A Short History of the Virtual Robot Competition

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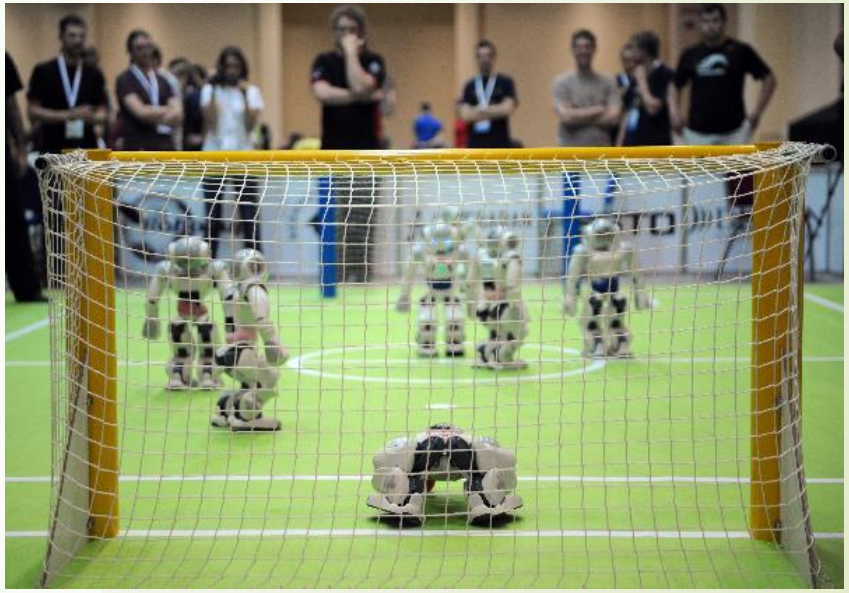
ROBOCUP

- RoboCup is an annual international robotics competition founded in 1997. The aim is to promote robotics and AI research, by offering a publicly appealing, but formidable challenge
- **Goal:**

"By 2050, a team of fully autonomous humanoid robot soccer players shall win a soccer game, complying with the official rules of FIFA, against the winner of the most recent World Cup."

RoboCup Events

1997 Nagoya
1998 Paris
1999 Stockholm
2000 Melbourne
2001 Seattle
2002 Fukuoka
2003 Padua
2004 Lisbon
2005 Osaka
2006 Bremen
2007 Atlanta
2008 Suzhou
2009 Graz
2010 Singapore
2011 Istanbul
2012 Mexico City
2013 Eindhoven
2014 João Pessoa
2015 Hefei
2016 Leipzig



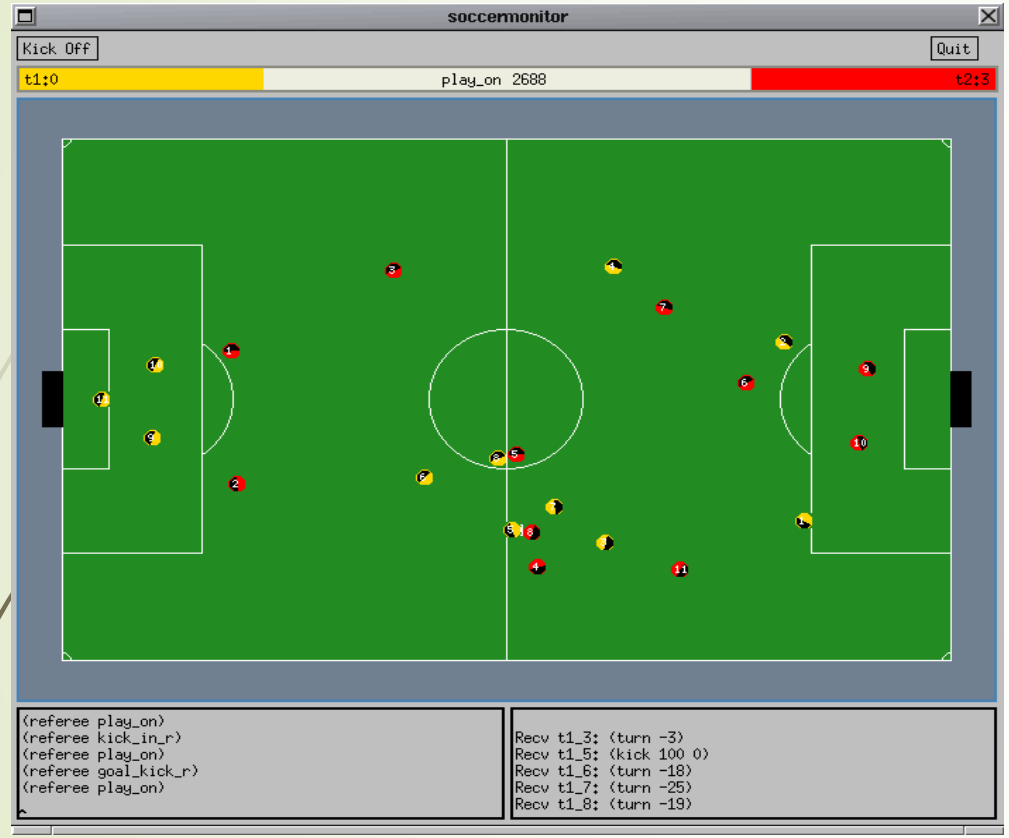
ROBOCUP LEAGUES

- **RoboCup Soccer**
  - Humanoid
  - Standard Platform
  - Small Size
  - Middle Size
  - Simulation
    - 2D Soccer Simulation
    - 3D Soccer Simulation
- **RoboCup Rescue**
  - Rescue Robot
  - Rescue Simulation
    - Rescue Agents
    - Virtual Robots
- **RoboCup@Home**: Focuses on using autonomous robots to human society
- **RoboCup@Work:** Focuses on using autonomous robots in work-related scenarios
- **RoboCup Logistics League:** Focuses on flexible solutions for industrial production using self-organizing robots.
- **Robocup Junior**

ROBOCUP JUNIOR

- Soccer
- Dance
- Rescue
- @ Home

SOCCER SIMULATION



2D

3D

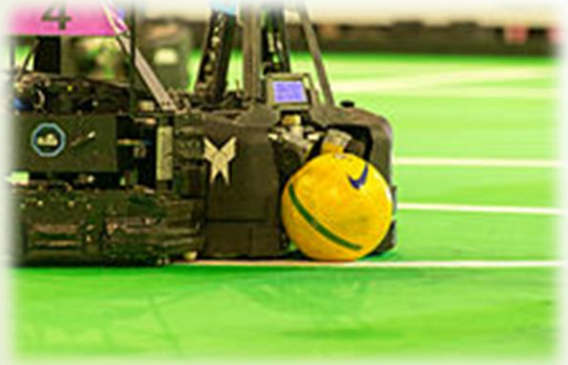
- ✓ A collective and dynamic game
- ✓ Individualistic task for each agent (self-localized, dribble,…)
- ✓ Cooperative tasks (passes, Complementary roles,…)

SMALL SIZE

- Small and very fast robots
- Global vision system
- Learning the opponent model
- Control in a highly dynamic environment with a hybrid centralized and distributed system
- Multi-agent cooperation

MIDDLE SIZE

- Information on the game acquired through on-board sensors
- Communication-based coordination
- Typically distributed decision making
- Cooperative localization
- Task assignment



HUMANOID

- The robots are divided into three size classes
  - KidSize (40-90cm height)
  - TeenSize (80-140cm height)
  - AdultSize (130-180cm height)
- Many research challenges have been addressed:
  - Dynamic walking, Running, and kicking the ball
  - Maintaining Robot balance
  - Visual perception of the ball, other players, and the field, self-localization

STANDARD PLATFORM (NAO)

- Standard Platform used NAO Humanoid by Aldebaran Robotics
- Focus on perception, decision, control algorithms

URBAN SEARCH & RESCUE (USAR)

- The goal of the urban search and rescue (USAR) robot competitions is to increase awareness of the challenges involved in search and rescue applications, provide objective evaluation of robotic implementations
- Robot requires capabilities in mobility, sensory perception, planning, mapping, and practical operator interfaces, while searching for victims in unstructured and unknown environments.

THE INITIAL APPLICATIONS OF RESCUE ROBOTS

- The trigger for the RoboCup Rescue initiative was the Hanshi-Awaji earthquake which hit Kobe City on the same year. (1995)

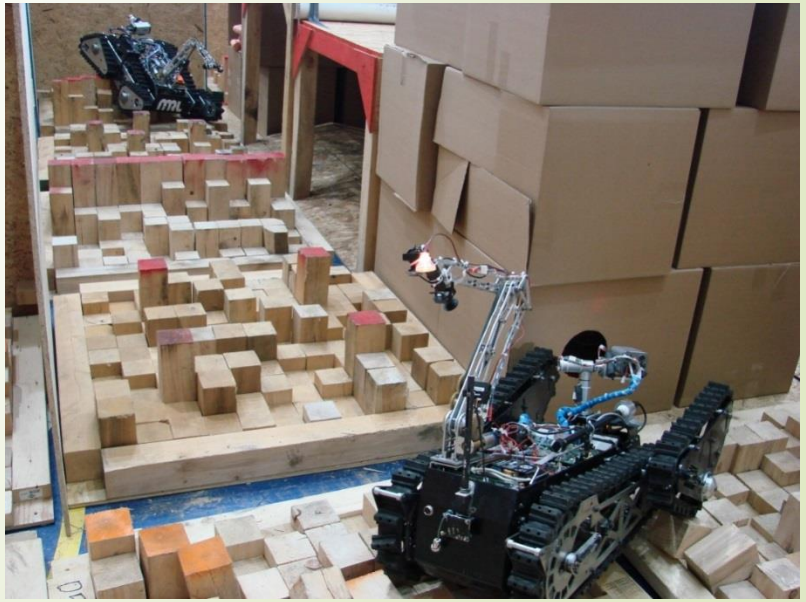
- Rescue robots were first used at the WTC 9/11 (2001). M. Micire analyzed the operations and identified seven research topics for the robotics community.

- After 2001, rescue robots were applied in several occasions:
  - Aerial robots were used after hurricane Katrina and Rita
  - Boat robots after hurricane Wilma
  - Snake robots after Bonn's city archive collapse
  - iRobot, BobCat and Talon at Fukushima Nuclear Power Plant

USAR Vision

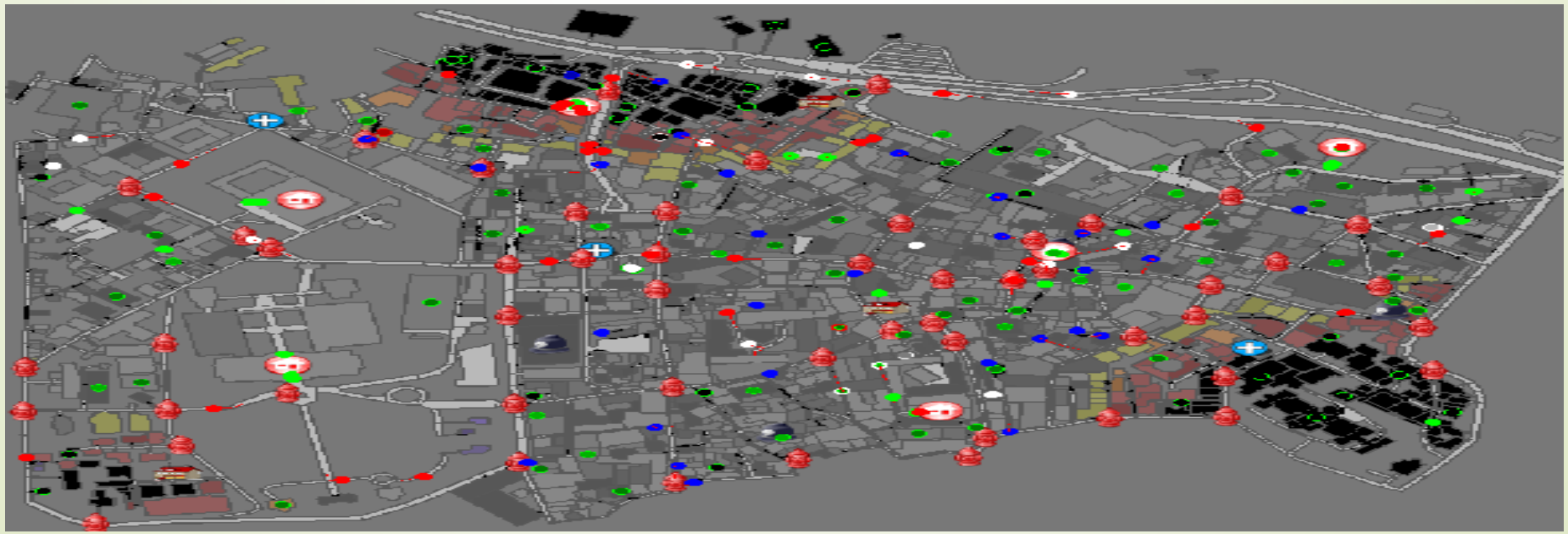
- When disaster happens, minimize risk to search and rescue personnel, while increasing victim survival rates, by fielding teams of collaborative robots which can:

- Autonomously negotiate compromised and collapsed structures
- Find victims and ascertain their conditions
- Produce maps
- Deliver sustenance and communications
- Identify hazards
- Emplace sensors
- Provide structural shoring



RESCUE SIMULATION

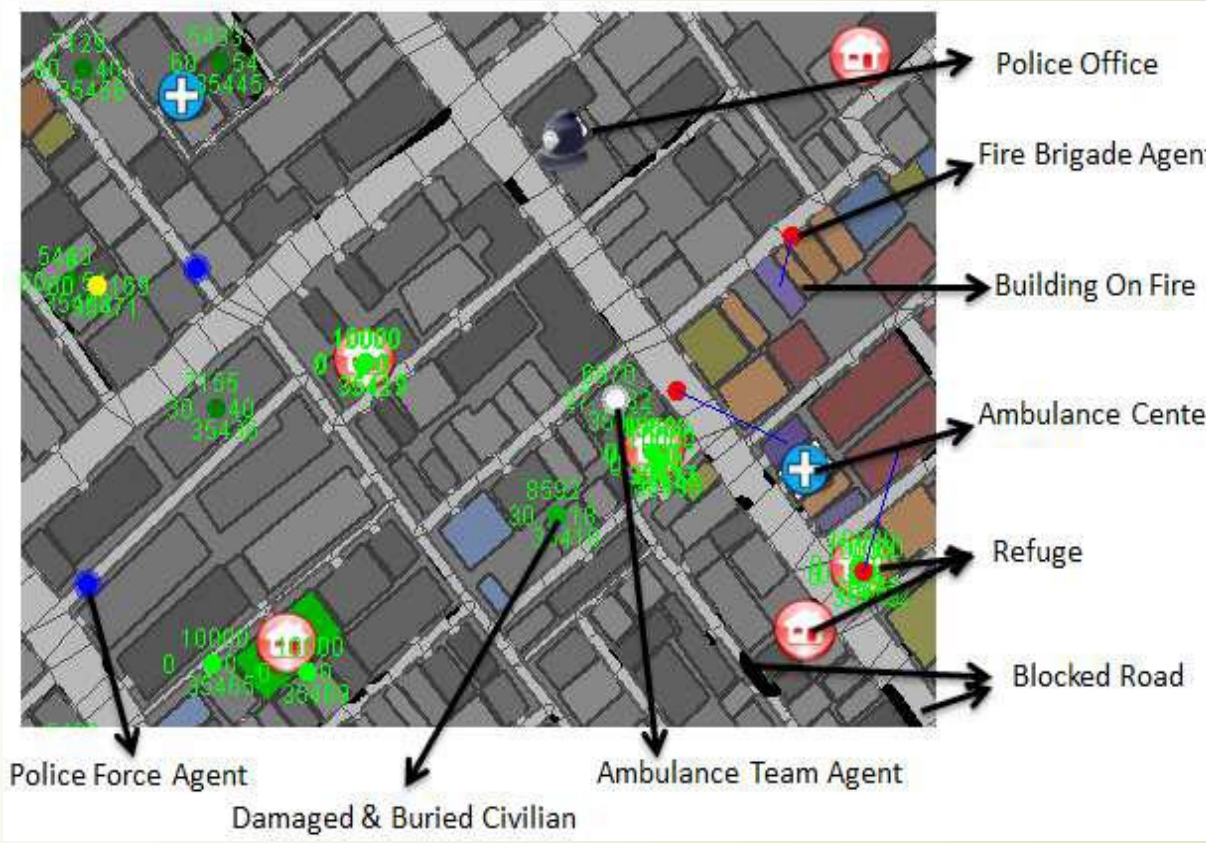
- Its aim is to manage the disaster when an earthquake happens in city.
- RoboCup Rescue uses real simulated city maps in order to make the process of disaster management more practical in future.
- The main purpose is to provide emergency decision support by integration of disaster information, prediction and planning.



RESCUE SIMULATION (CONT.)

- Design and development of intelligent agents including Fire Brigades, Ambulance Teams and Police Forces.

- **Research Areas**
  - Large Multi-Agent Systems
  - Decision Making Algorithms
  - Task Allocation Methods
  - Multi-Agent Coordination
  - Behavior Modeling



VIRTUAL ROBOTS

- The goal of the competition is to foster research in cooperative autonomous multi-robot systems engaged in USAR vision in simulation environment.

About the Virtual Robot Competition

- The Virtual Robot Competition was held for the first time in 2006
- Users can simulate multiple agents, whose capabilities closely mirror those of real robots
- Essential research topics include, but are not limited to:
  - human-robot interfaces
  - Autonomous navigation
  - Sensor fusion
  - Localization and map building
  - Distributed planning and learning
  - Multi agent cooperation

SEARCH SCENARIO AND SIMULATED ENVIRONMENT

- The simulated environment models both indoor (building, factory) and outdoor environment(street) that have partially collapsed due to earthquake
- The indoor map includes a maze of walls, doors, different floors, overturned furniture, and problematic rubble which provide various tests for robot navigation, communication and mapping capabilities.
- Realistic environment (physic engine)
- The victims are distributed throughout the environment
- The mission for the robots and its operators is to find victims, determine their location in its global map while each robot stay near a victim for further assistance

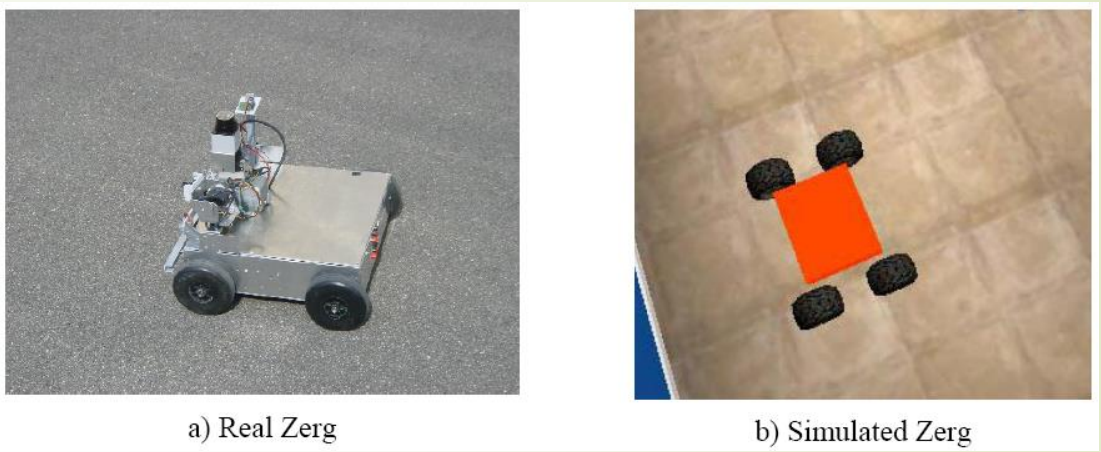
VIRTUAL ROBOT SERVER

- The Virtual Robot competition is based on the simulation environment USARSim. USARSim is a physical realistic environment based on Unreal Tournament.
- Until 2009, USARSim was based on UT2004.
- From 2009 until 2011 USARSim was based on UT3.
- From 2011 until 2014 ,USARSim was based on UDK
- Currently USARSim is based on Gazebo/ROS.

USARSim

ROBOT AND SENSOR

- ✓ P3AT (Odometry, INS, Camera, Battery, Sonar, Laser range finder)
- ✓ AirRobot (Camera, Battery)
- ✓ Kenaf (Odometry, INS, Camera, Battery, Sonar, Laser range finder)

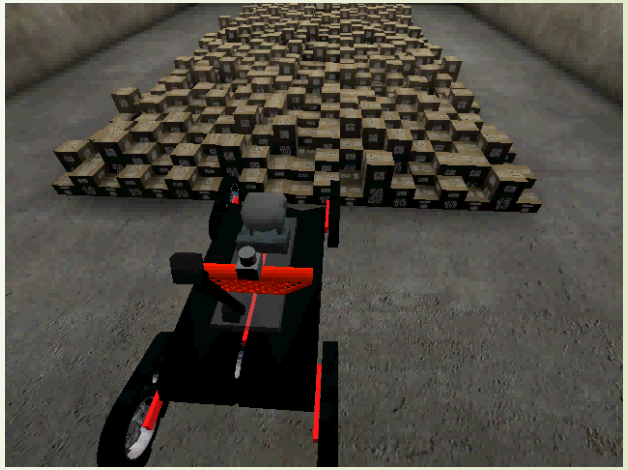


a) Real Zerg

b) Simulated Zerg

UT2004

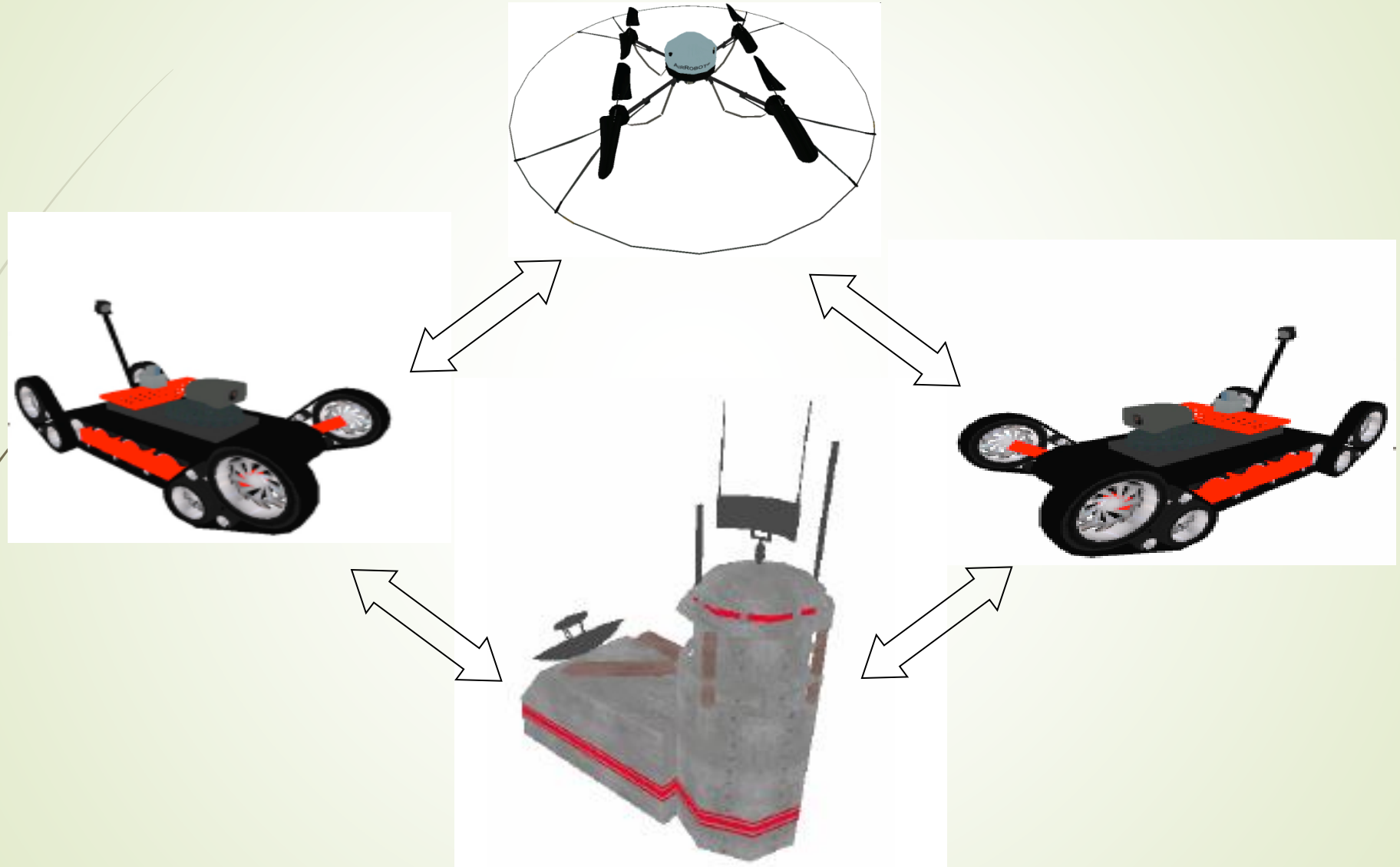
Real Kenaf



Simulated Kenaf

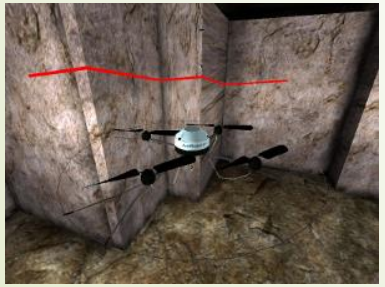
AirRobot

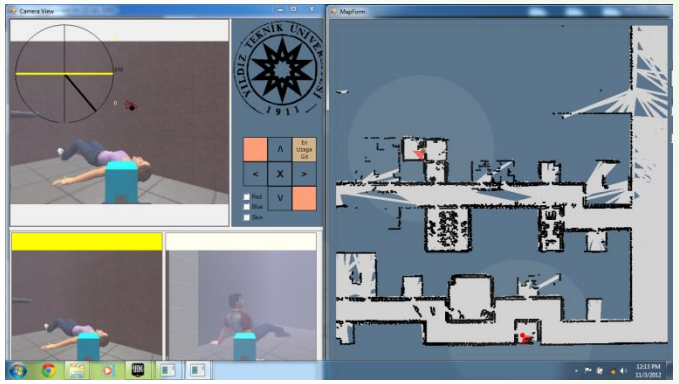
NETWORKED ROBOT TEAM



The robot team is controlled by a single operator located at a basestation.

A System for the Virtual Robot Competition





Base station

ACHIEVEMENTS OF THE VIRTUAL ROBOT COMPETITION

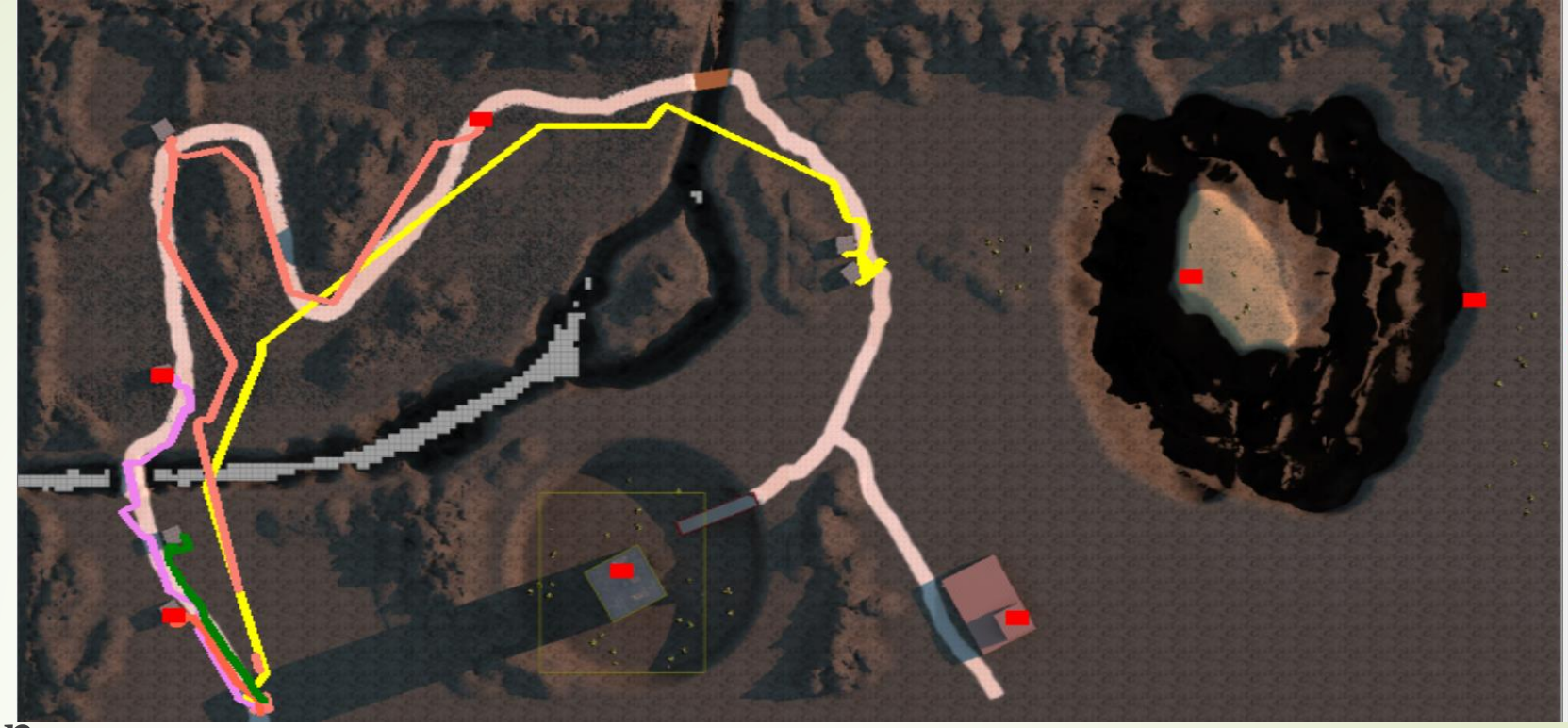
- Development of solid techniques for coordinating the autonomous exploration of initially unknown environments by means of multiple robots
- Development of effective human-robot interfaces for supervising and operating teams of exploring robots
- Development of autonomous victim detecting by image processing
- Development of routing algorithm in ad-hoc network which are suitable for online application
- Development of SALM algorithms (2D, 3D) which are suitable for an online operation beside there robust

MRL Technical Video

Achievements of the Virtual Robot Competition (cont.)

- Real time visualization of the runs for the audience
- Fully automated scoring program
- Improving transparency of the competitions
- Promoting autonomy by calculating explored area
- Reducing the role of luck in the competitions by benefiting from a fair scoring formula

REAL TIME VISUALIZATION



- Top View of Map
- Red points are victim positions
- Robots are distinguished by different colors
- Path of Robot movement is shown by its color on map
- Each team is scored based on
  - Number of detected victims
  - Explored area

THE VIDEIO SHOWS YILDIZ TEAM- ROBOCUP 2013

Future of the Virtual Robot Competition

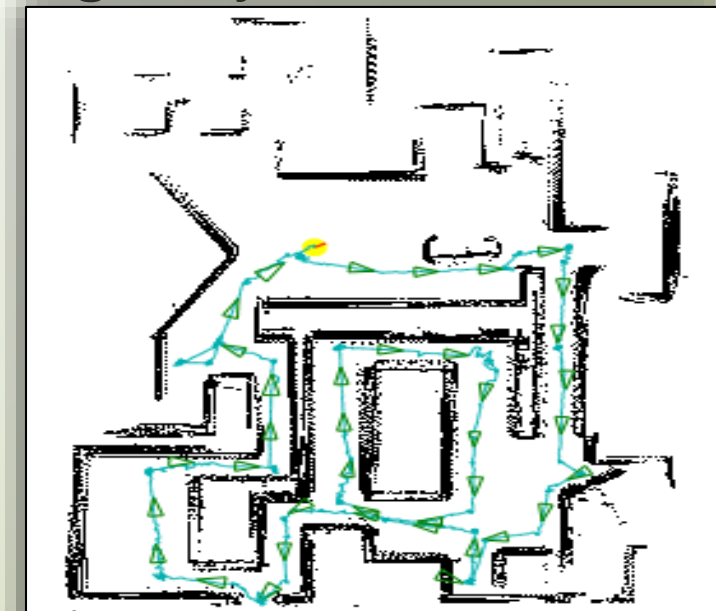
- Finding an optimal balance between autonomy of the robots and human control in challenging environments with constraints such as limited time and network range.
- Effectively sharing components and codes – having well defined standards by utilizing USARSim based on Gazebo/ROS

Open Research Topics

- There is a close correlation between results obtained within USARSim and the corresponding real robots
- VR Competition provides a suitable environment for research in several areas

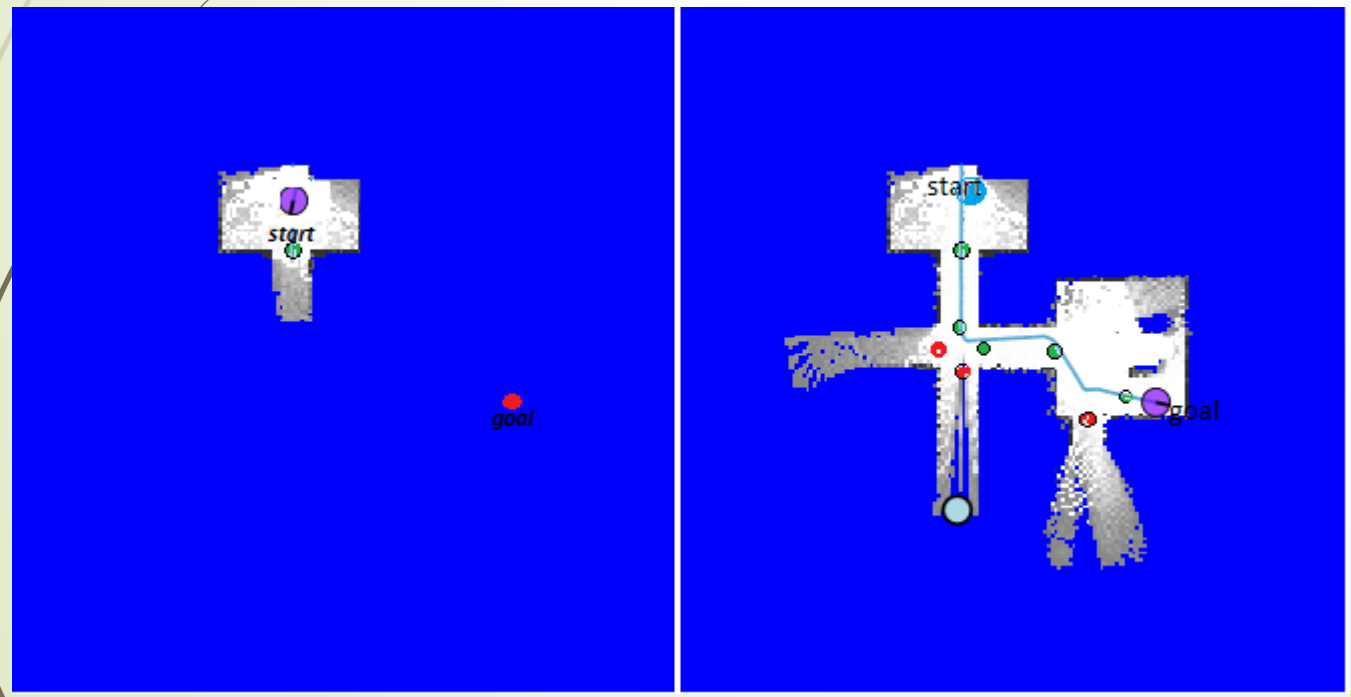
Open Research Topics (cont.)

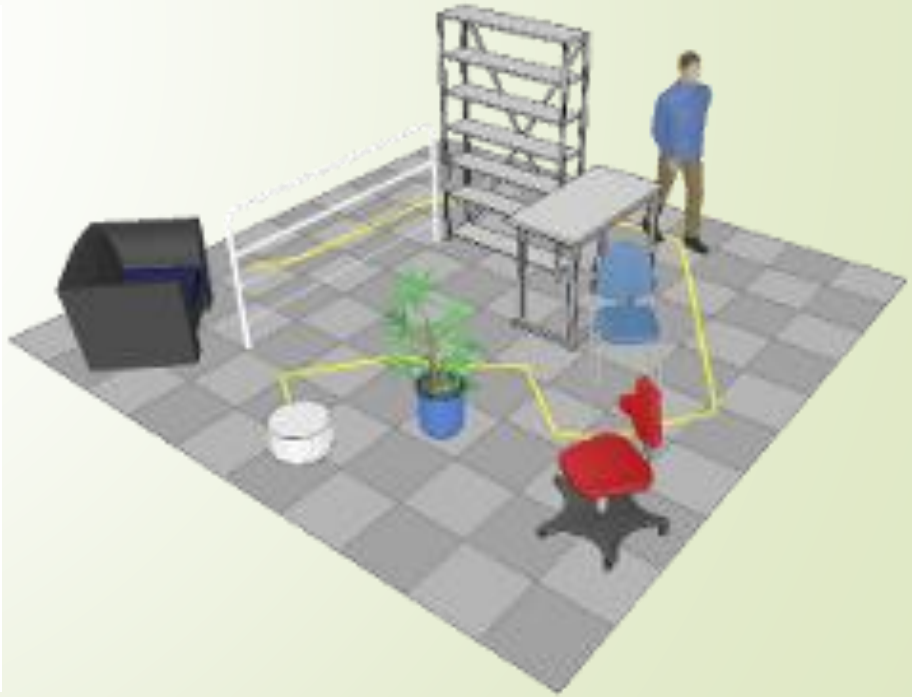
- Simultaneous Localization and mapping (2D, 3D)
  - Robots rely only on data acquired by their sensors, like laser range scanners, camera,…
  - How do they represent the environment by a global map with all robots?
  - How do they localize themselves with considering noisy sensors?



OPEN RESEARCH TOPICS (CONT.)

- Autonomous exploration and path planning





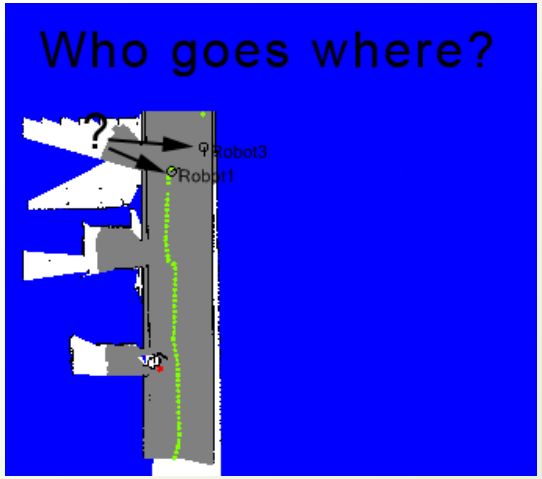
OPEN RESEARCH TOPICS (CONT.)

- Exploration strategies

  Where to go next?

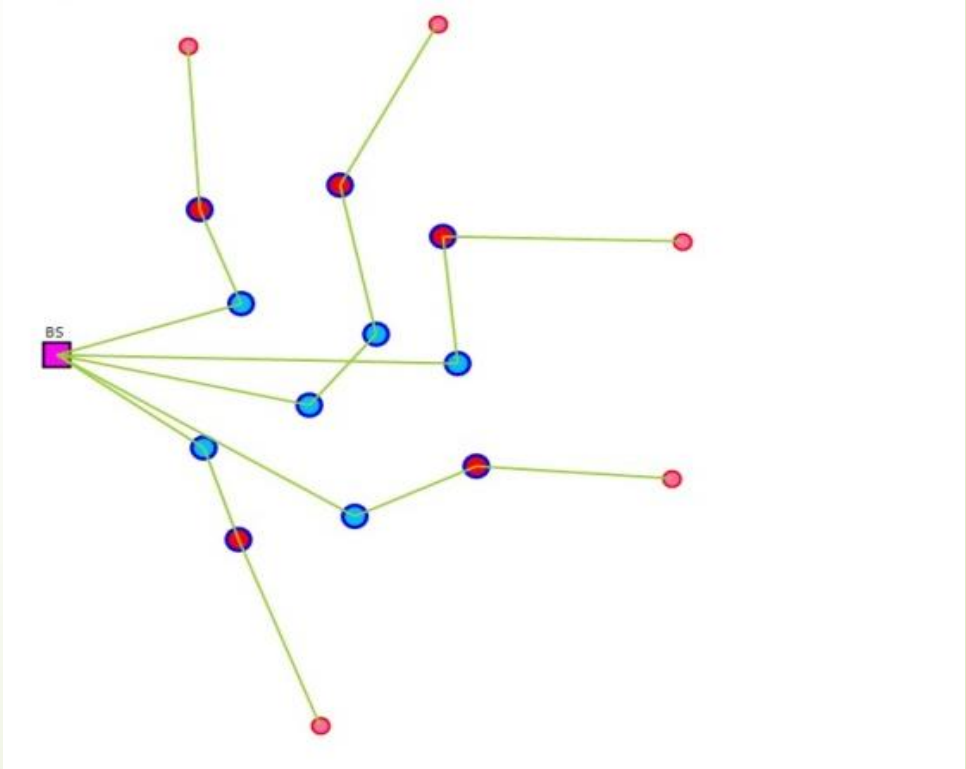
- Cooperation strategies for large heterogeneous robot teams

  Who goes where?



Open Research Topics (Cont.)

- WSS (Wireless Simulator Server) simulates a wireless LAN in a USARSim environment
- Development of effective routing algorithms for robot communication in harsh environments

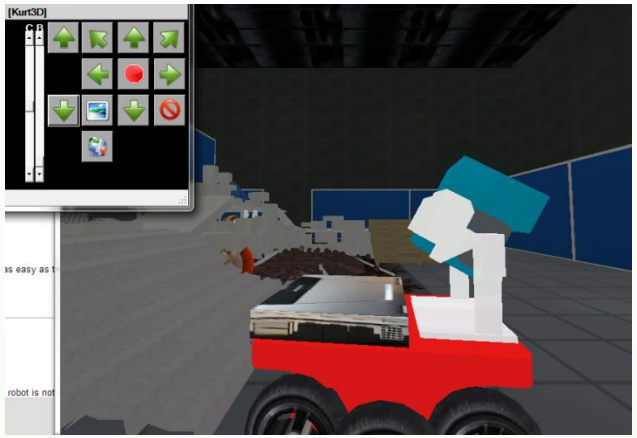


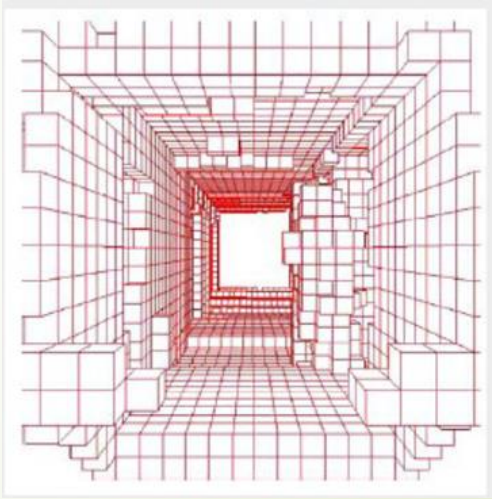
Open Research Topics (cont.)

- Distributed sensor and information fusion
- Human-robot interfaces
- Visual SLAM
- Victim detection by image processing

Main Contributions of Amsterdam Oxford Joint Rescue Forces 2014

- Improved communication performance
- Optimized Video Streams
- 3D mapping based on efficient implementation of point clouds





Other assets:

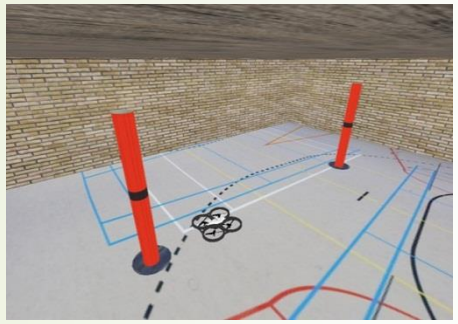
- Can control many robots (Kurt3D, Matilda, Element, Talon, AirRobot, Nomad, etc.)
- Graph based map, which can be easily shared and corrected
- Smooth transition from teleoperated to fully autonomous behavior

Universiteit van Amsterdam

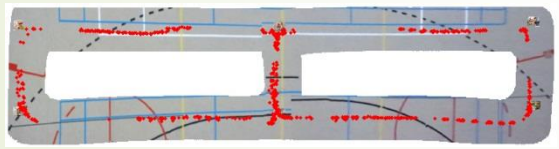
Main Contributions of UvA Rescue 2012

Intelligent Systems Laboratory

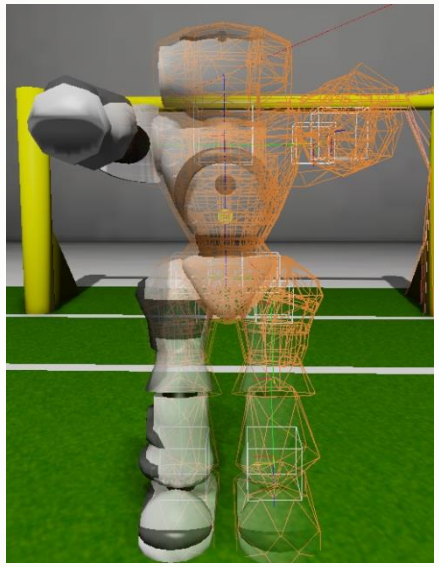
- Visual Localization And Mapping



AR.Drone localizing on visual map



- Nao humanoid robot



collision frame Nao

- Automatic map generator

map generated with high difficulty

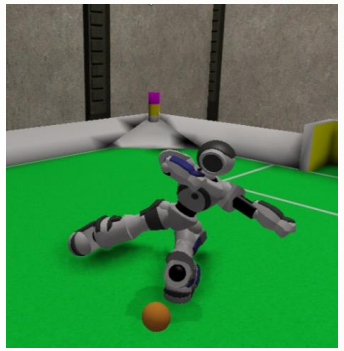
Other assets:

- Can read many logfile formats (Radish, Carmen, etc.)
- Graph based map, which can be easily shared and corrected
- Smooth transition from teleoperated to fully autonomous behavior

MAIN CONTRIBUTIONS OF AMSTERDAM OXFORD JOINT RESCUE FORCES 2011

- Realistic Victim behaviors
- Nao kinemetics model
- AR Drone model
- Kenaf model

AR.Drone (including camera and sonar)

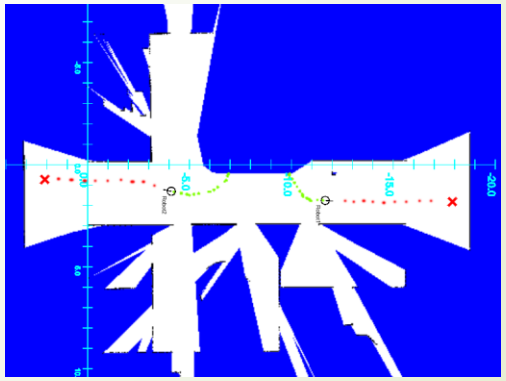


Nao (balancing on one foot)

Kenaf robot with flippers

2011 TEAM BEHAVIOUR INNOVATIONS:

- Graph based map, which can be easily shared and corrected
- Smooth transition from teleoperation to full autonomy
- Waypoint following behaviour



Using waypoints for improved exploration

AWARDS OF UVA TEAM

- Second Place in Iran Open Competition; Tehran, Iran, 2014

- First Place in RoboCup Dutch Open Competition, 2012

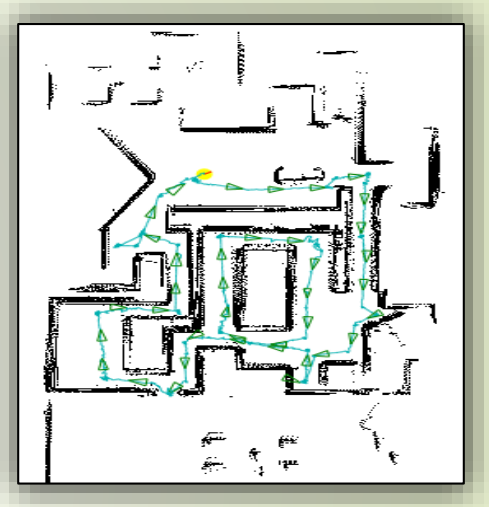
- Best scientific presentation at the RoboCup Iran Open Competition 2012

- USARsim Development prize at the presentation at the RoboCup Iran Open Competition 2010

- 3rd Place in RoboCup World Championship Graz Austria 2009.

MAIN CONTRIBUTIONS OF MRL TEAM

- ICE Matching, Featured-based Scan Matching
  [Journal of Experimental & Theoretical Artificial Intelligence]

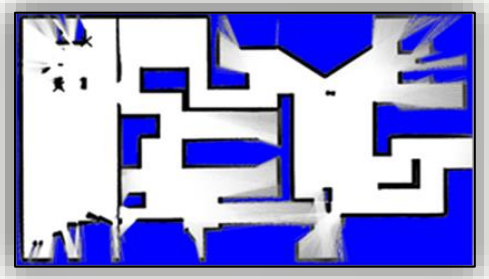


3 point-type features

Intersection

Corner

End Of Wall (EOW)

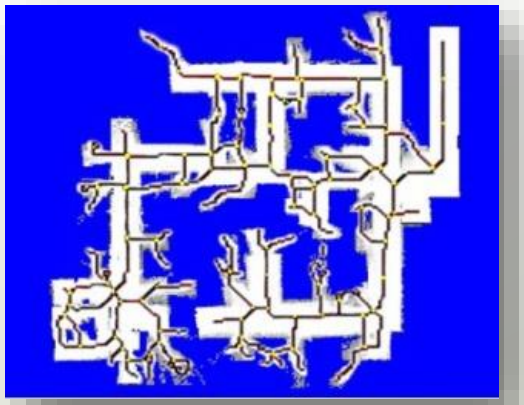


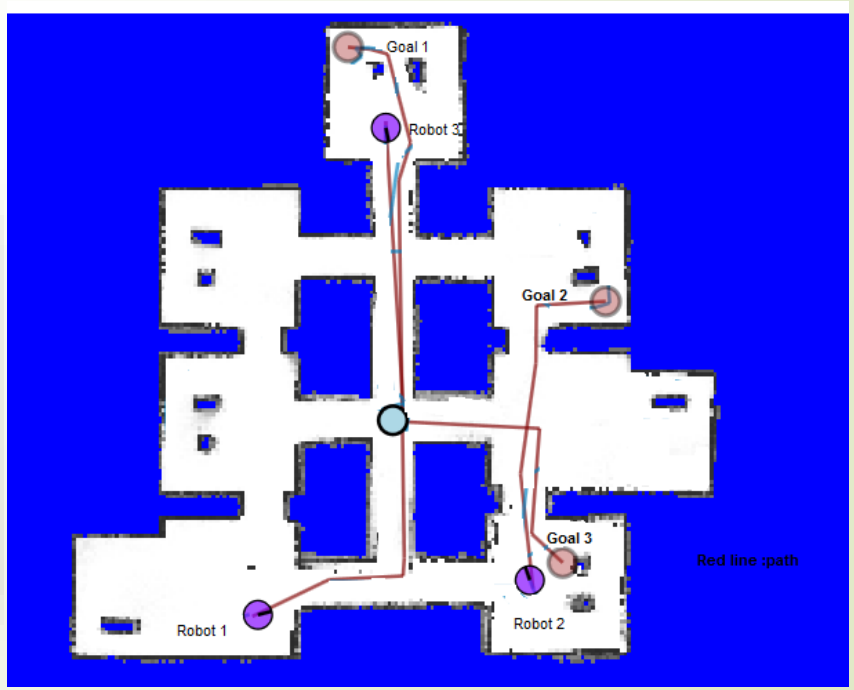
Defining new informative features and novel matching and optimization hierarchical mechanisms, congregated in this method created a robust practical technique in terms of accuracy and convergence rate.

Main Contributions of MRL Team (Cont.)

Navigation

- Path planning: RRT-connect, Improved A* [IEEE International Conference in Robotic and automation, Greek,2012]
- Obstacle Avoidance: A New Method with Combination of 2 approaches
  - ✓ Modified VFH
  - ✓ NFGM

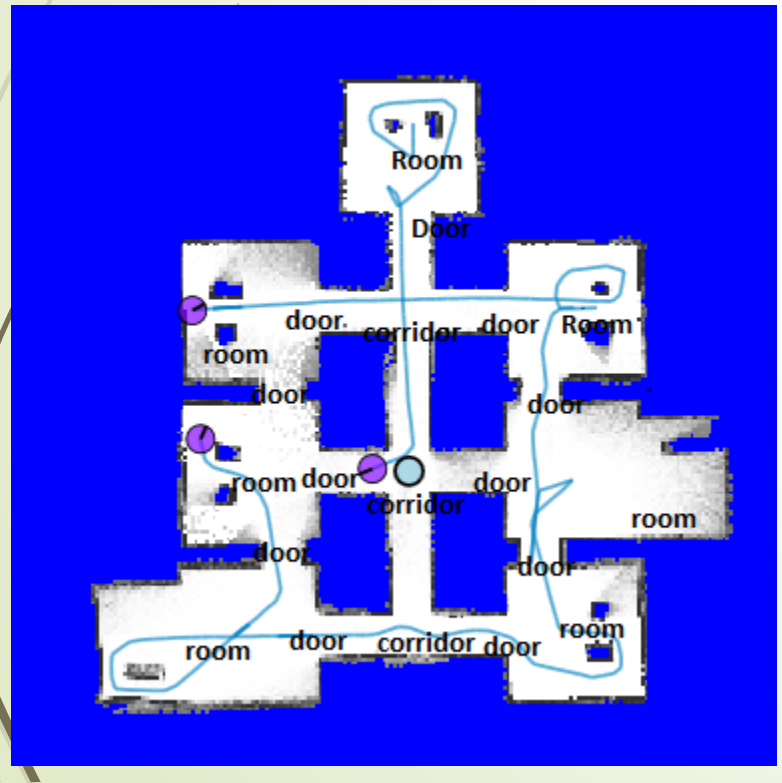




Goals are assigned by RRT-Connect path planning

Main Contributions of MRL Team (Cont.)

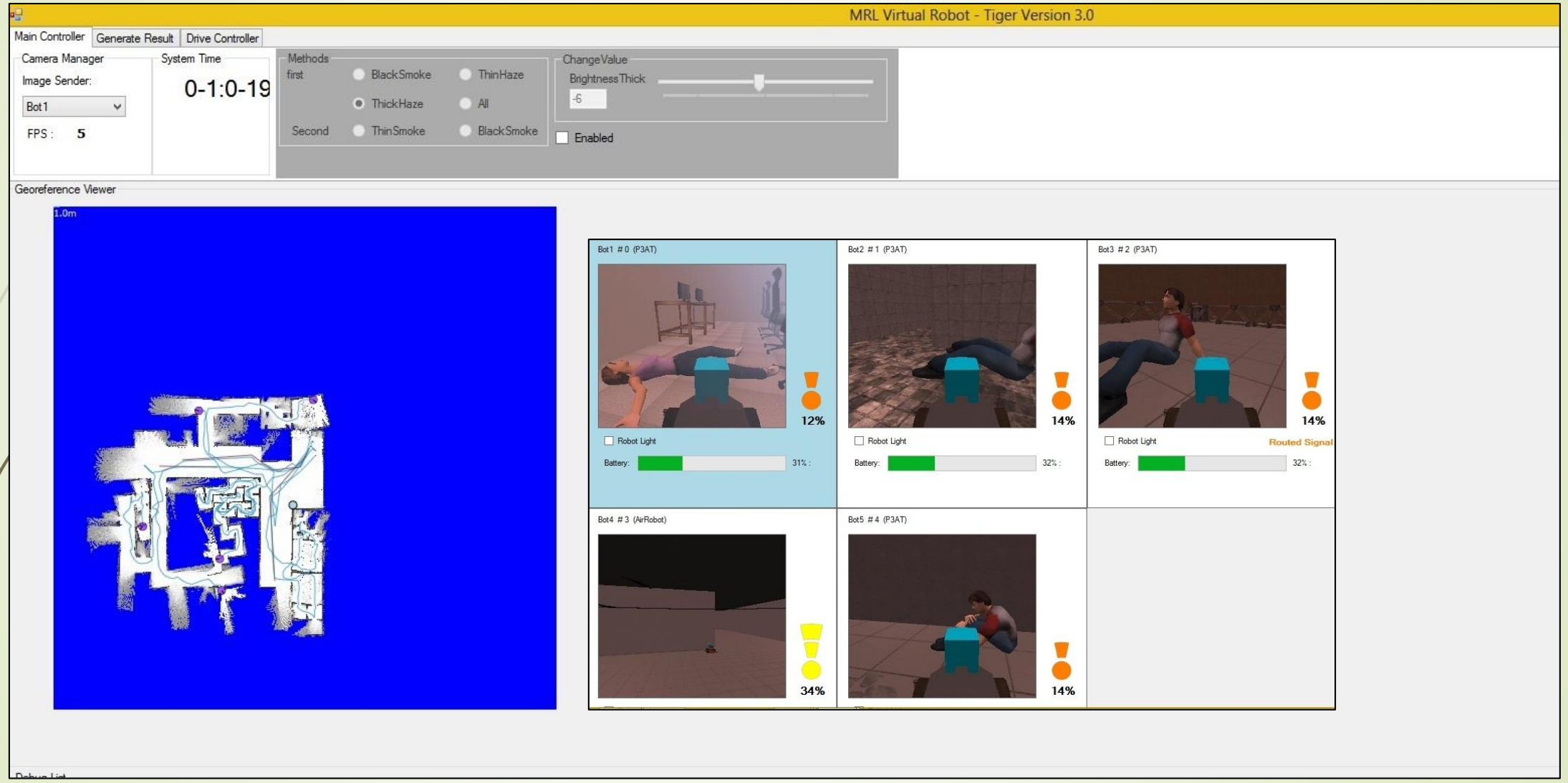
- Multi Agent Exploration [Iran Open Symposium 2010]
- Semantic Mapping
- Motion Detection
- Victim Detection



Semantic Mapping

Automated body detection

HUMAN-ROBOT INTERFACE- MRL TEAM



AWARDS OF MRL TEAM

- First place award in RoboCup World Championship 2014

- First place award in RoboCup World Championship 2013

- First Place in Iran Open Competition; Tehran, Iran, 2014

- First Place in Iran Open Competition; Tehran, Iran, 2013

- First Place in Iran Open Competition; Tehran, Iran, 2012

- Second Place in RoboCup World Championship Singapore, 2010.

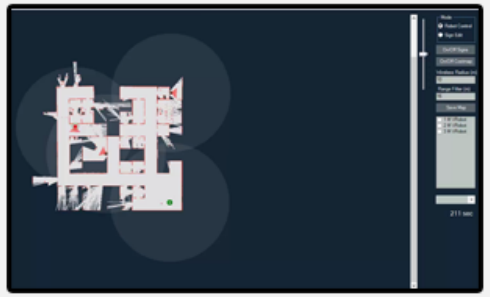
Main Contributions of Team YILDIZ

- Air Robot Localization
- Effective Message Passing [RoboCup Symposium 2013]
- Autonomous Navigation
- Autonomous Victim Detection

Main Contributions of Team YILDIZ 2014

Contributions

- User firendly control panel,
- Multi robot mapping with grid based mapping,
- Automatic door detection and passing,
- Autonomous multi robot exploration,
- Obstacle avoidance,
- Multi-Robot Routing under Limited Communication Range



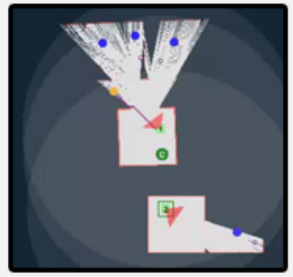
Team YILDIZ

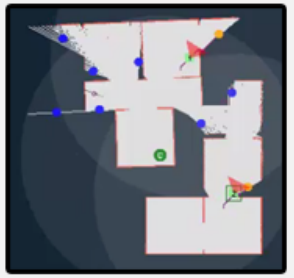
Virtual Robot Simulation League

Yıldız Technical University

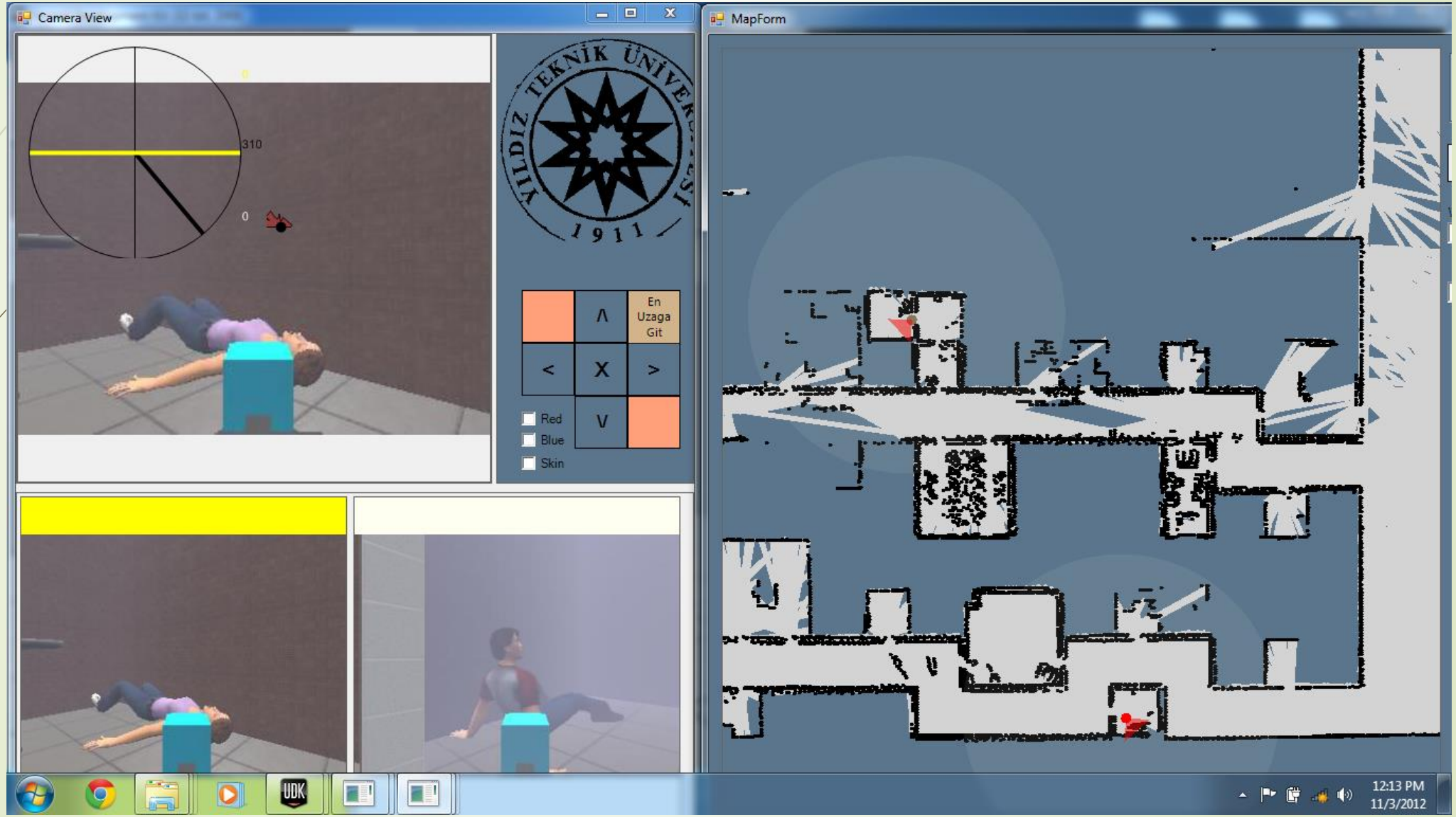
Team Members

Okan YILDIRAN●
Muhammet BALCILAR●
M. Fatih AMASYALI●
Sırma YAVUZ●
Erkan USLU●
Furkan ÇAKMAK●
Nihal ALTUNTAŞ●





HUMAN-ROBOT INTERFACE- YILDIZ TEAM



AWARDS OF YILDIZ

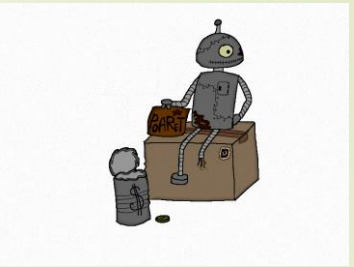
- Second place award in RoboCup Iran Open 2012

- Second place award in RoboCup World Championship 2012

- First place award in RoboCup Iran Open 2013

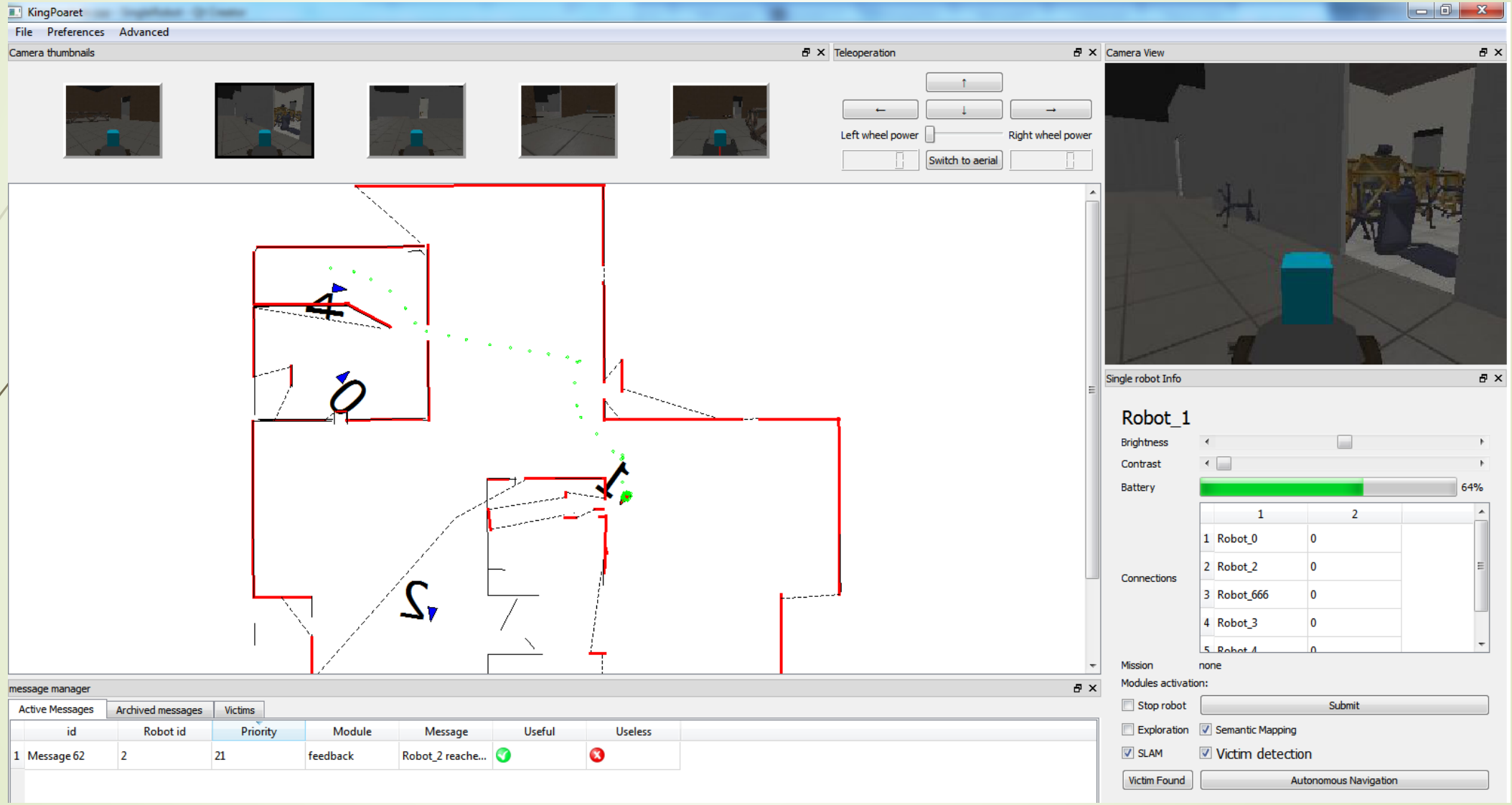
- Second place award in RoboCup World Championship 2013

MAIN CONTRIBUTIONS OF POARET TEAM



- Human-robot interaction
  [RoboCup Symposium 2013]
- Semantic mapping of environments [RoboCup Symposium 2013]
- Exploration strategies and coordination methods
  [RoboCup Symposium 2012]
- Mapping and localization based on line segments[ICRA 2014]

PoAReT Human-Robot Interface



AWARDS OF POARET TEAM

- First place award in RoboCup World Championship 2012

VIRTUAL ROBOTS TECHNICAL COMMITTEE

Francesco Amigoni (Politecnico di Milano)

Shimizu Masaru (Chukyo University)

Sanaz Taleghani (Qazvin Azad University)

Executive Committee: Arnoud Visser

•Former Committee members

Amir Abdi, Sharif University of Technology, Iran
Behzad Tabibian, The University ofEdinburgh, UK
Andreas Kolling (USA)

RoboCup
LEIPZIG GERMANY 2016
30 JUNE to 4 JULY

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ROBOTS AND FRIENDS

Thanks for your kind attention