Autonomous and Intelligent Systems Partnership

Presented by Dr. Jeffrey A. Kuo
CONTENTS

• Introduction to NNL
• NNL’s remote nuclear deployment capability
• Tele-operation
• Autonomy
• Autonomous and Intelligent Systems Partnership (AISP)
NNL – Facts & Figures

• History
  - NNL was the R&D department of BNFL (British Nuclear Fuels Ltd)
  - Operated UK’s nuclear fuel cycle

• Size
  - Around 780 staff
  - Over 60% have science or engineering degrees, Masters and PhDs
  - Annual turnover of approximately £80M

• Key customers
  - Sellafield Ltd, NDA, Magnox, Westinghouse, EDF Energy, MoD, UK Government, Regulators

• Commercial business
  - Operate as a commercial business
  - No direct funding or grants from UK government
NNL R&D nuclear programmes

- Fuel and radioisotope technology – nuclear physics, reactor design, performance, new nuclear build

- Waste – vitrification, immobilisation, behaviour, chemical processes, characterisation

- Legacy and future decommissioning – robotics, remote handling, characterisation, decontamination

- Support operations of existing reactors and fuel cycle facilities e.g. fuel fabrication and reprocessing

- Asset care – impact, structural and thermo fluids modelling, robotics and remote handling

- Geological disposal, space propulsion systems
Where are our unique facilities?

- Central Laboratory, Sellafield – radioactive laboratories and a rig hall for Pu, U, and α
- Windscale – radioactive laboratories for nuclear fuel, examination and testing
- Preston – radioactive facility for fuel manufacture and testing
- Risley, Stonehouse and Harwell – office based, simulation and modelling
- Workington – non-radiological facility for mechanical testing
NNL Remote Engineering

• Introduction to NNL’s remote operations experience
  • Design and deployment of teleoperable systems.
  • Manipulator tooling development.
  • Remote intervention and repair.
  • Remote plant inspection and condition monitoring.
  • Sampling and characterisation.
  • Windscale Laboratory PIE caves.
NNL Remote Engineering
Tele-operation - manual control of a robot by an operator

Multiple highly skilled operators

Barrier: - distance, hazard, shielding

CCTV feedback

Input via joystick / control desk

Joint encoder data

Single teleoperated device
Tele-operation – can be difficult

- No visible line of sight
- Congested and hazardous environment
- Non-linear motion
- Response time
- Repeatability performance

Multiple highly skilled operators

Barrier: - distance, hazard, shielding

Single teleoperated robot / device

CCTV feedback

Input via joystick / control desk

Joint encoder data
What is Autonomy?

‘A system that can make decisions with some or no human intervention’

How are autonomous decisions made?

- Using complex mathematical formulations
- Neural networks
- Fuzzy logic
- Genetic and biologically inspired algorithms
Why do we need autonomy?

• Used for Dull, Dirty, Dangerous and Dark applications

• Remotely deploy complex hardware that present tele-operational challenges e.g. a multi-jointed robot in a highly congested nuclear cave is deployed to cut a pipe

• Such deployments are difficult for human operators – spatial awareness, positional control, avoid obstacles, avoid hazards

• Nuclear Decommissioning Authority (NDA) stated that decommissioning must be cheaper, faster and more reliable
Autonomous and Intelligent Systems Partnership (AISP)
## AISP History

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>2010</td>
<td>Discussions BAE Systems and EPSRC</td>
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<tr>
<td>2010 / 2011</td>
<td>Formation of industrial partnerships</td>
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<tr>
<td>June 2011</td>
<td>Preparation of industrial scenarios</td>
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<tr>
<td>July 2011</td>
<td>EPSRC issued call with £6 million</td>
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<tr>
<td>August 2011</td>
<td>Call closes - 73 proposal submitted</td>
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<tr>
<td>August / December 2011</td>
<td>Proposals assessed</td>
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<tr>
<td>December 2011</td>
<td>EPSRC panel review</td>
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<tr>
<td>January 2012</td>
<td>8 projects funded with £8.65 million</td>
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<tr>
<td>February 2012</td>
<td>7 projects funded with £5.5 million</td>
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<tr>
<td>July 2012</td>
<td>Business agreements in place</td>
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<tr>
<td>July 2012</td>
<td>Launch at Schlumberger Cambridge</td>
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<tr>
<td>December 2012</td>
<td>Individual project starts</td>
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### 8 Proposals Co-Funded

£8.65 million

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AISP Reconfigurable Autonomy

• Academic Partners:
  • University of Liverpool
    • Centre for Autonomous Systems Technology
    • Logic and Computation Group
  • University of Sheffield
    • Automatic Control and Systems Engineering Department
  • University of Surrey Space Centre
    • AI Department and Autonomy Group

• Industrial Lead Partners:
  • National Nuclear Laboratory Ltd. and Sellafield Ltd.
The Reconfigurable Autonomy Project aims to deliver:

- An open-source rational agent architecture that controls autonomous decision-making
- An architecture that is re-usable and generic, and can be reconfigured for many different autonomous platforms
- A verifiable core that is dynamically reconfigurable for mission goals, capabilities and control sub-systems
- Hardware can be exchanged / removed / added at run time
NNL’s Simulator and AISP’s Reconfigurable Autonomy

**Why simulate autonomy?**

- Autonomy is presently unacceptable within the nuclear industry

- Demonstrate task execution without damaging plant, equipment and people

- Demonstrate reliability and repeatability

- Test mathematical formulations and algorithms

**Simulator Features**

- Controlled by joystick

- Operator training

- Design phase - evaluate reach, dexterity, human factors, ergonomics

- Mission and task feasibility

- Controlled as a slave for AISP, research
Thank you for your attention!

Questions?