

RP 12

*Interconnection of
multi-robot and multi-user systems
for cooperative tasks*

Alexander Owen-Hill

Manuel Ferre
Universidad Politécnica de Madrid

Project: 07/11 – 06/14



Background Information



Edinburgh, Scotland



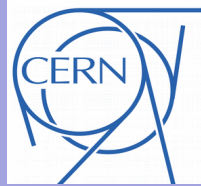
Madrid, Spain

Alex Owen-Hill

- Completed PhD in 3 years
 - July 2011 – June 2014
 - Defended in October 2014
- Host University
 - Manuel Ferre
 - Universidad Politécnica de Madrid

Final Conference, 19th – 23rd January 2015

Geneva, Switzerland



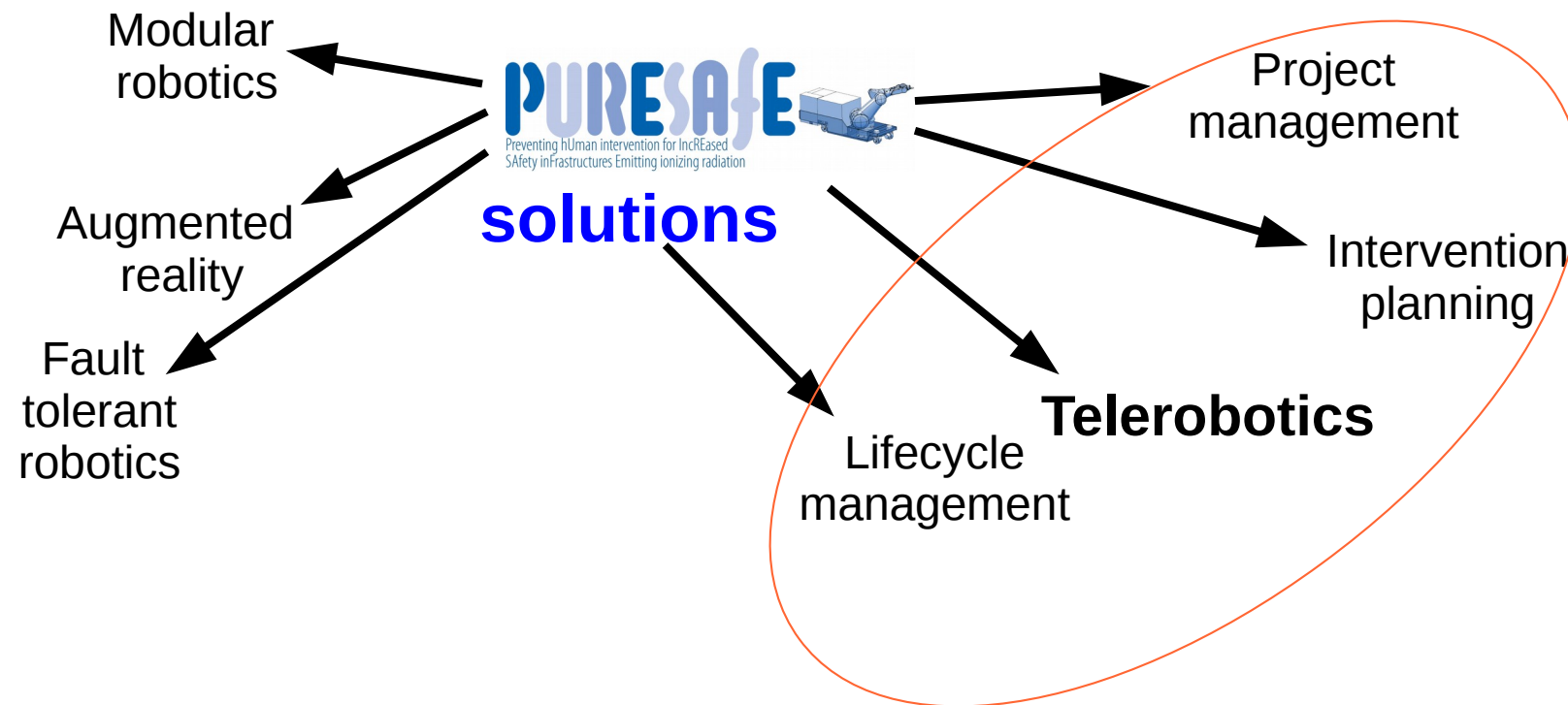
Research Goals

Multiple Perspectives



Research Goals

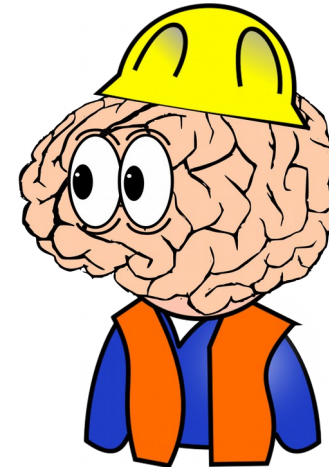
Multiple Perspectives



Why telerobotics?

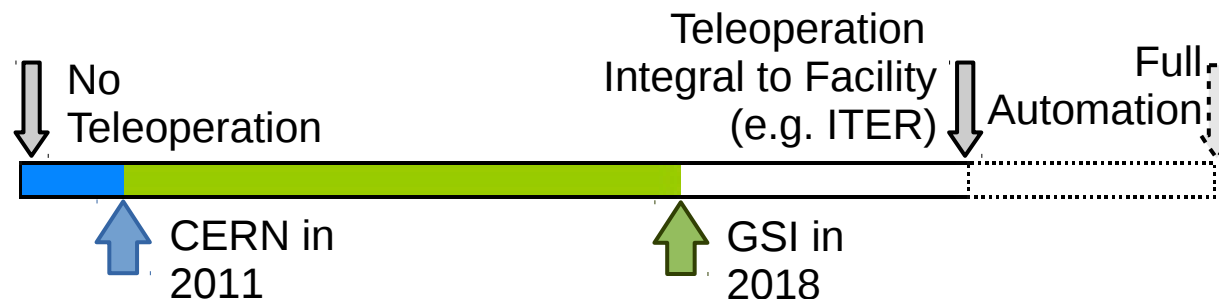


- Remote operation of robot(s) in dangerous environments
- Cognitive advantages of the human brain
- In an ideal world, sending a telerobot is exactly like sending a human worker.
- Generally, research focus is on low-level control systems



Research Goals

- Multi-user, Multi-robot systems
- Looking at whole system, not just individual telerobots
- Interconnection of multiple robots and human operators
- **Collaborate** to Evaluate needs at CERN and GSI
 - Full teleoperation for the distant future
 - No frameworks in place to handle telerobotics



Revised Research Goals

How can teleoperation tasks be formalised to include into facility planning?

What tasks are actually performed with teleoperation?

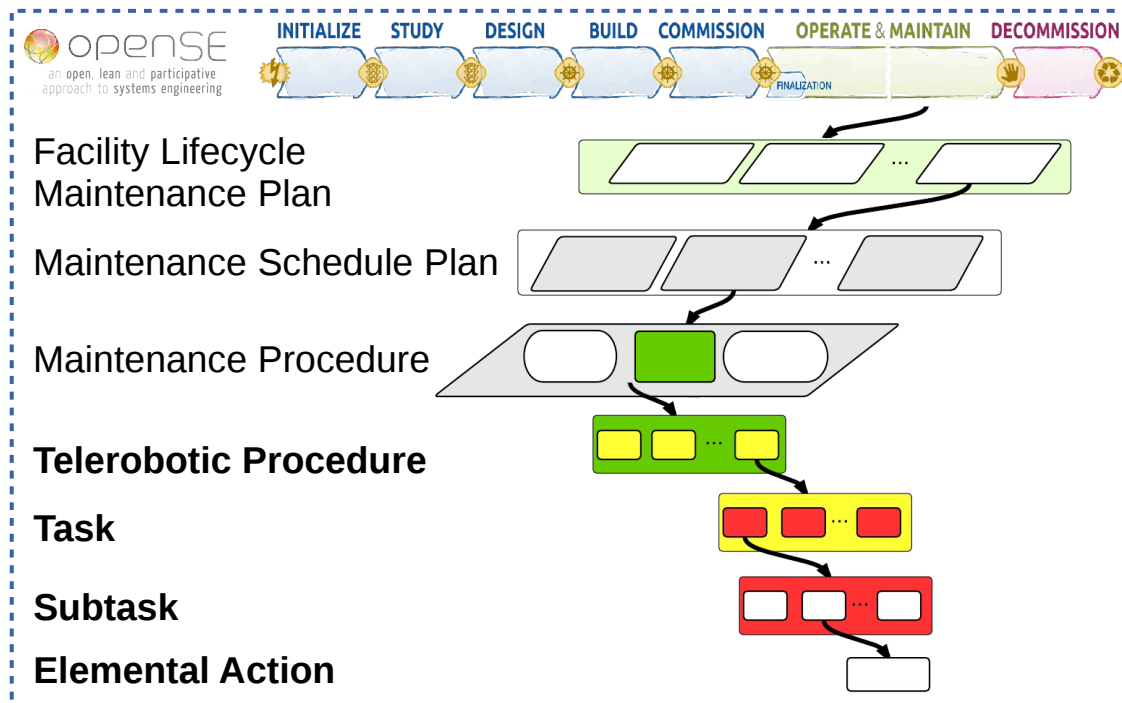
How can we know if certain telemanipulators suit task needs?

How do we ensure multiple telemanipulators don't collide in shared workspaces?



Hierarchical approach to robotic procedures

How can teleoperation tasks be formalised to include into facility planning?

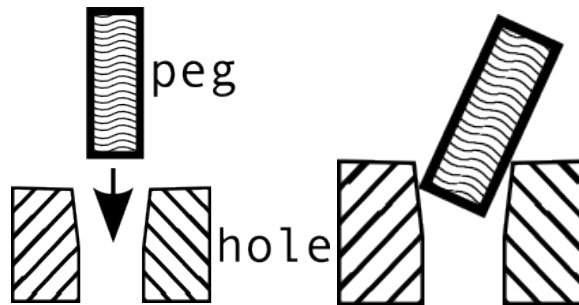


Lack of formalisable models for **multi-robot telemanipulation** in current literature

Survey of Telerobotics Experts

What tasks are actually performed with teleoperation?

- Research focus on “tasks” as small, isolated actions

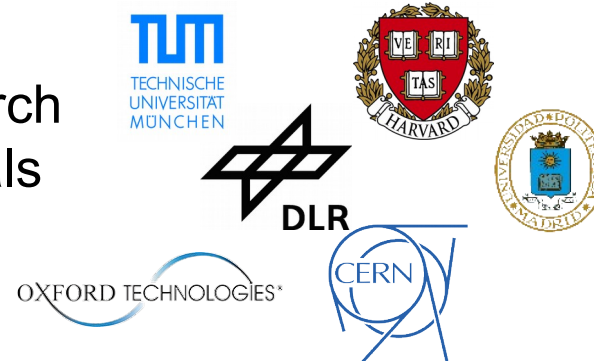


- Very few common tasks across studies
- Not “realistic” tasks (important for **real-world use**)

Survey of Telerobotics Experts

What tasks are actually performed with teleoperation?

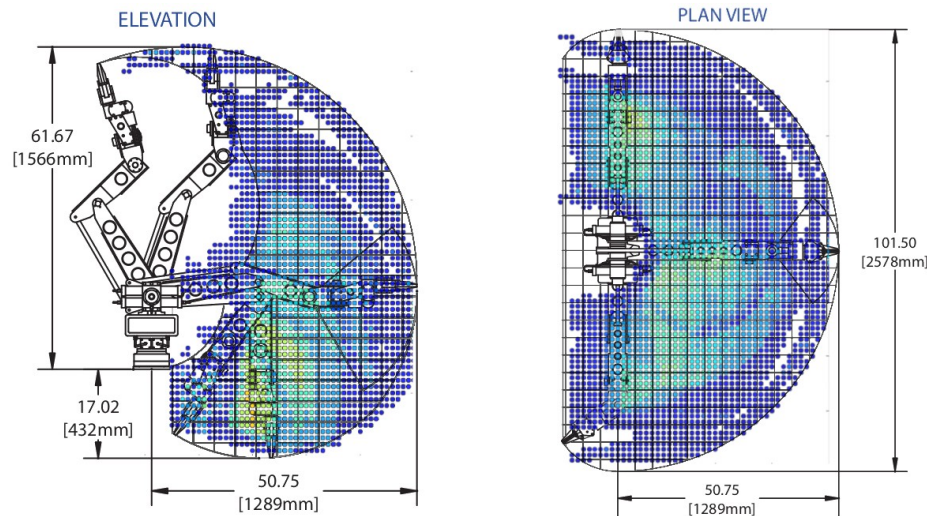
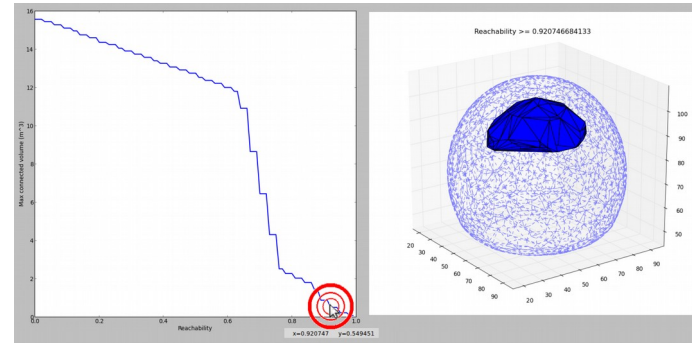
- Directed Survey of Experts
- Surprisingly little telerobotics research which consults industry professionals
- Long form responses
- Thematic Analysis Methodology
- Results revealed “missing categories” in most studies
 - Connectors (e.g. electrical, mechanical)
 - Fixings (e.g. screws, bolts, nuts)
 - Aiming/aligning parts



Benchmarking Test

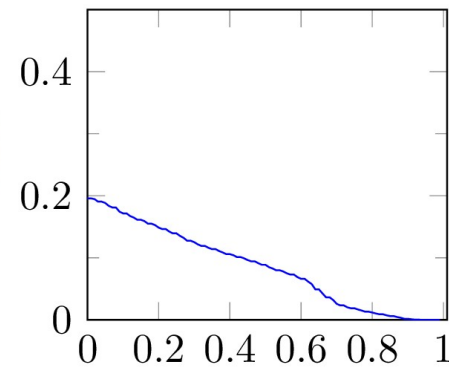
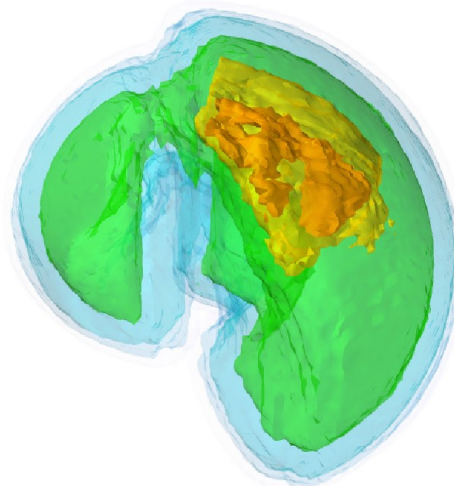
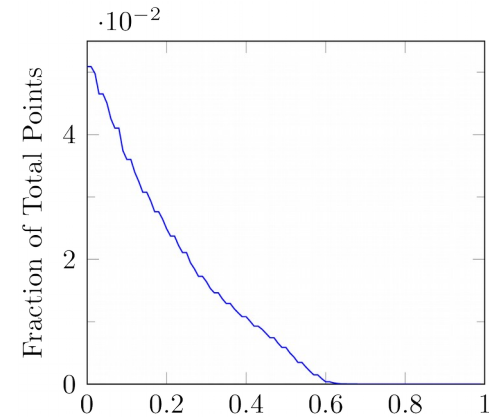
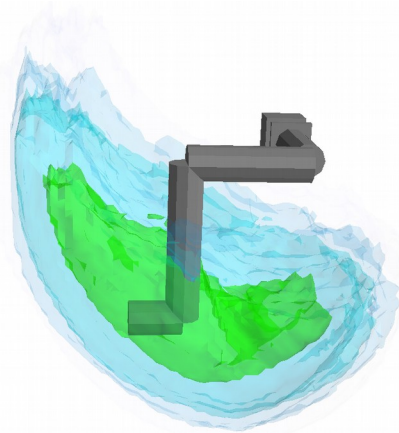
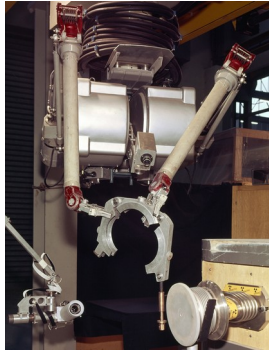
How can we know if certain telemanipulators suit task needs?

- Three-stage test suite
 1. General Characteristics
 2. **Kinematic Reachability**
 3. Physical Testing



- Analysis and visualisation of telemanipulator dexterity

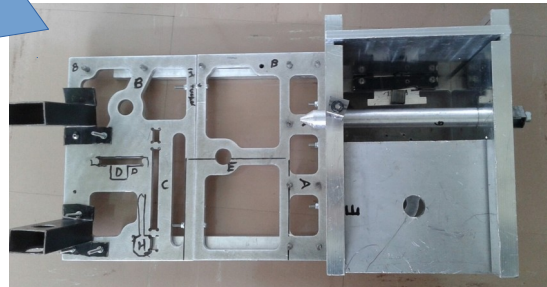
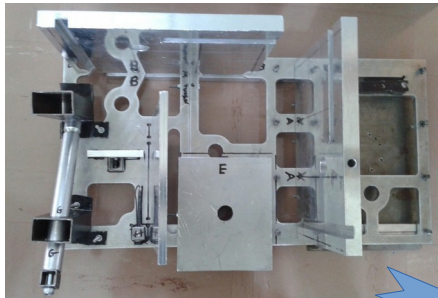
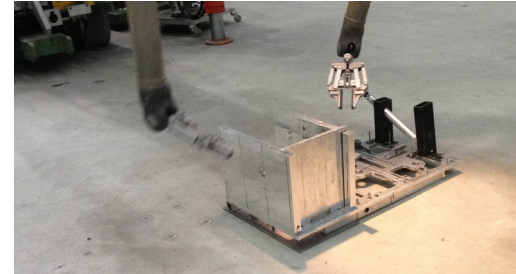
Benchmarking Test



Benchmarking Test

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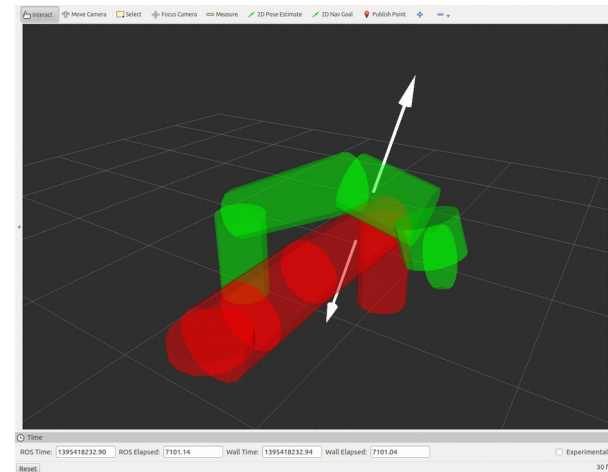
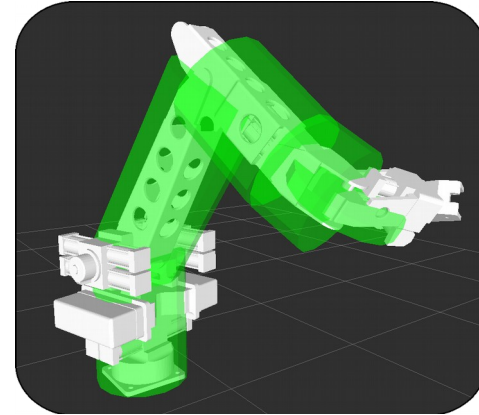
- Three-stage test suite
 1. General Characteristics
 2. Kinematic Reachability
 3. **Physical Testing**



Capsule Collision

How do we ensure multiple telemanipulators don't collide in shared workspaces?

- Haptic collision algorithm
- Operators feel other telerobots without physical collision
- Real-time function with over 8 telerobots in close contact



Overall Project Success

Goal	Success?
Carry out PhD-worthy research into multi-system telerobotics	✓
Collaborate between partners to gain wide perspectives on research	✓
Contribute new knowledge and approaches to the telerobotics field	✓
Become proficient in research and communicating results effectively	✓
Developing useful, directly applicable research for real-world problems	🤔
Gained knowledge, experience and connections in research and industry across Europe.	✓



Future of this research

- Basis theoretical framework for more targeted, holistic approach to telerobotics procedures and tasks
- Further development and standardisation of dexterity testing for telemanipulators
- Application of refined algorithmic tools for comparing telerobot capabilities



Collaboration and Interaction

- Amongst the PURESAFE ESRs
 - Valuable academic (and emotional) support network
 - Interaction with RP2, RP6, RP8 and RP9 across project strongly affected research outputs and approach
- Interaction with other PURESAFE personnel
 - Keith Kershaw – introduced to Dexterity Test, facilitated physical tests with Mantis and input knowledge
 - Alan Rolfe – collaborated in survey research
- Research colleagues within UPM
 - Technical cross-sharing of knowledge
 - Personal support and connection



Summary

- Have presented the four main research contributions
 1. Hierarchical framework for telerobotic procedures
 2. Survey of telerobotics experts and results
 3. Basis benchmarking tests for telemanipulators
 4. Multi-robot, haptic collision algorithm
- Successes of project:
 - Completion of PhD
 - Forging of professional connections across Europe
 - Development of research and communication skills

