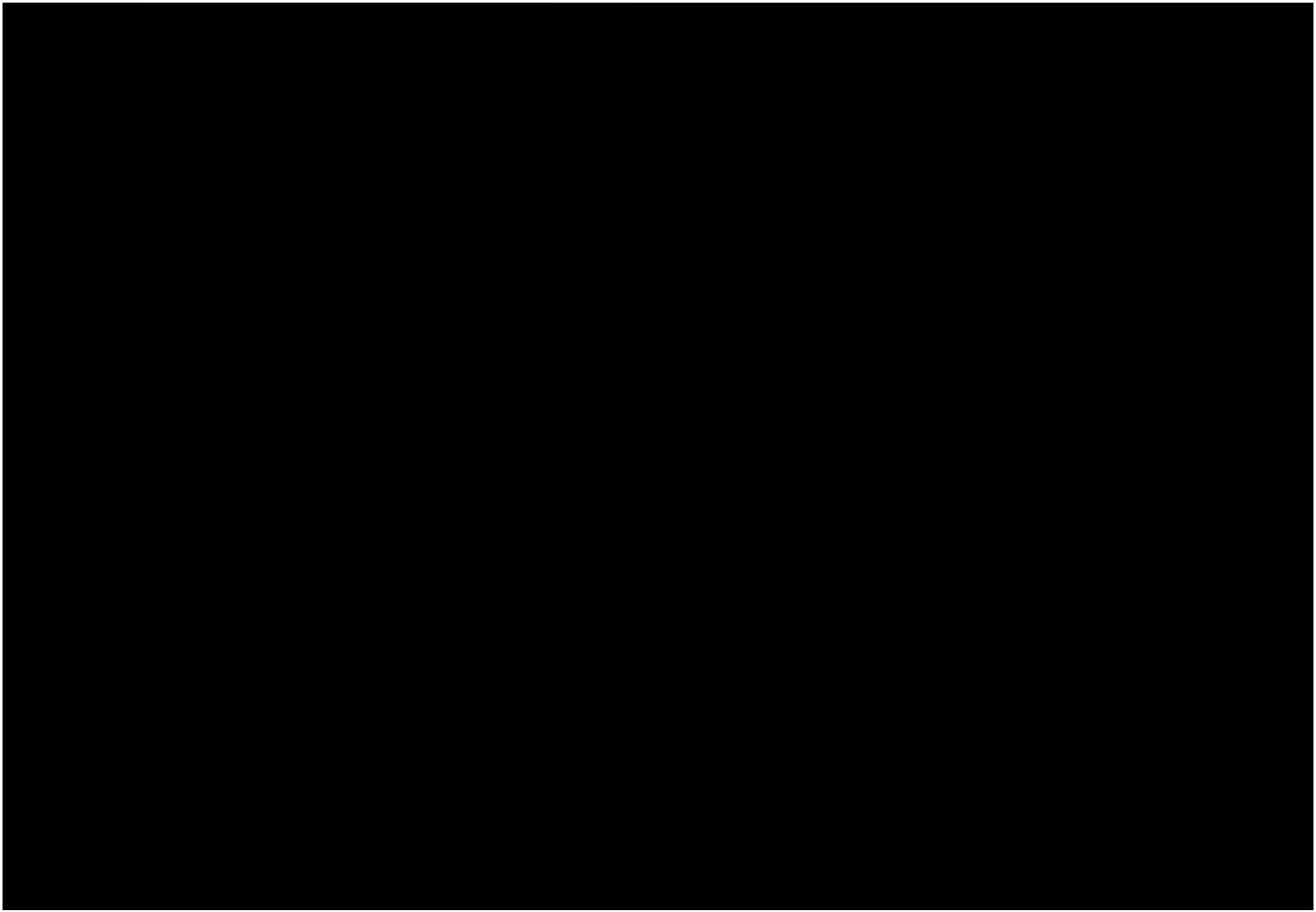

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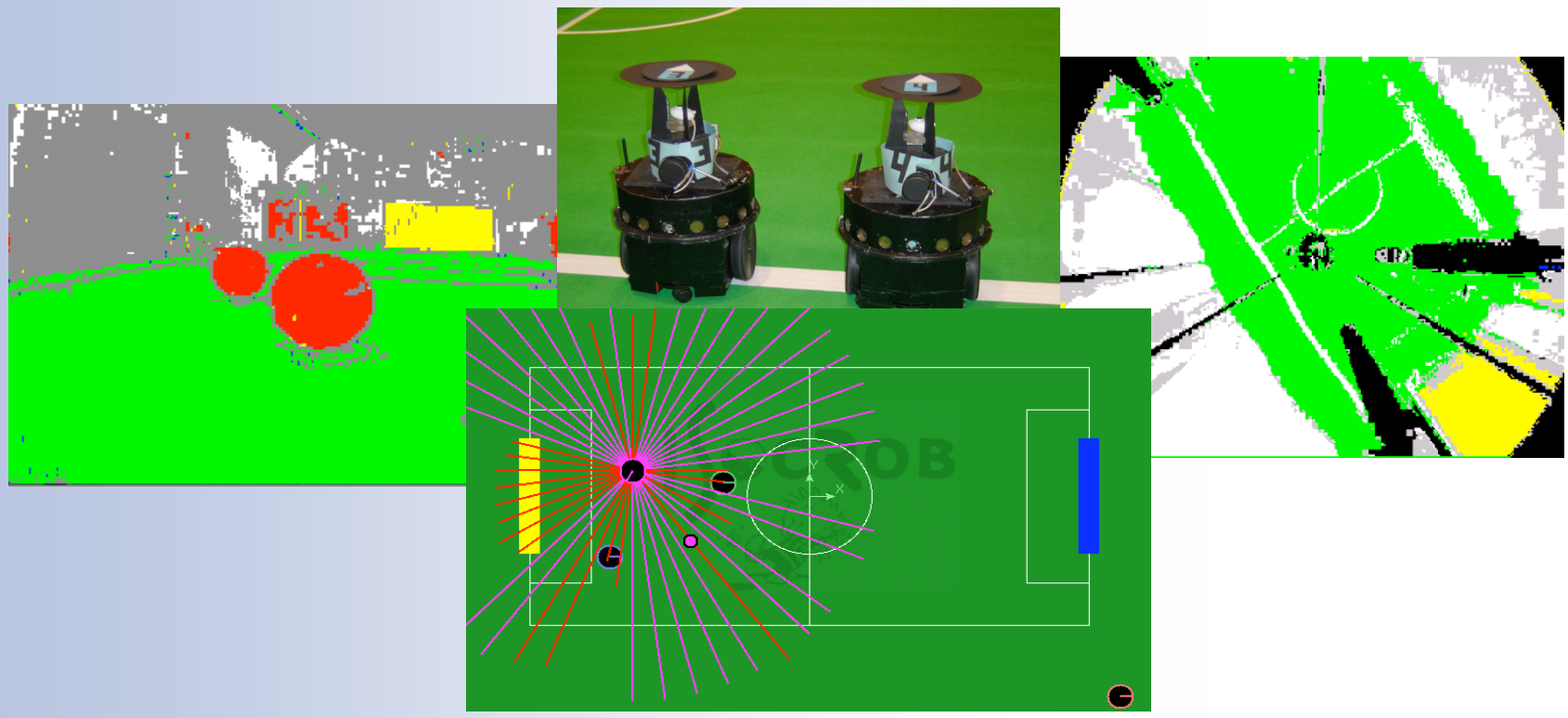
"Bayesian Sensor Fusion for Cooperative Object Localization and World Modeling"



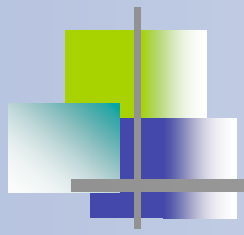
Prepared by: Pedro Pinheiro

Instituto de Sistemas e Robótica

12 de Novembro de 2004

Topics

- Motivation
- Sensor Fusion Methods
- World Model
- Experimental Setup
- Experimental Results
- Conclusions



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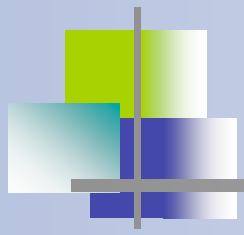
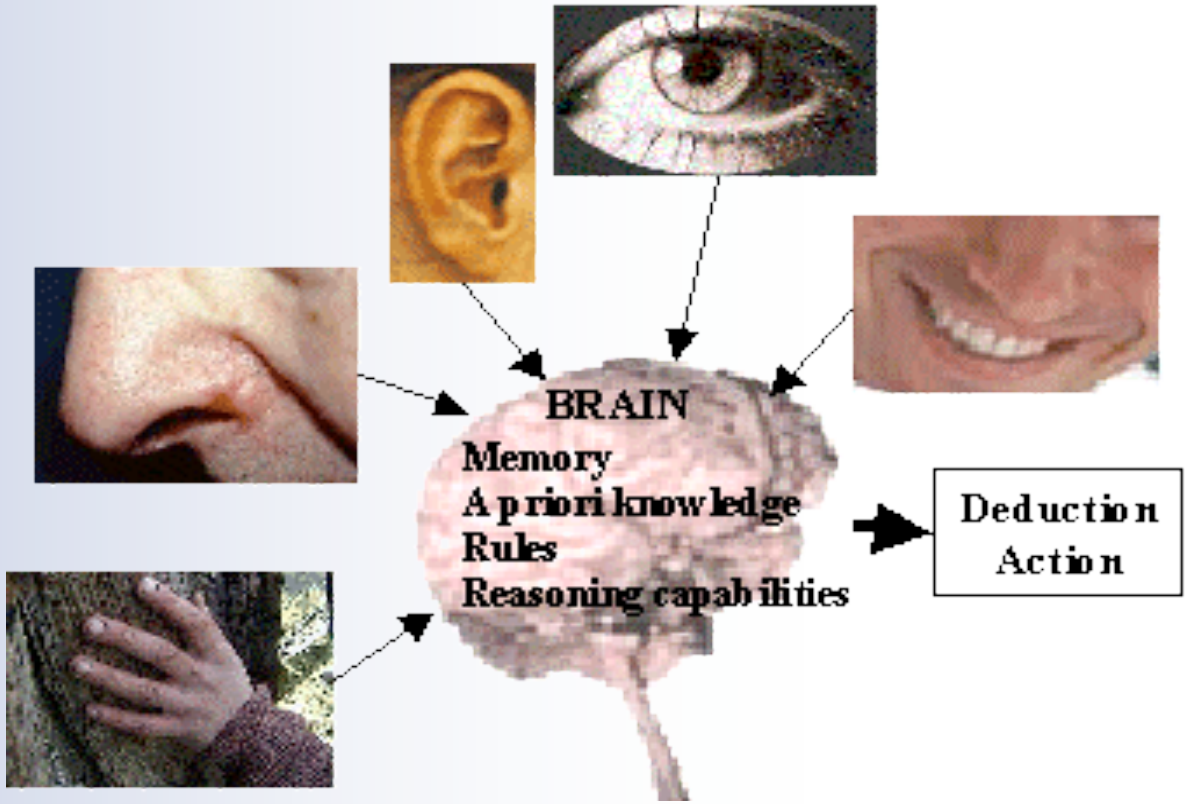


Motivation

- Limitation in environments reconstruction
- Observation errors
- Partial or incomplete information
- Cooperation between the several robots
- Robust and persistent description of the world
- Create more complex and rich behaviors
- Inspire in the biological systems

Motivation

- Memory
- Experience
- Priori Knowledge



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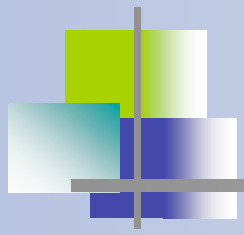
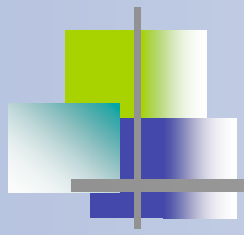


Sensor Fusion Methods

- The sensor fusion is the process of combining data and knowledge of different sources with the goal of maximizing the utility of the information
- The method used depends of the format of the data used by the sensors
- Levels of fusion
  - Pixel level
  - Feature Level
  - High level

Sensor Fusion Methods

Pre-processing	Data alignment	Post-processing
Rect. and elliptical gating	Euclidian, Minkowsky, Manhattan, Mahalanobis distance metrics	Classical Inference: Maximum a-posteriori, Neyman-Pearson, Minimax, Baye's cost
Linear and Non-linear PCA	Correlation metrics	Bayesian, Dempster-Shafer, Generalized Evidence
FFT, Cepstrum, Enveloping, Thresholding	Figure of Merit	Voting, Consensus, Scoring
Wavelets	Least square, Mean square error, Maximum likelihood	Fuzzy logic, Logical templates, Expert systems.
Image processing	Kalman filtering	
	Parametric templates, Clustering, Neural Networks, Voting, Entropy, Image Algebra	



"Bayesian Sensor Fusion for Cooperative Object Localization and World Modeling"

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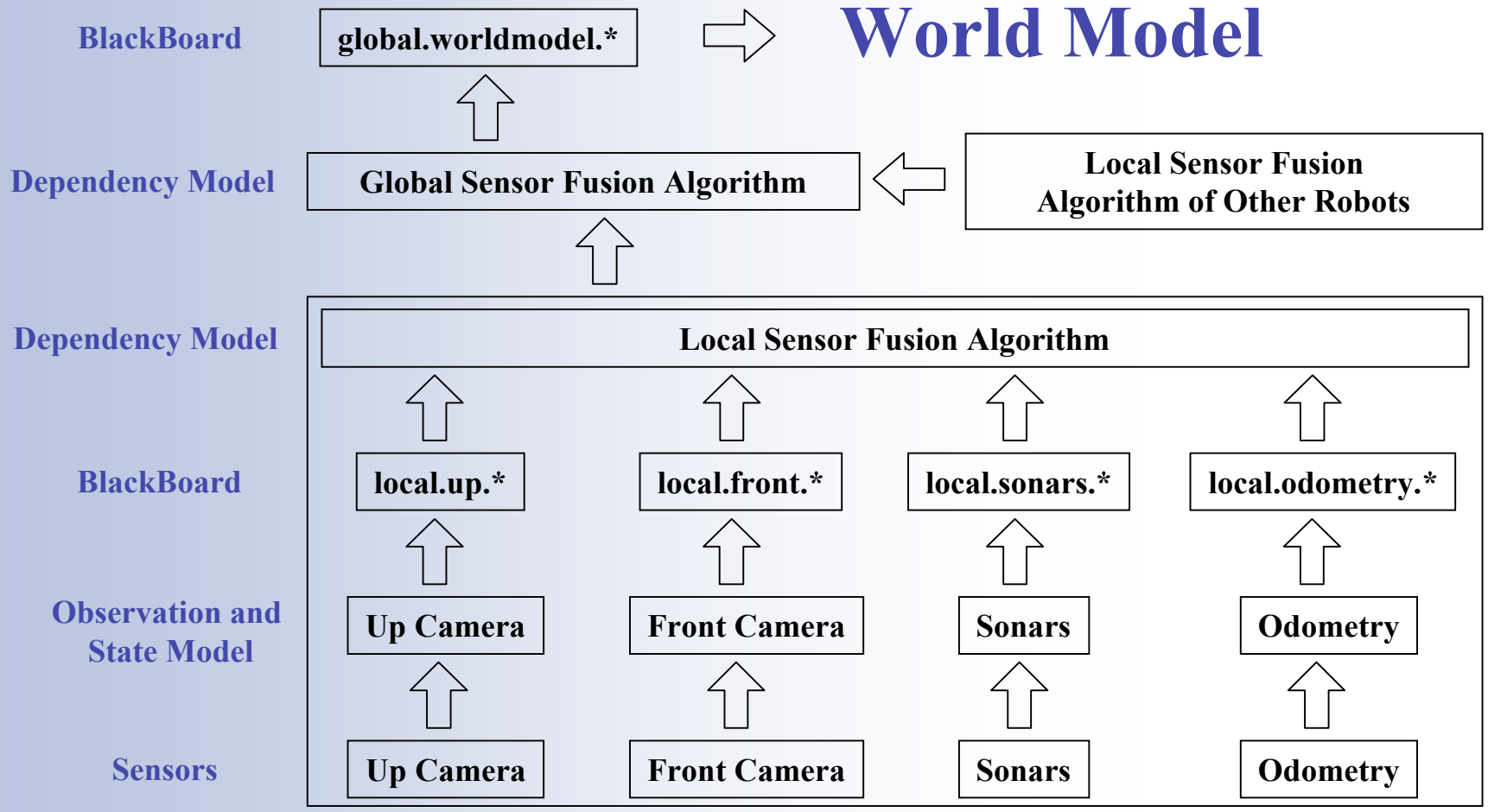
World Model

Sensor	Ball	Adversary Players	Friendly Players	Goals	Robot Posture
Catadioptric System	V	V	V	V	V
Front Camera	V	V	V	V	V
Sonars		V	V	V	V
Odometry					V

- Build the world model based on several different sources of information
- Detect the greatest number possible of features relevant of the environment

World Model


BlackBoard
global.worldmodel.*
World Model
Dependency Model
Global Sensor Fusion Algorithm
Local Sensor Fusion Algorithm of Other Robots
Dependency Model
Local Sensor Fusion Algorithm
BlackBoard
local.up.*
local.front.*
local.sonars.*
local.odometry.*
Observation and State Model
Up Camera
Front Camera
Sonars
Odometry
Sensors
Up Camera
Front Camera
Sonars
Odometry

Topics

- Motivation
- Sensor Fusion Methods
- World Model
- **Experimental Setup**
- Experimental Results
- Conclusions

Experimental Setup

- Nomadic Scout Platform
- Pentium III 1GHz
- 2 x Philips USB Webcams
- Polaroid Sonars
- Wireless communication 801.11.b a 11 Mbps
- Robots were positioned in several game configurations

Topics

- Motivation
- Sensor Fusion Methods
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- **Experimental Results**
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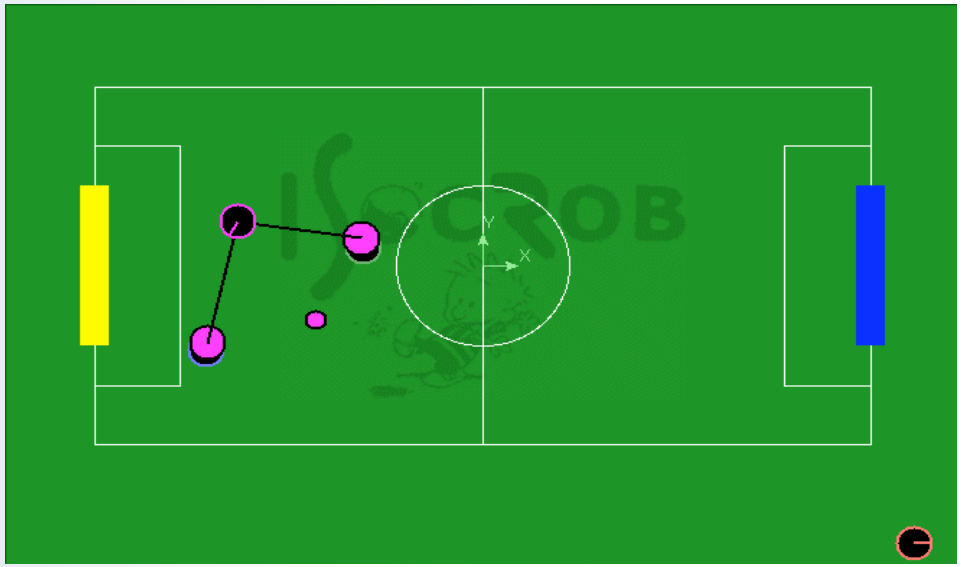
Experimental Results - Opponents

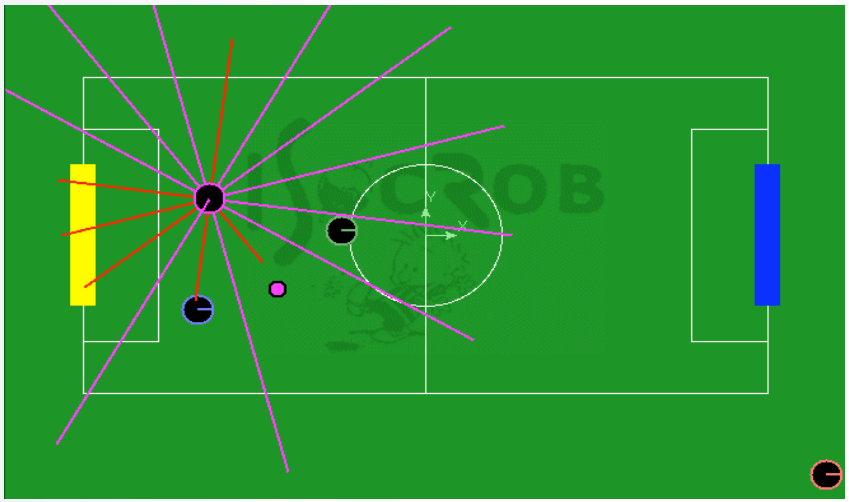
- Adversaries and teammates detection
- Posture information of each teammate is transmited to the team
- Try to fuse the local information with the one obtained form the team

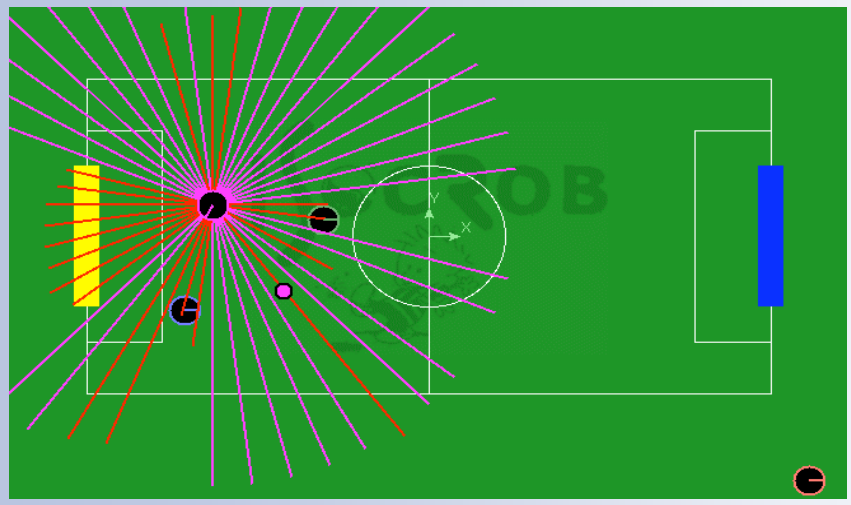


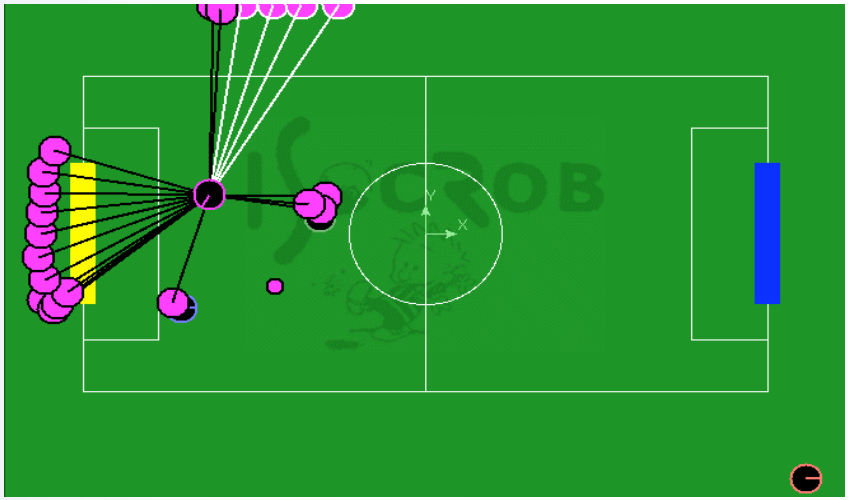
"Bayesian Sensor Fusion for Cooperative Object Localization and World Modeling"

Experimental Results - Sonars

- Real and Virtual Sonar fusioned
- Building the obstacles structure







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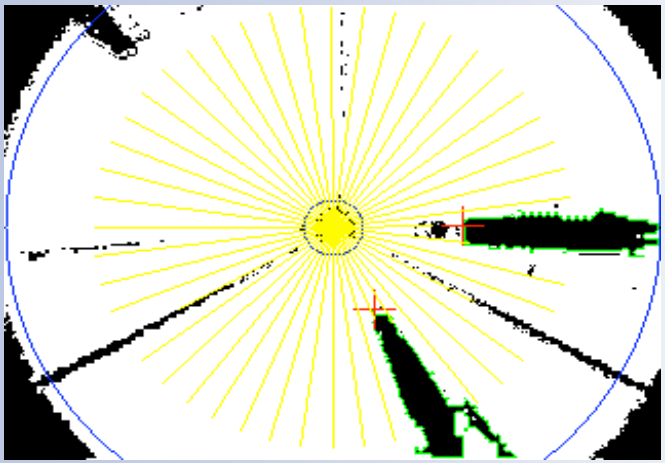
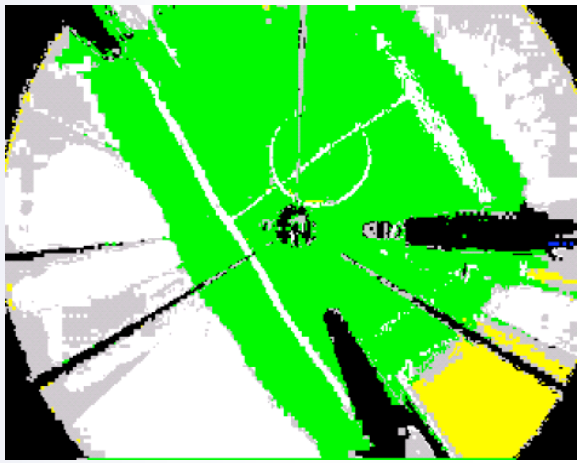
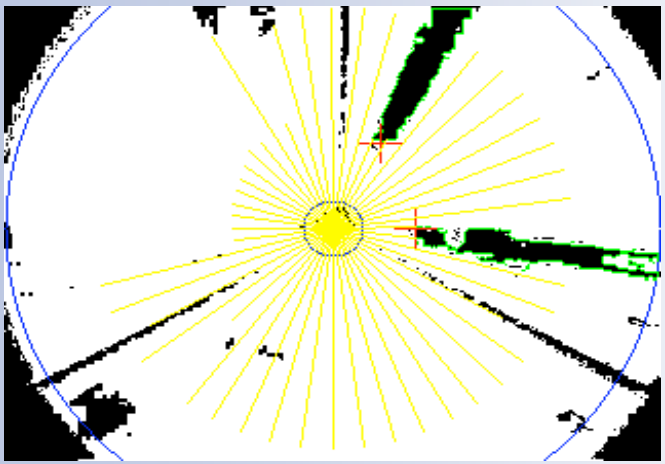
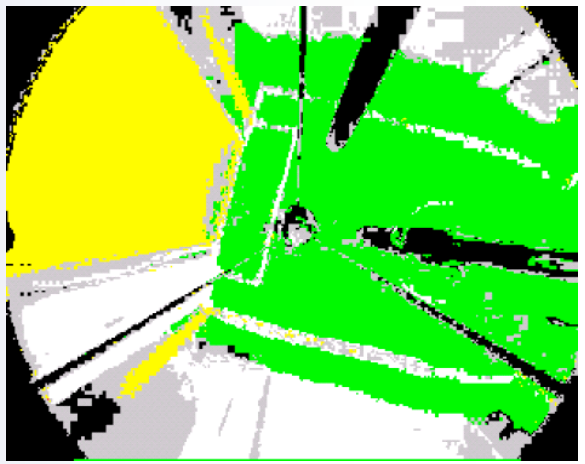
Experimental Results - Sonars









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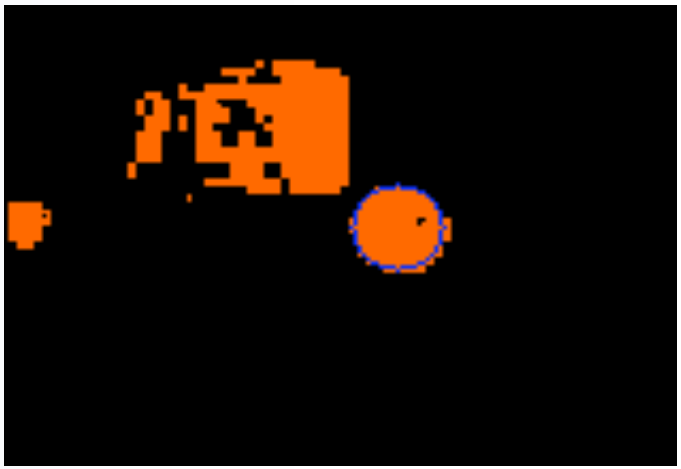
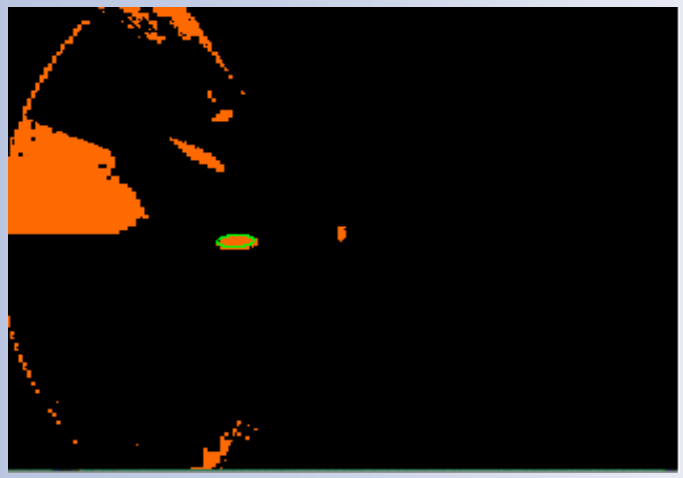
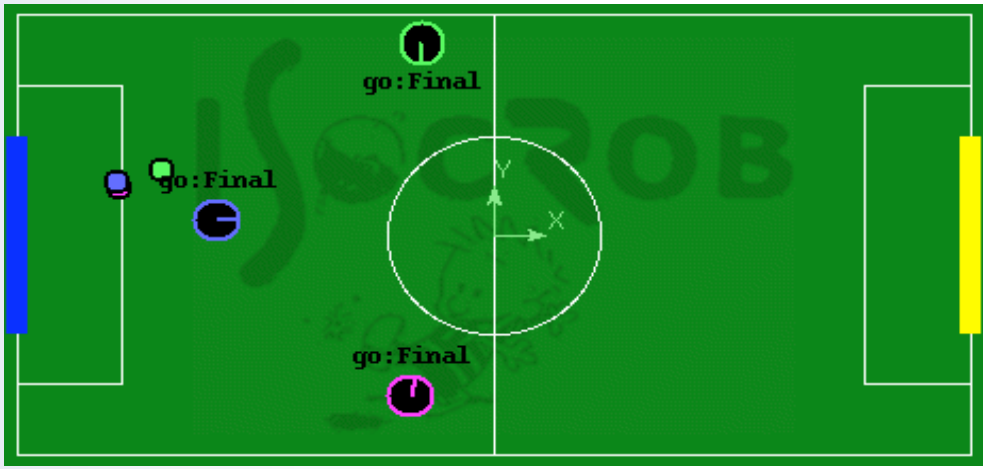
Experimental Results - Ball







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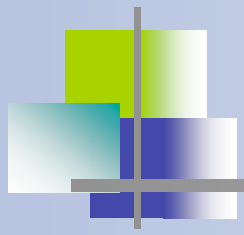

Conclusions

Advantages

- World described in probabilistic terms
- We have a world representation distributed by the team
- More robust to errors and bad observations
- Creation of a world vision from partial and incomplete views of the world
- Possibility of creating new team strategies and more complex behaviors

Conclusions

Disadvantages

- The communication of the world vision of each robot can become and overload to the communications and grows linear for each new member added to the team
- Elements that have a partial view of the a world feature and reach and agreement can make the team go after "*bogey man*"

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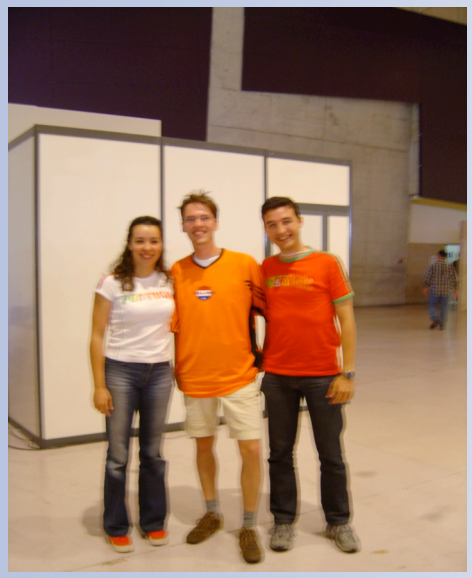
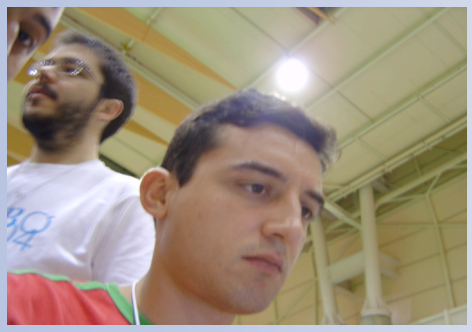
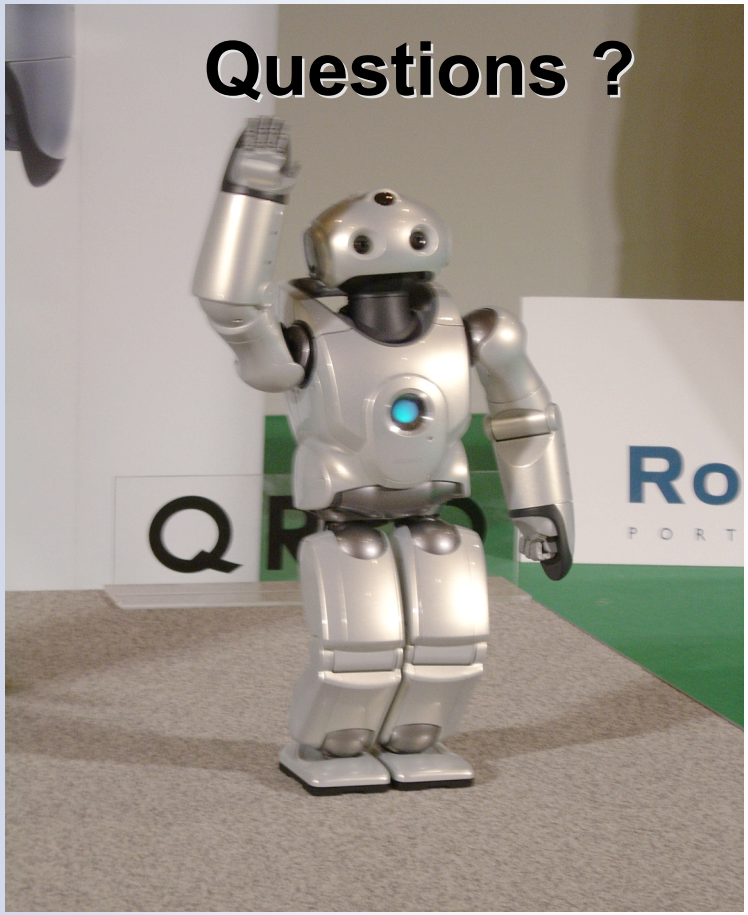
End







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