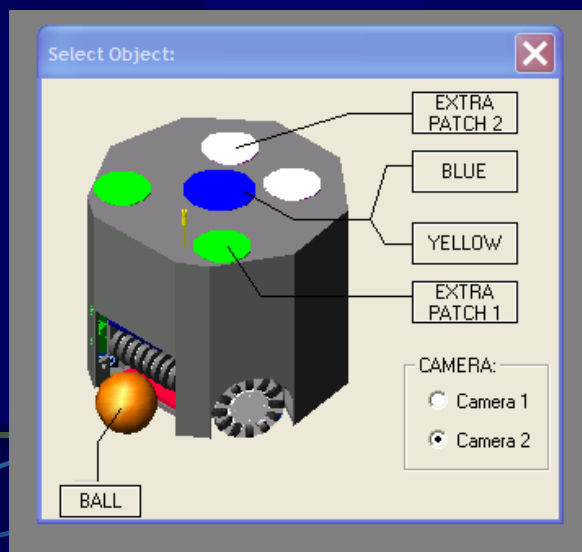


*<http://www.data-compression.info/Algorithms/RLE/>

Recognition

Small-size League

- Ball (orange)
- Robots
 - Own - Central markers (yellow/blue)
 - Adversary - Complementary central markers (blue/yellow)



Identification

Small-size League

Robots to Search:

EAGLE KNIGHTS:

- ROBOT 1
- ROBOT 2
- ROBOT 3
- ROBOT 4
- ROBOT 5

OPPONENT TEAM

- ROBOT 1
- ROBOT 2
- ROBOT 3
- ROBOT 4
- ROBOT 5

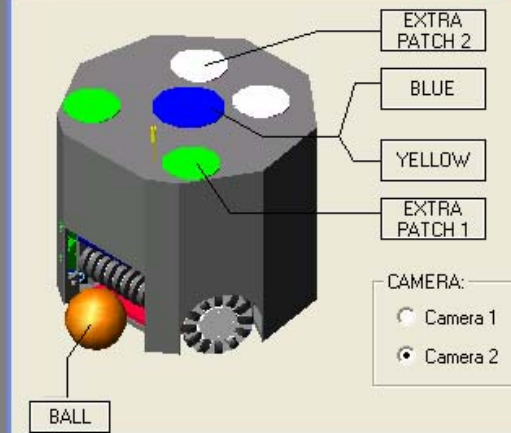
BALL:

- ON/OFF

CENTRAL PATCH:

- BLUE
- YELLOW

Select Object:

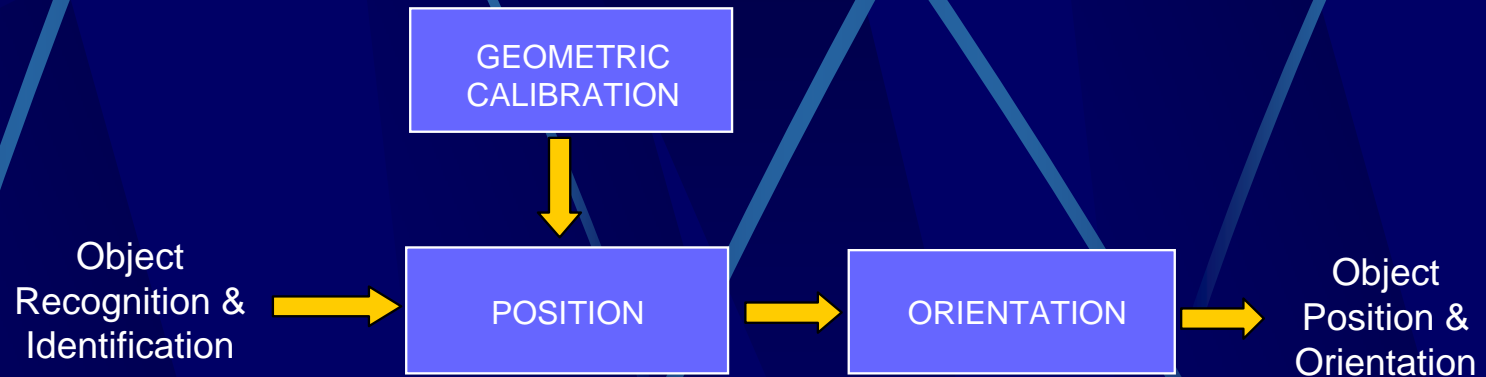


● Ball

● Robots

- Own - Surrounding markers (light green, white)

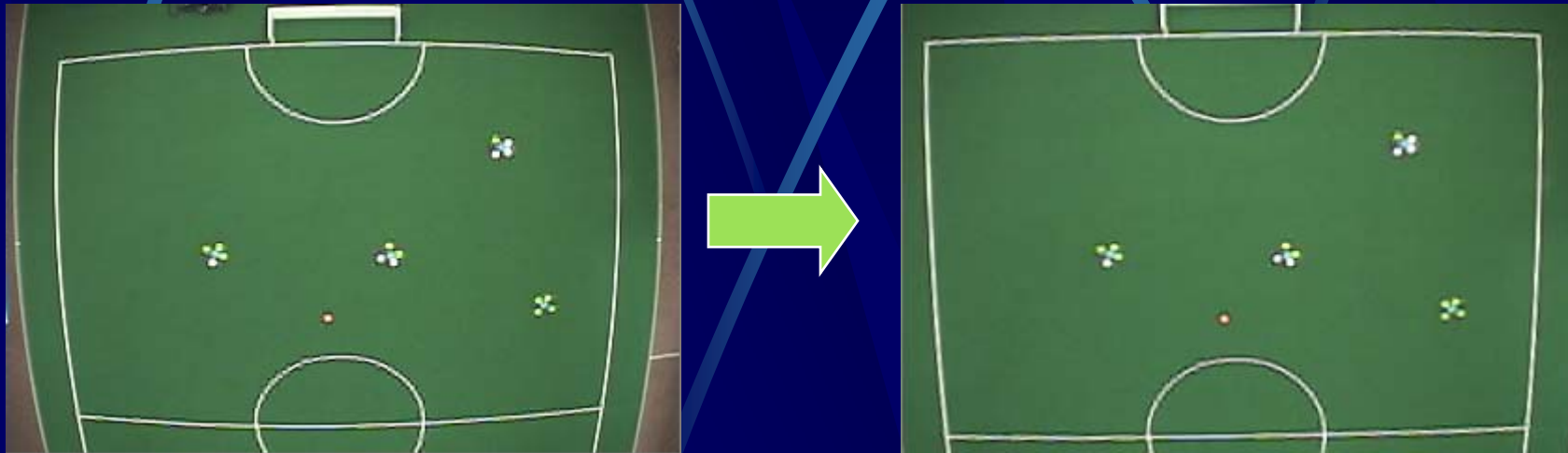
Localization



Localization Small-size League

Geometric Calibration

- Calculate Lens Distorsion
 - Tsai [1987] algorithm to eliminate camera lens distorsion.

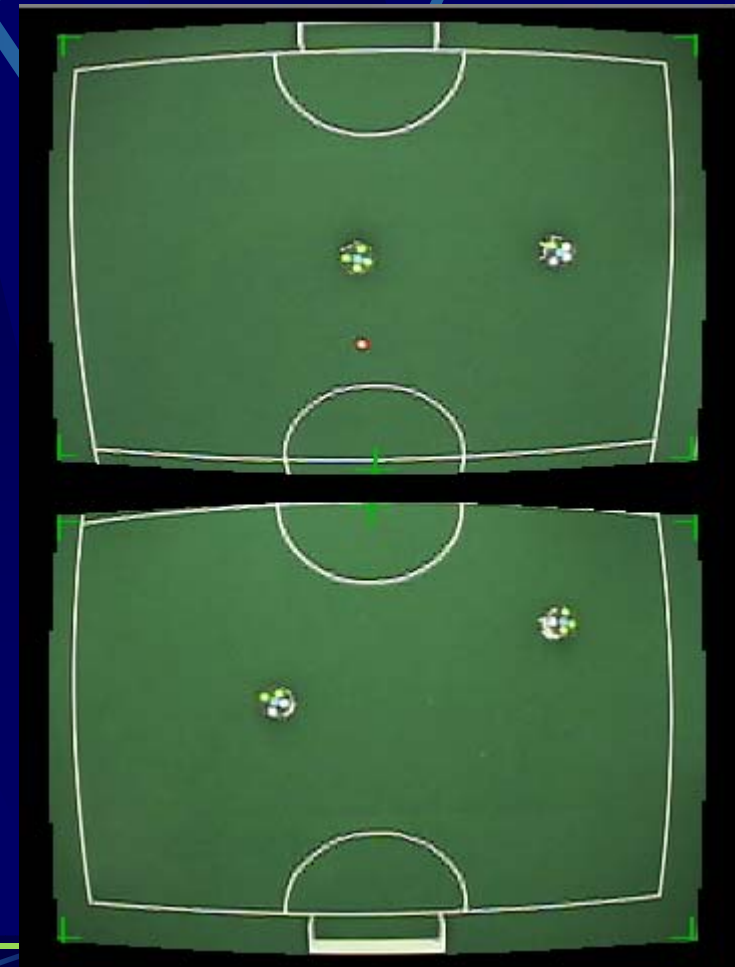
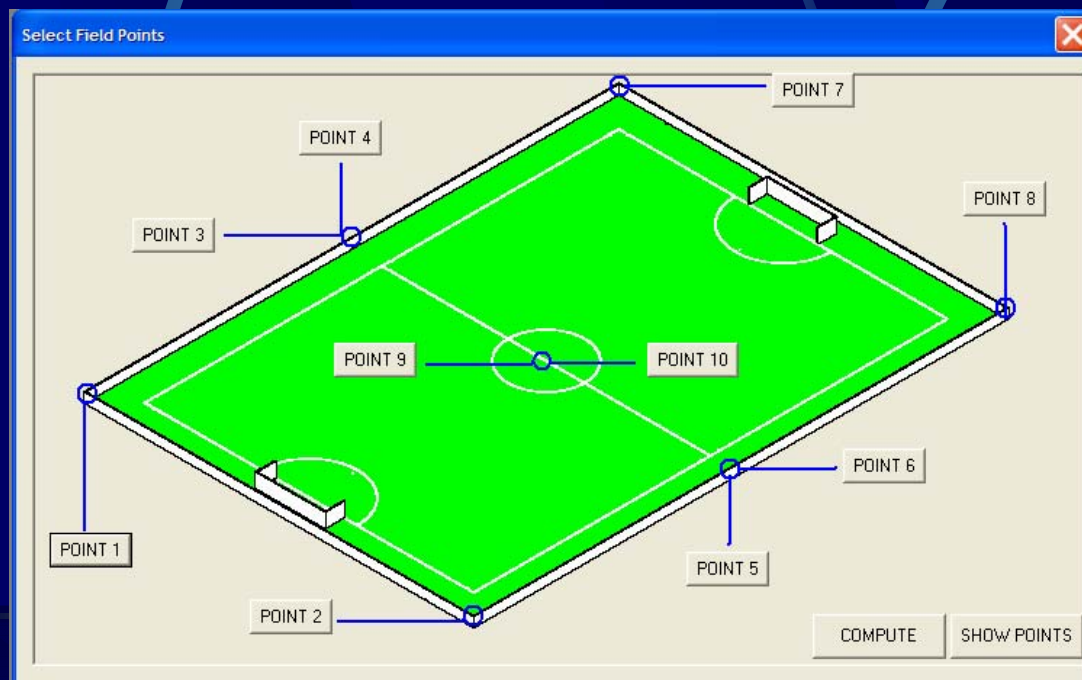


R. Y. Tsai, "A Versatile Camera Calibration Technique for High-Accuracy 3D Machine Vision Metrology Using Off-the-Shelf TV Cameras and Lenses," *IEEE Journal of Robotics and Automation*, vol. 3, pp. 323-344, 1987.

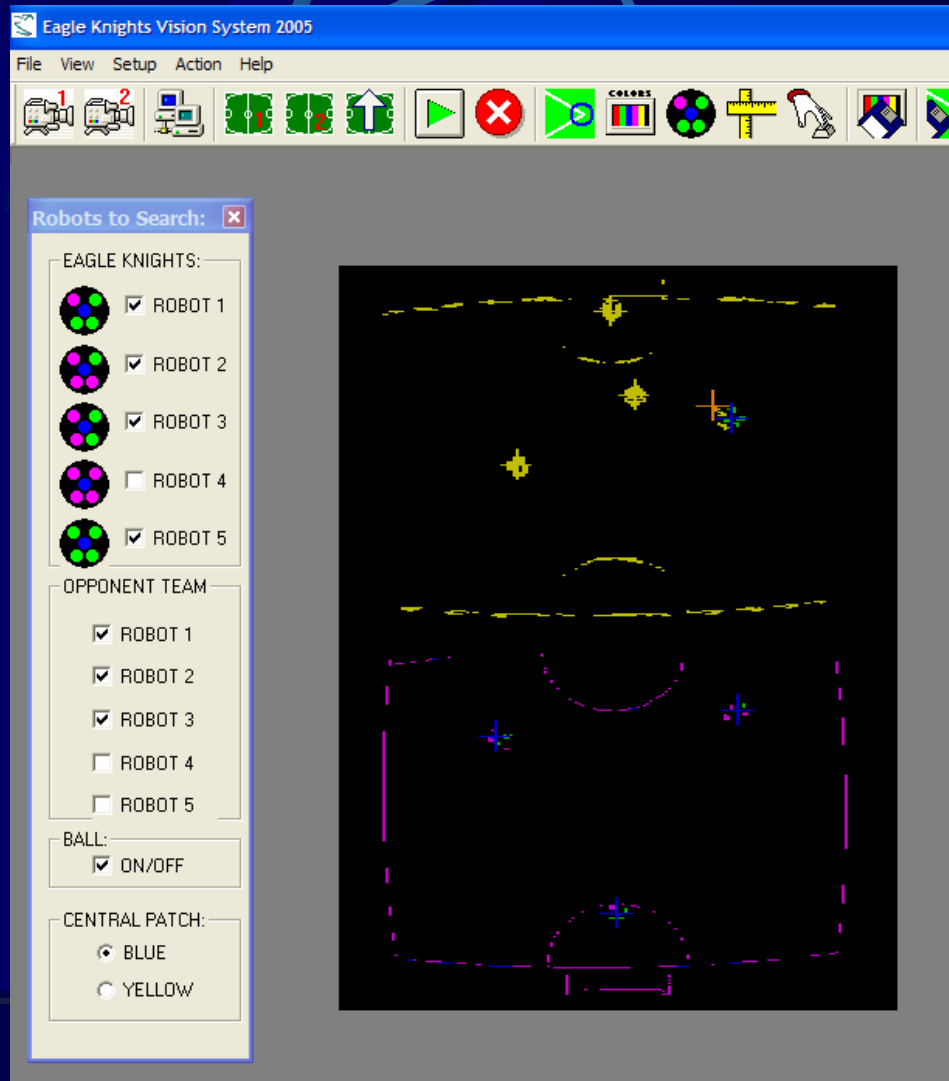
Localization Small-size League

Geometric Calibration

- Calculate Image Overlap
 - Field Corners (2 points)
 - MidField (overlapping 3 points)



Localization Small-size League



Position Calculation

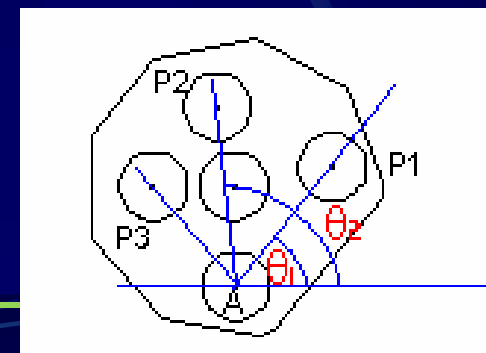
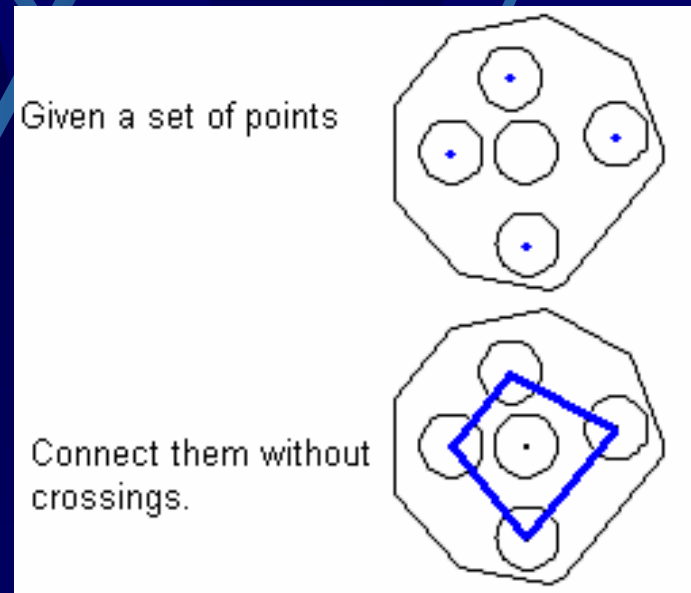
- Compute Object Centroids
- Apply Lens Correction to Centroids
- Transform to Field Coordinates

Localization

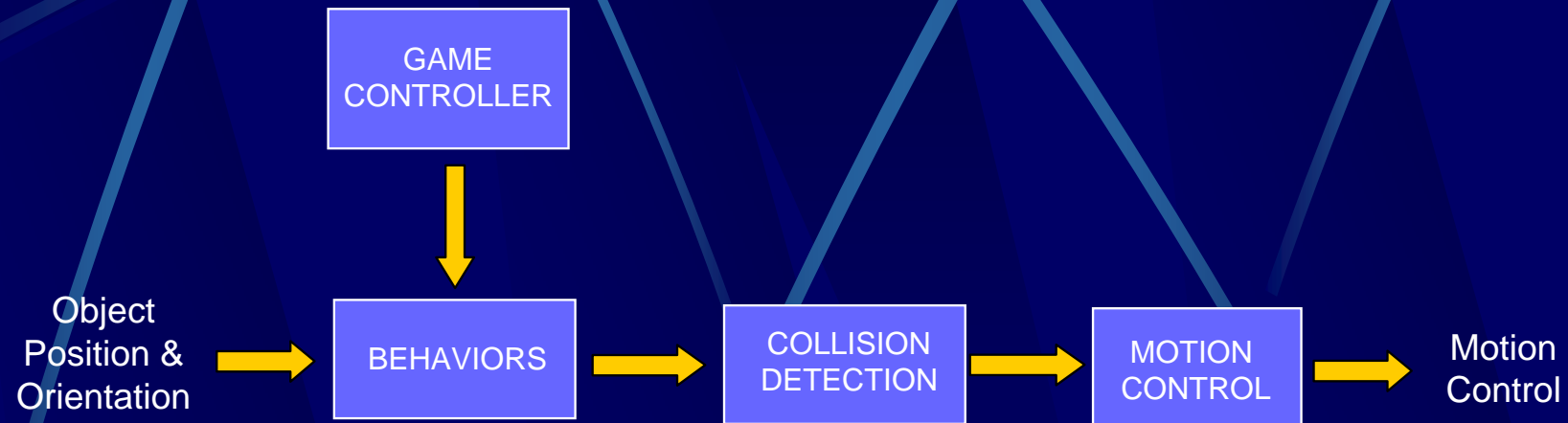
Small-size League

Orientation Calculation

- Compute robot surrounding markers centroids
- Compute robot surrounding markers relative position
- Compute robot surrounding markers orientation

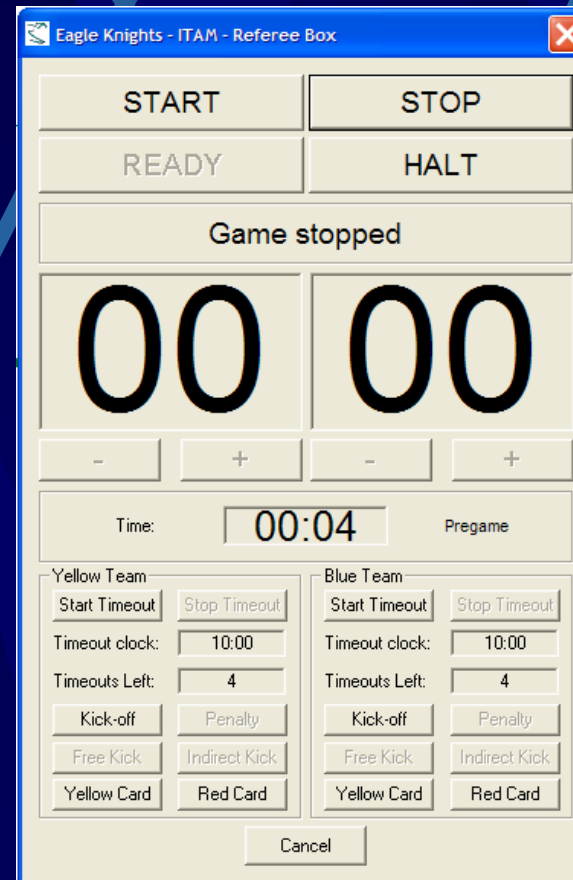


Artificial Intelligence



Game Controller Small-size League

- Computer controlled by human referee sending game states to teams.



Behaviors

Small-size League

Control Interface

Robot 1
ID: Goalkeeper ON Test
Status _____ Dr: 0 K: 0
M1: 5 M2: -7 M3: 2
X: 2803 Y: 1195 An: 69

Robot 2
ID: Defense ON Test
Status _____ Dr: 0 K: 0
M1: -3 M2: 1 M3: -16
X: 1870 Y: 1730 An: 189

Robot 3
ID: Defense ON Test
Status _____ Dr: 0 K: 0
M1: 8 M2: 25 M3: -15
X: 1982 Y: 681 An: 32

Robot 4
ID: Defense ON Test
Status _____ Dr: 0 K: 0
M1: 6 M2: 6 M3: 6
X: 0 Y: 0 An: 93

Robot 5
ID: Forward ON Test
Status _____ Dr: 0 K: 3
M1: -4 M2: 22 M3: -17
X: 627 Y: 1672 An: 137

Communications
Referee: ON OFF
Transceiver: ON OFF
Visión: ON OFF

Drive Control
Collision Detection: ON OFF
Paint Mask: ON OFF

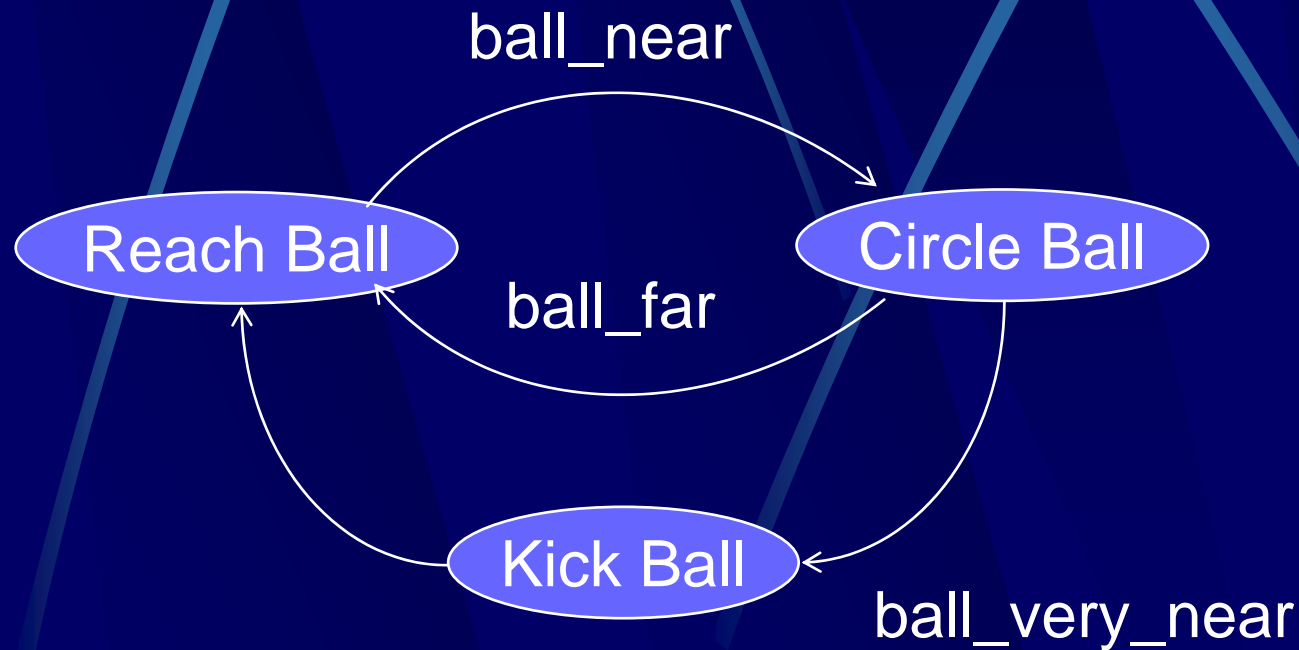
IA
Test Collision Detection
Amarillo Azul < > Stop Start

- Roles
 - Goalie
 - Defender
 - Attacker
- Kicking
- Direction
- Active Robots
- Strategy
 - Defensive
 - Offensive

Behaviors

Small-size League

Basic “Reach & Kick” Behavior



- Zone
 - Goalie
 - Defender
 - Attacker
- “Reach & Kick”
- Pass
- Receive
- Track
- Ball/Player
- Special Plays

Collision Detection Small-size League

Collision Avoidance

The screenshot displays the Eagle Knights software interface, which is used for controlling a robot in a soccer league. The central part of the interface is a green soccer field with a white center circle and two goal areas (yellow on the left, blue on the right). Several robots are positioned on the field, each represented by a colored circle with a smaller colored circle inside. One robot in the lower-left quadrant is circled in red, and red arrows point from it towards the center and right, indicating its movement or collision avoidance path. Another robot is circled in cyan in the lower-right quadrant.

The interface includes several control panels:

- Robot 1:** ID: Goalkeeper, Status: ON, Dr: 0, K: 0, M1: 5, M2: -7, M3: 2, X: 2803, Y: 1195, An: 69.
- Robot 2:** ID: Defense, Status: ON, Dr: 0, K: 0, M1: -3, M2: 1, M3: -16, X: 1870, Y: 1730, An: 189.
- Robot 3:** ID: Defense, Status: ON, Dr: 0, K: 0, M1: 8, M2: 25, M3: -15, X: 1982, Y: 681, An: 32.
- Robot 4:** ID: Defense, Status: OFF, Dr: 0, K: 0, M1: 6, M2: 6, M3: 6, X: 0, Y: 0, An: 93.
- Robot 5:** ID: Forward, Status: ON, Dr: 0, K: 3, M1: -4, M2: 22, M3: -17, X: 627, Y: 1672, An: 137.

At the bottom of the interface, there are three main control sections:

- Communications:** Referee: ON OFF, Transceiver: ON OFF, Vision: ON OFF.
- Drive Control:** Collision Detection: ON OFF, Paint Mask: ON OFF.
- IA:** Test Collision Detection (dropdown), Amarillo, Azul, <, >, Stop, Start.

The Eagle Knights logo is visible in the bottom-left corner.

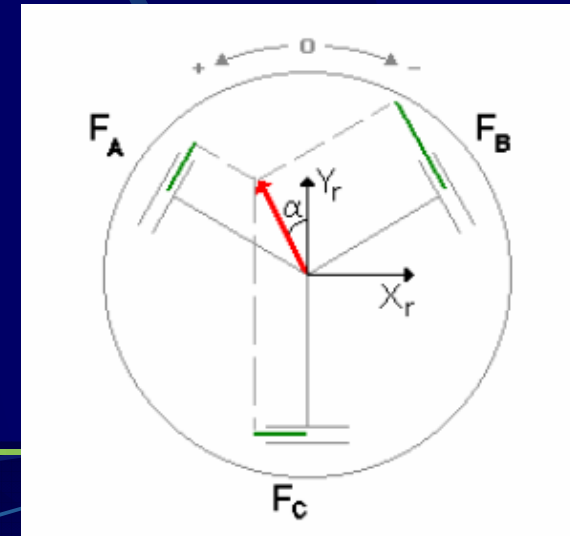
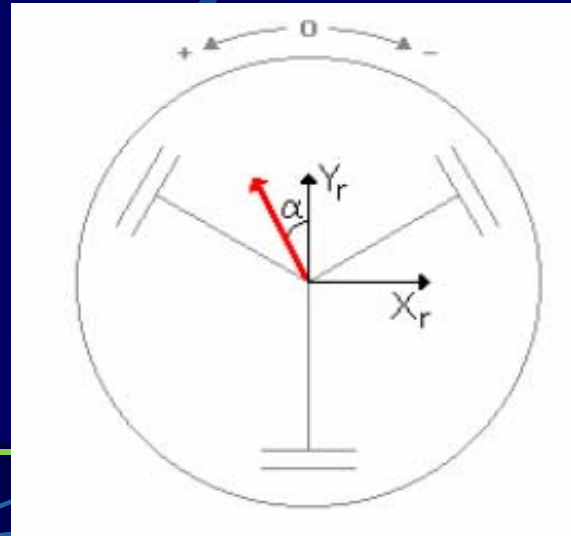
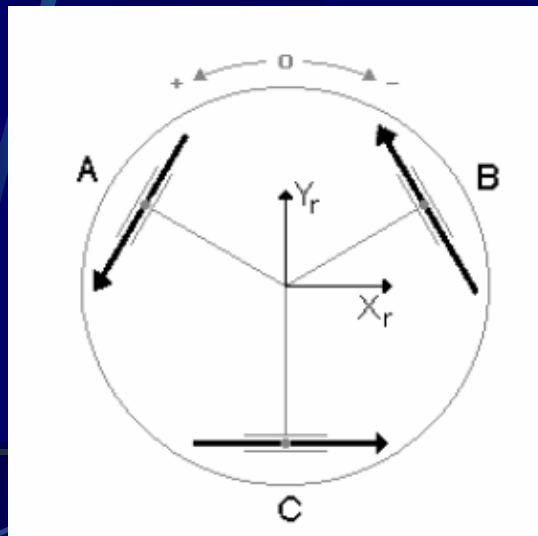
Wireless Communication Small-size League

- Communication
 - Motion Commands (wheels & dribbler)
 - Action Commands (kicker)
 - 20 byte messages (4 bytes per robot)
 - Transceiver (413/433 MHz or 869/914 MHz)
 - Single/Dual Direction

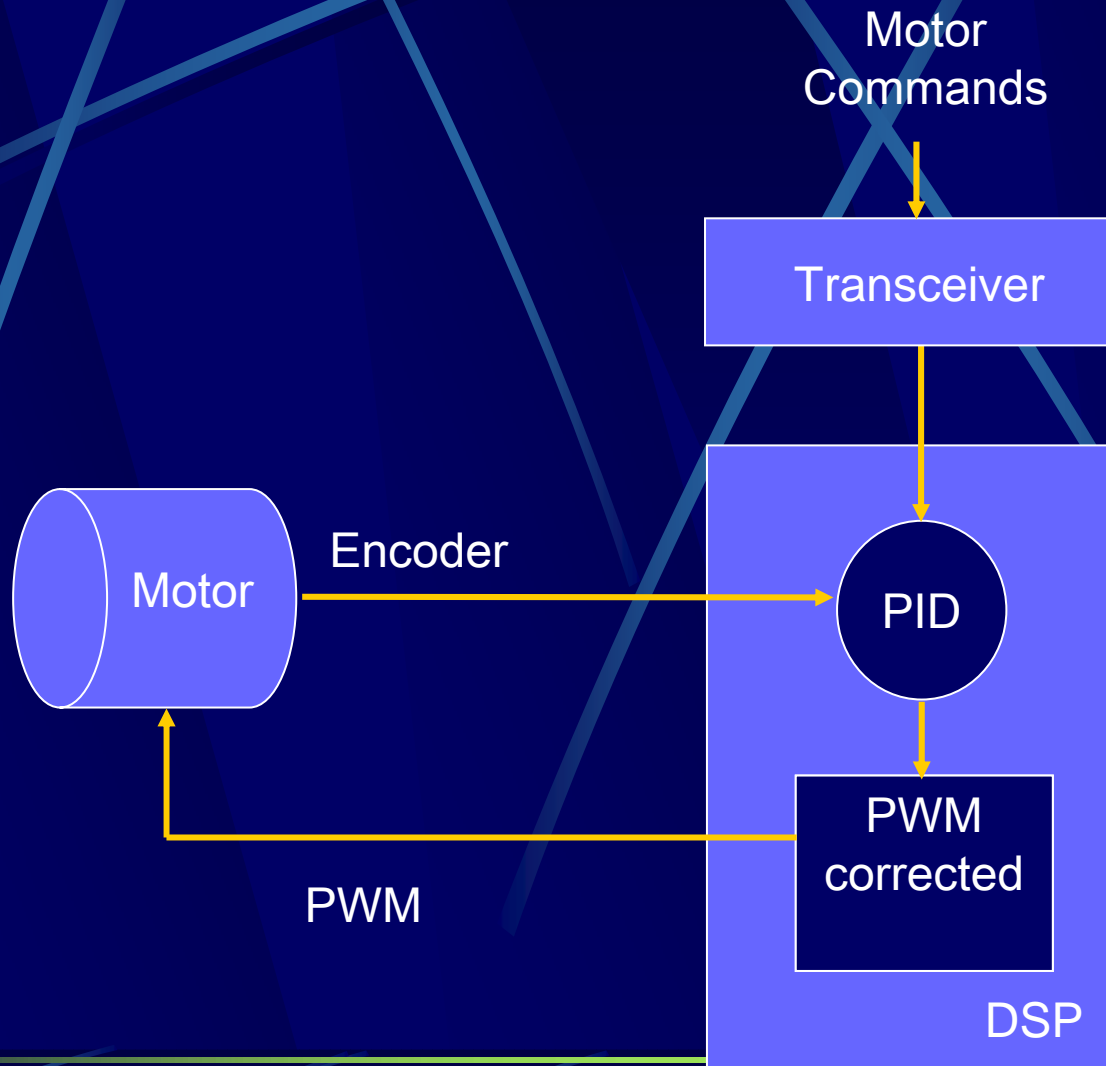


Motion Control Small-size League

- Differential (2003)
 - Orientation
 - Forward/Backward Motion
- Omnidirectional (Holonomic)
 - Integrated Vector Motion
 - 3 wheels (2004)
 - 4 wheels (2005)

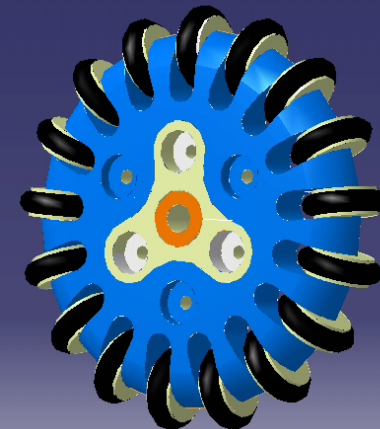
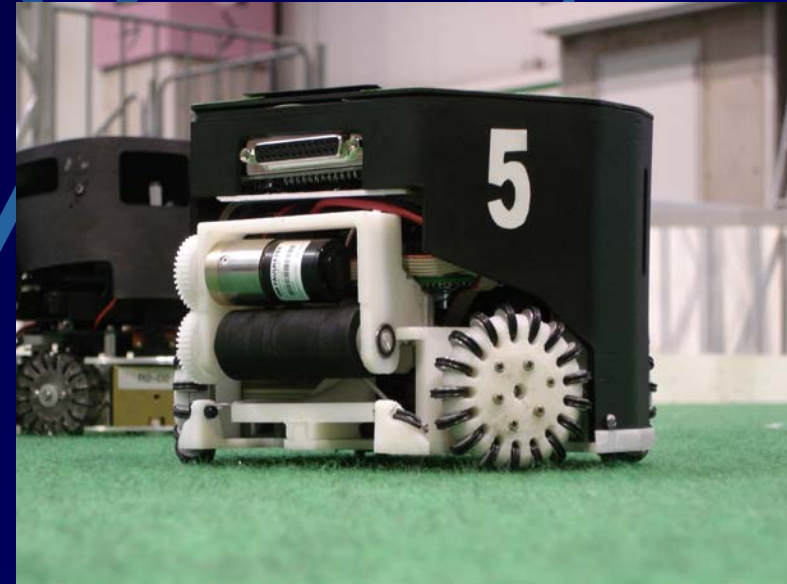
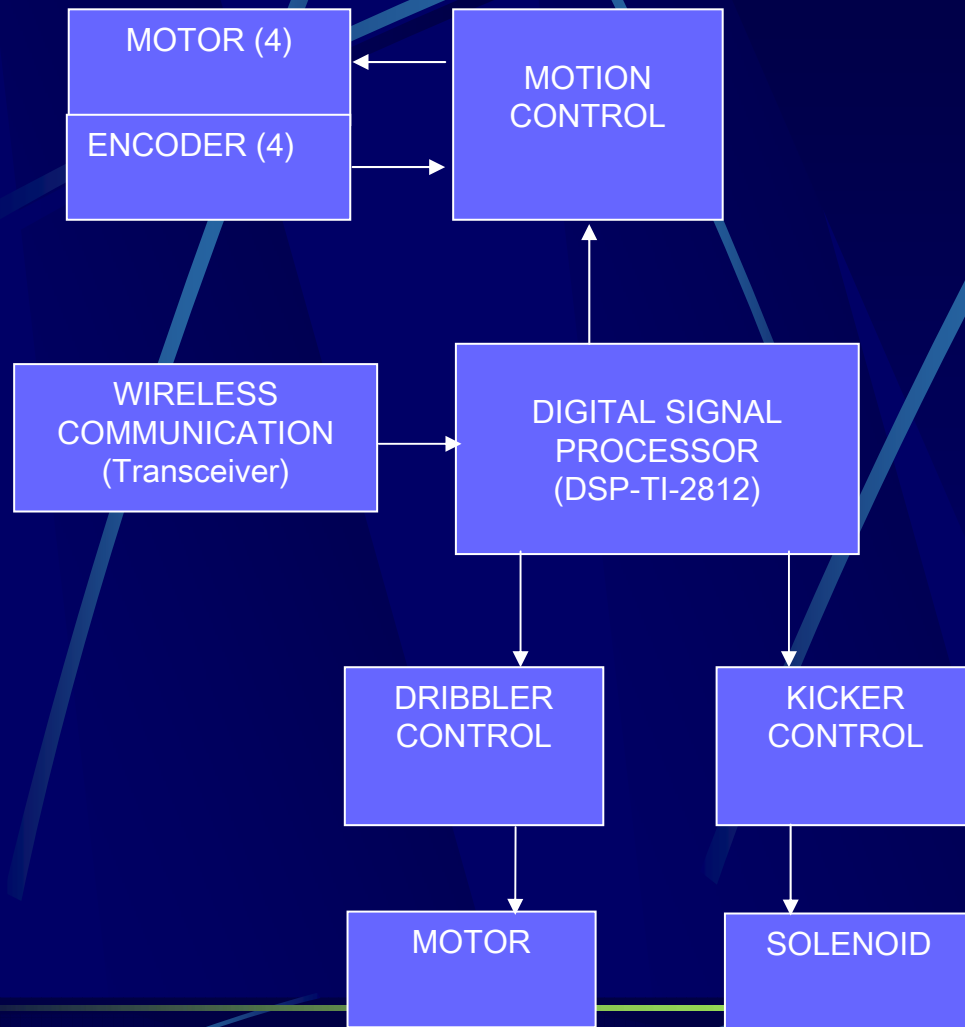


Motion Control Small-size League



Robot Design

Small-size League





RoboCup
2005
OSAKA

Eagle Knights SSL Results



ROBOCUP 2006
BREMEN·GERMANY



2005

2004

2003

- 10th World RoboCup, Bremen, Germany, June 2006 (1st round)
- 1st Latin American RoboCup Open, Sao Luis, Brasil, Sept 2005 (1st place)
- 9th World RoboCup, Osaka, Japan, July 2005 (1st round)
- 3rd Latin American Robotics Comp, Mexico City, Oct 2004 (1st place)
- 2nd US Open Robocup, New Orleans, May 2004 (2nd place)
- 1st US Open Robocup, Pittsburgh, May 2003 (3rd place)