RoMaNS – Robotic Manipulation for Nuclear Sort and Segregation

€6.8million 3 year R&I project
(€6.4million EU, €400k UK)
1st May 2015 – 31st March 2018

| UoB, UK (lead) | Rustam Stolkin
Ales Leonardis
Marek Kopicki |
|---------------|------------------|
| TUDa, Germany  | Jan Peters
Gerhard Neumann |
| CEA, France    | Mathieu Grossard
Yvan Measson et al. |
| CNRS, France   | Paolo Robuffo Giordano
François Chaumette |
| NNL, UK        | Jeffrey Kuo
Bob Bowen |

www.h2020romans.eu

Co-funded by the Horizon 2020 Framework Programme of the European Union
Nuclear sort and segregation problem

• Cleanup of legacy nuclear waste in the UK alone is the largest environmental remediation project in the whole of Europe.
  — UK has 1.4 million cubic metres of intermediate level waste (ILW) alone.
  — At a single UK site (Sellafield), 69,600 cubic metres of ILW waste will have to be placed into 179,000 storage containers in near future.

• Much of this was stored decades ago, in containers with unknown (or partially known) contents and mixed contamination levels.
  — Old containers must be cut open.
  — Their contents must be examined, sorted and separated.
  — Highly contaminated waste must be extracted and placed into special new storage containers.

Co-funded by the Horizon 2020 Framework Programme of the European Union.
This poses an enormous challenge for remote manipulation.

- Waste comprises a vast array of objects and materials, with a vast complexity of shapes, appearances, properties.
- Each object must be recognised, identified, grasped and manipulated.
- Tangled objects must be pulled apart – perhaps by bimanual manipulation.
- Current state of the art is either 1960s style mechanical MSM devices, or tele-operated arms typically controlled joint-by-joint by human operator (e.g. Brokk robots).

Hypothesis - required throughput rates cannot be achieved safely and efficiently without:

- Increased autonomy.
- Enhanced tele-presence, force-reflection and bi-lateral feedback, HRI, and situational awareness.
- A new generation of robot hardware is needed.

Co-funded by the Horizon 2020 Framework Programme of the European Union.
New robot Testbed at NNL – beyond SOA in UK nuclear robotics

- Robotic waste processing plant at Sellafield will take in legacy waste, cut open containers, inspect/sort/segregate and re-package in newer, safer containers.
- 500 kg payload 6-axis KUKA robot arms
- Exciting – MAJOR investment by UK nuclear in advanced, modern robotics

But so far..

- No autonomy.
- No telepresence or haptics.
- No compliance or force control.
- Limited visualisation.
- Limited situational awareness.

Co-funded by the Horizon 2020 Framework Programme of the European Union
Robot actions using simulated waste

- All controlled by teams of human operators using joystick and CCTV.
- Quite slow and painstaking – movies sped up a lot.
- Very interesting/complex manipulative tasks.
RoMaNS research activities

- Plant-representative industrial test-bed
- Advanced autonomy
- Simulation and visualisation
- Advanced tele-presence
- New master-slave hardware
CEA master-slave hand-arm hardware

- Bi-manual force-feedback hand-arm master.
- Slave robots— inherently back-drivable, low-inertia actuators— compliance without delicate electronics – hence nuclearisable.
- Dexterity with more industrial ruggedness than delicate research hands.

Co-funded by the Horizon 2020 Framework Programme of the European Union

RoMaNS
ROBOTIC MANIPULATION FOR NUCLEAR SORT AND SEGREGATION
Computer vision challenges beyond SOA - understanding heaps of junk...

- Vision challenge – understanding heaps of occluded objects (at ICCV soon).
- Active segmentation – vision by poking...
- Can we create a repeatable heap-poking/grasping robotic challenge?
• Sensor fusion – rgb, range images, thermal IR, radiation images, other(?)
• Tracking occluded objects, and deformable objects during manipulations.
• Visual servoing (above to be applied to nuclear objects soon...)
Autonomous grasping and manipulation

Autonomous grasping of:
- Unknown objects
- Arbitrary shapes
- Partial views/point-clouds
- Deformable objects
- “Click-and-grasp” operator assistance tool

Advanced skills:
- Bi-manual “disentangling”
- Forceful interactions/contacts
- Robust reactive grasping
- Semi-autonomous grasp learning

Co-funded by the Horizon 2020 Framework Programme of the European Union
Combining tele-operation and autonomy

**Autonomy -> teleop:** (CNRS-IRISA)
- Mixed-initiative and shared control
- Variable autonomy

**Teleop -> autonomous system:**
- Learning from demonstration
- Human feedback on robot actions
- Teleop annotation of proposed robot actions (via simulation)
  (TUDa and UoB)

Co-funded by the Horizon 2020 Framework Programme of the European Union
Industrial test-bed and demonstrator

- Building test-bed at NNL Workington plant-representative industrial site.
- RoMaNS test-bed sited next to Sellafield robot test-rig (accessible to end-users).
- Begin with baseline industrial technologies.
- Gradually add advanced capabilities during 3 years.
- Aim for TRL 6 demo of some of the technologies.
- Lower TRL demos of more advanced research contributions.
- Rigorous human-factors studies – human test-subject experiments.
- Performance evaluations of overall human-robot system.

Co-funded by the Horizon 2020 Framework Programme of the European Union
Public communication of science
- educational outreach work

Co-funded by the Horizon 2020 Framework Programme of the European Union
Thank you for your attention!

www.h2020romans.eu

r.stolkin@cs.bham.ac.uk