

# Teleworkbench: The Tele-operated Platform for Robotic Experiments

Felix Werner<sup>1</sup>, Andry Tanoto<sup>2</sup>, Jaan Welzel<sup>2</sup>, and Ulrich Rückert<sup>1</sup>

<sup>1</sup>Cognitronics and Sensor Systems Group  
Cognitive Interaction Center of Excellence (CITEC)  
Bielefeld University  
Bielefeld, Germany  
{fwerner,rueckert}@cit-ec.uni-bielefeld.de

<sup>2</sup>Systems and Circuit Technology Group  
Heinz Nixdorf Institute (HNI)  
Paderborn University  
Paderborn, Germany  
{andry.tanoto,jwelzel}@hni.uni-paderborn.de

Workshop on Good Experimental Methodology and  
Benchmarking in Robotics Research

Euron/Europ Annual General Meeting  
Donostia-San Sebastian, Spain  
March 10-12, 2010

# Experiments in Robotics

---

## Experimentation in Science

- Validate / refute theories
- Support approaches and methods
- Comparison of approaches and methods

## Problems of Experimentation in Robotics

- Variety of Robot Platforms
- No Standard Environments for Experiments



Difficulties in comparing results from experiments

Difficulties in measuring the performance of approaches

# Datasets / Teleworkbench

---

## Datasets

- RADISH, the Rawseeds project
- Benchmarking and comparison of methods

## But ...

- Robots are not able to interact with the environment
- Difficult to capture dynamic environments

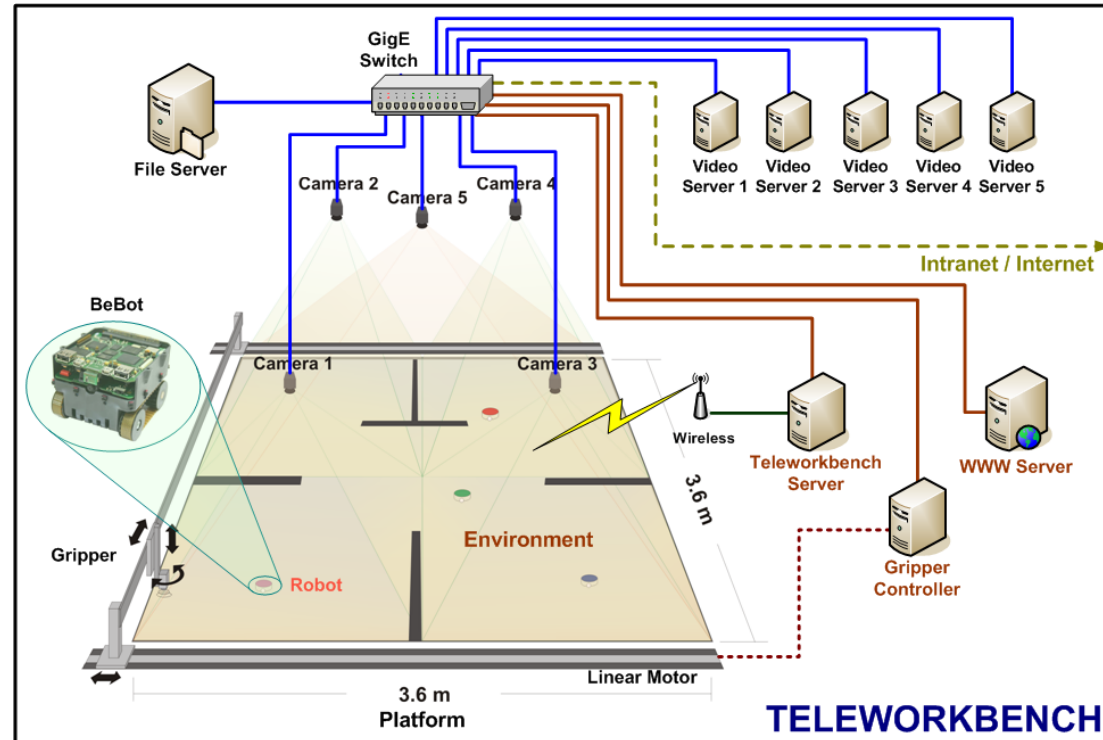
## Teleworkbench

- Provides access to the ingredients of an experiment
  - Robot platforms (behaviour, sensing, ...)
  - Environment
- Ground truth for experiments in navigation (mapping, localisation, slam)
- Web-based remote control

# Hardware Components

## Experiment Field

- 3.6m x 3.6m
- Up to 4 subfields
- Maze-like box-world environments
- “special environments”



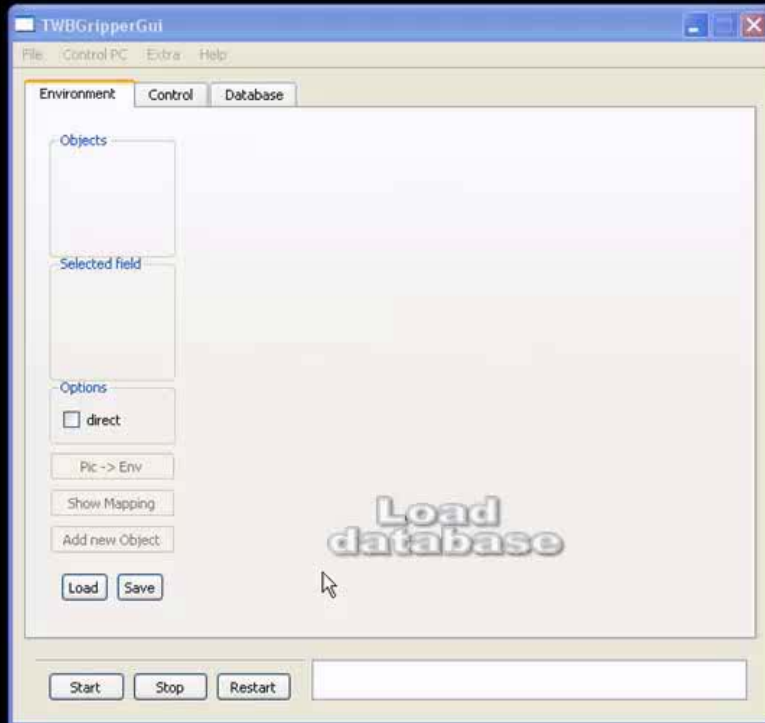
## Gripper Module

- 4 degrees of freedom:  $x, y, z$  translation, rotation around  $z$  axis
- Deploy and collect plastic blocks and robots
- Software interface for environment modelling
- Dynamic environments
- Robot kidnapping

# Hardware Components



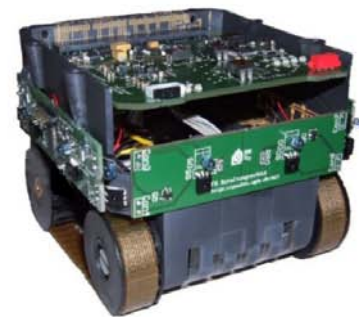
# Hardware Components



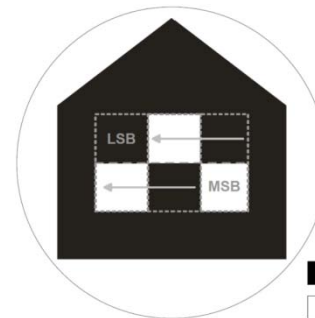
# Hardware Components

## Robot Platforms

- Khepera II, Khepera III, BeBot
- Sufficient sensor technologies and computation performance
- Size relation: Khepera II (0.07m diameter) equals a Pioneer on a 21m x 21m field



- Marker for robot identification and localisation
  - Identification of 64 robots
  - Reliable localisation

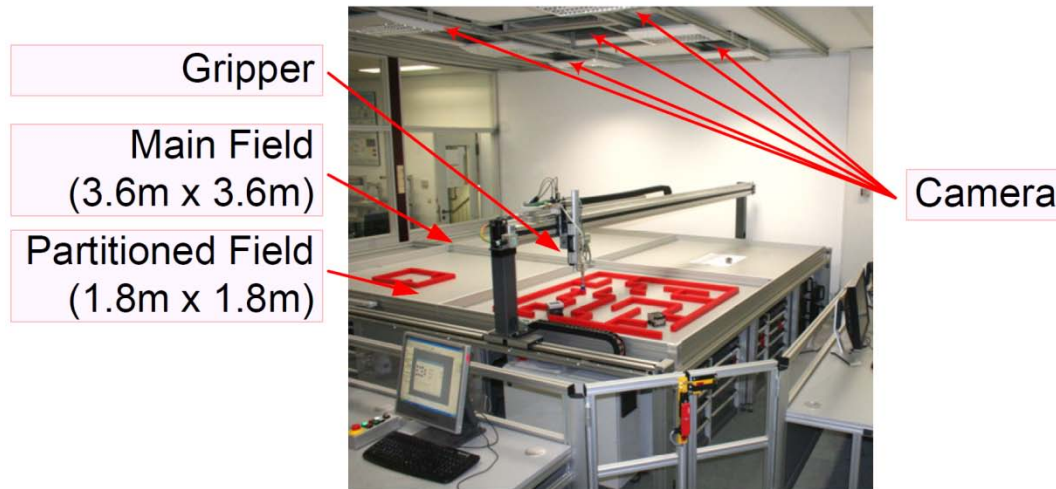


■ Bit 1  
□ Bit 0

# Hardware Components

## Monitoring Cameras and Video Servers

- 5 Prosilica GE1050 CCD cameras, 1024x1024 resolution, 60fps
- 2.1m above the field
- Monitoring of the experiment(s)
- Vision-based GPS-like system for localisation
- Identification of the robots using the markers





## **Simulation of Panic Situation**

# Hardware Components

## Teleworkbench Server

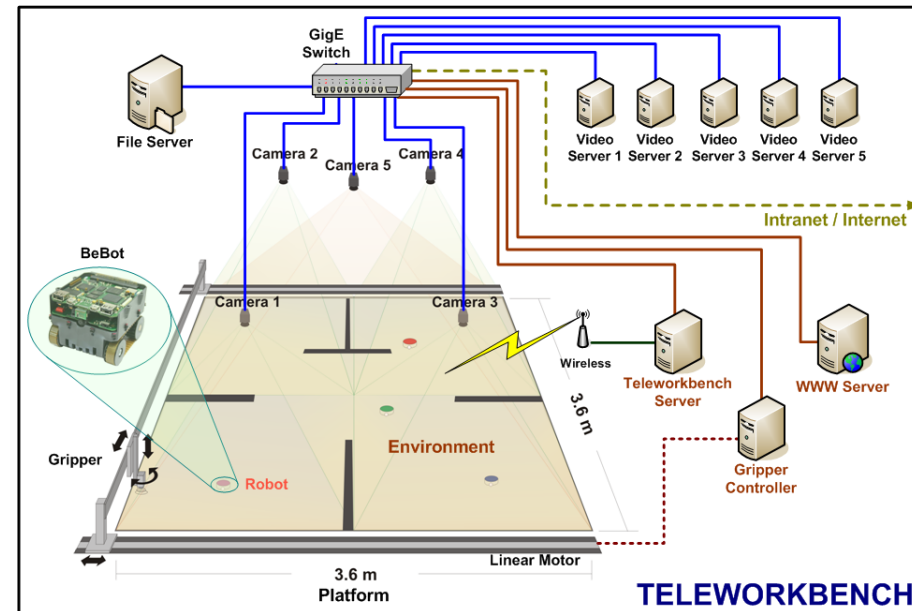
- Queuing, scheduling and execution of experiments
- Handles communication between components
- Forwards data to the file server for storage
- Provides positioning information to the robots

## File Server

- Stores the specified data

## WWW Server

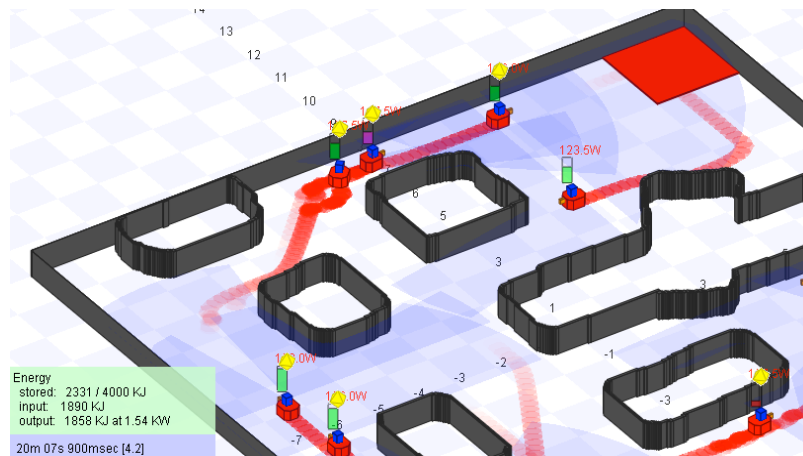
- Hosts the web interface
- Submission of experiments
- Live video of experiments
- Data retrieval from finished experiments



# Software API

## Player/Stage Emulation

- Functionality of the Teleworkbench (localisation, logging, communication)
- Drivers for the robot platforms (motion, sensor perceptions)
- Emulate blocks-world environments
- Simplifies the development of new algorithms
- Transfer from Simulation to the Teleworkbench



# Experimentation using the Teleworkbench

## Principles for good experimenting practice in robot navigation<sup>1</sup>

- Reproducibility: Reproduce the experiment from someone else
- Repeatability: Repeat an experiment multiple times
- Comparison: Compare results with the results of others
- Explanation: Explain and interpret the results

 Draw solid and well justified conclusions

1) Amigoni et al., Auton. Robot., 2009

# Experimentation using the Teleworkbench

**Reproducibility:** Reproduce the experiment from someone else

- All parameters of the experiment are known
- Environment
- Robot configuration
- Robot behaviour

**Repeatability:** Repeat an experiment multiple times

- Probabilistic / randomised methods
- Robustness of methods
- Test a behaviour in different environment setups
- “Special environments” that model difficult scenarios

# Experimentation using the Teleworkbench

Comparison: Compare results with the results of others

- Data logging for quantitative comparison
- Some ground truth measures

Explanation: Explain and interpret the results

- Data logging for quantitative justification
- Monitoring cameras for qualitative interpretation

# Conclusions

---

- Teleworkbench provides access to ingredients of experiments
- Remotely accessible
- Benchmarking, comparison of results, performance measures