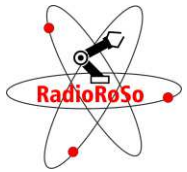
ECHORD++



RadioRoSo

Experiment presentation

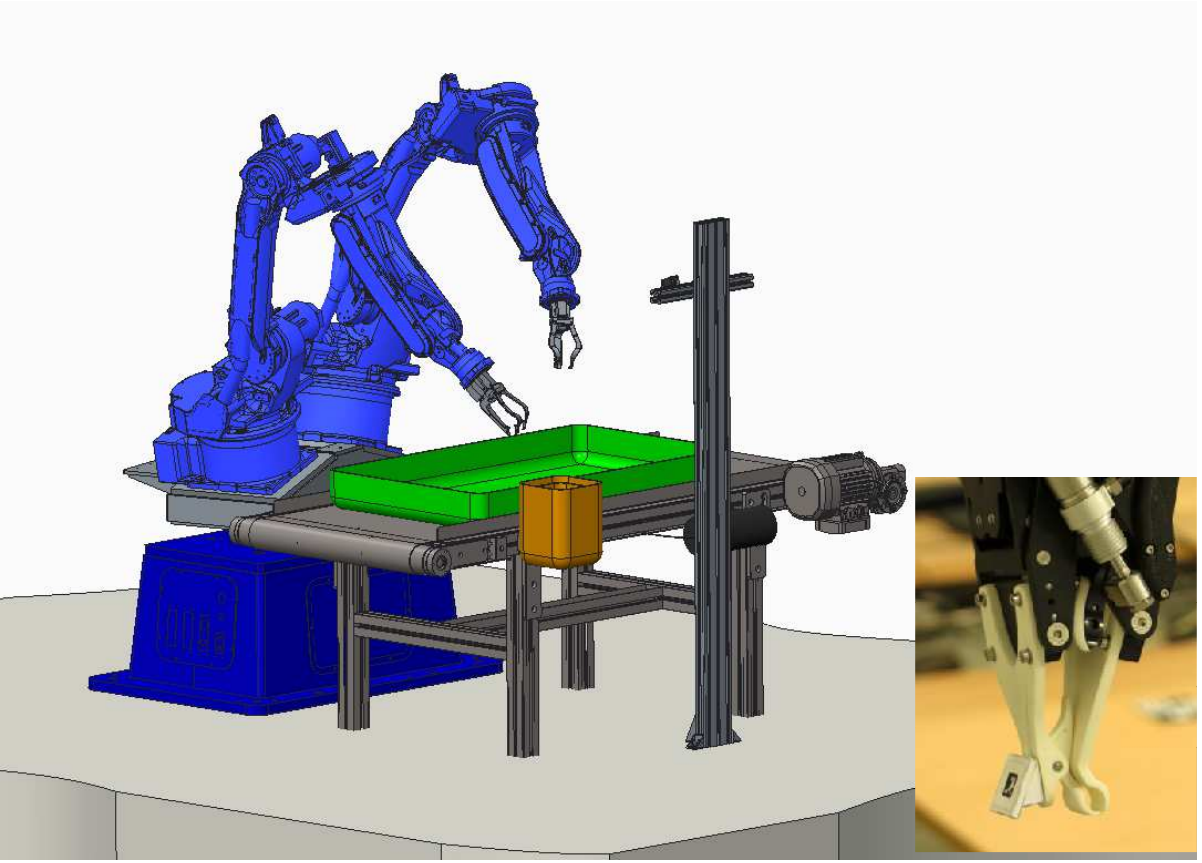
RadioRoSo Project Facts

- Running under the umbrella of EU FP7 project ECHORD++
  - ECHORD++ mission is to bring results from lab to market
- ECHORD++ experiments:
  - Impact oriented use cases with industrial user participation
- RadioRoSo is one of 16 experiments
  - Starting 1st September 2016
  - Duration 18 months (to end March 2018)

RadioRoSo Experiment Goal

- Demonstrate robust autonomous or semi-autonomous **sorting of nuclear waste.**
- Aiming at **reduction of cost** of nuclear plant decommissioning operations:
  - By improving process throughput.
- Improve **health and safety of workers** in such operations.
  - Typically the task is currently performed using manually operated master-slave robots and is tedious and error prone.

Experimental Testbed



- Two independent industrial 6-DoF manipulators (Motoman MA1400) on a rotating base
- ROS based control software.
- Temporary pinch-like grippers to be replaced by RadioRoso grippers

- Drivers for all hardware and basic software for collision-aware motion planning, calibration and control available from previous projects

First Year Application Scenario
Sorting of Magnox Fuel Element Debris

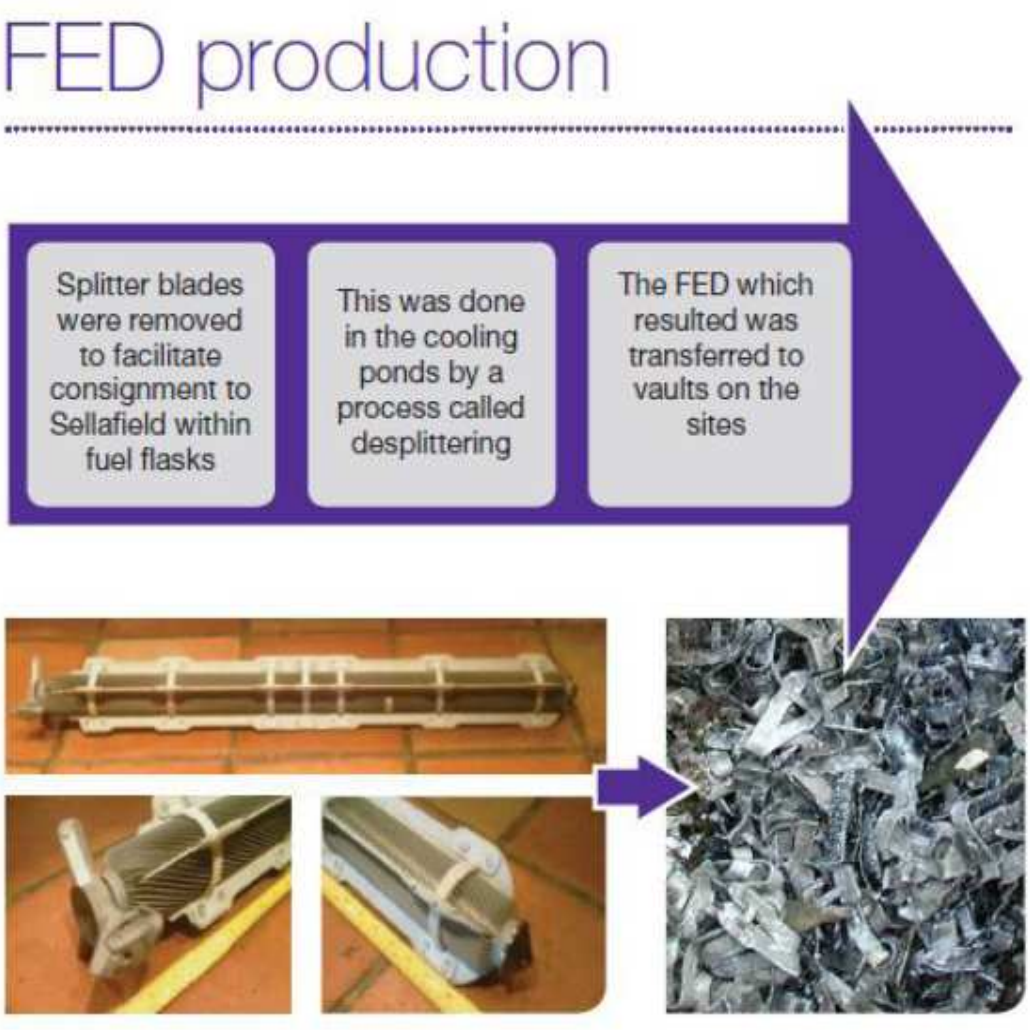
Fuel Element Debris (FED) from Magnox canisters broken down with a special machine

- uranium pellets immediately separated and reprocessed
- manganese/aluminum canister debris encapsulated in concrete and stored, or dissolved in acid
- springs (very radioactive) cannot be dissolve in acid and cannot be encapsulated in concrete

→ picked up and usually carefully stored in led pots

Large decommissioning market

- 11 Magnox power stations in UK (26 units or reactors), 1 in Italy, 1 in Japan at Tokai



https://magnoxsites.com

First Year Application Scenario

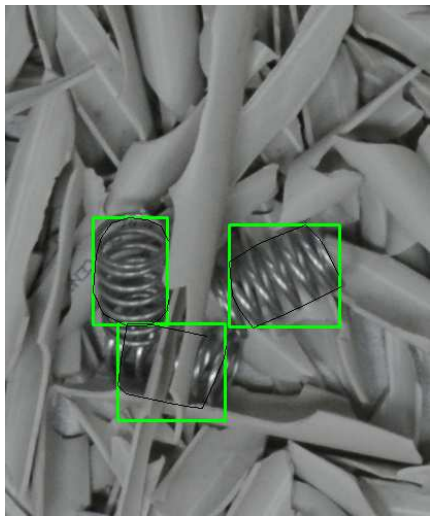
Sorting of Magnox Fuel Element Debris

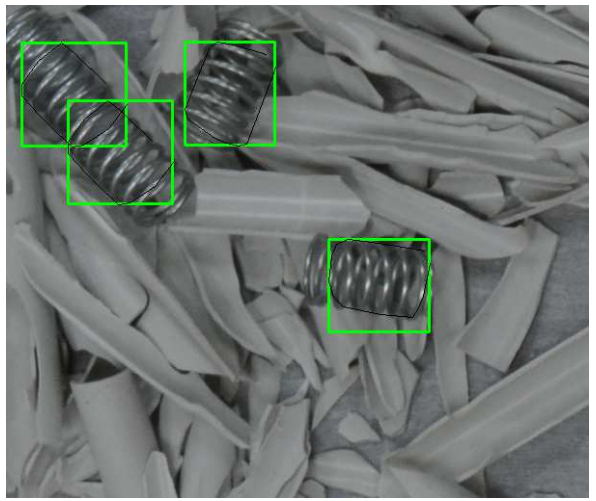
- Environment:
  - Debris is put in a tray containing both low-activity waste (swarf) and high-activity springs (hot-spots).
  - Robots, sensors and grippers should be resistant to radiation.
- Robotic Skills
  - Detects springs using vision (maybe partially occluded).
  - Robot grasps springs and puts them away.
  - If no spring visible radioactivity sensor used to detect remaining springs covered by swarf.
  - Steer the contents of the tray and repeat the process until all springs have been recovered.
- Targets
  - Improve sorting speed compared to humans

Current Results

Vision-based localization and grasping

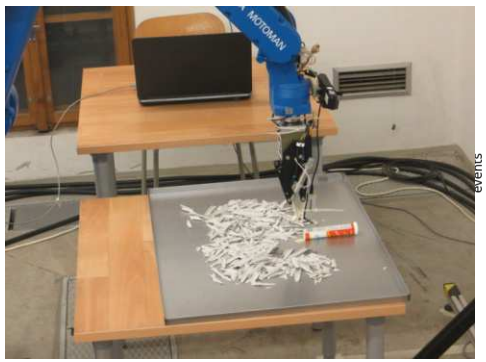
- Using overhead SLR camera.
- Highly accurate detection of springs (accuracy ~ 98%)
- Processing time < 2sec.
- Accurate orientation estimation (MSE ~ 10°)
- Grasping success ~ 80%

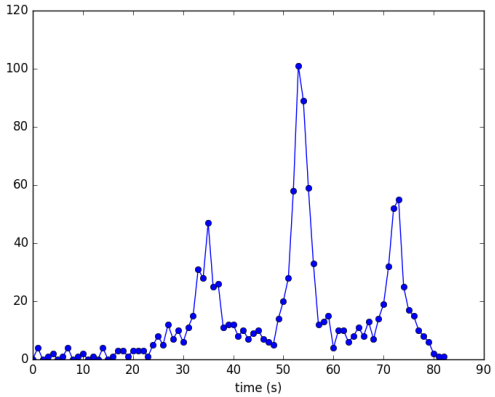




Current Results

Radioactivity sensor-based localization of hot spots





- Springs significantly more radioactive than the rest of the swarf and environment
- Detection of presence on the tray with a sensor developed by the partner SURO.
- Sensor placed on robot arm that scans the surface.
- Proof of concept with 3 detectors (ModuPix, TimePix, plastic scintillator)

Current Results
Radioactivity proof gripper

- Two independent hydraulic actuated axes
- Separate power unit
- Passive finger compliance
- Different grasping configurations for different tasks and object dimensions.
- The paired fingers can form 2- and 3-point closures with the single finger
- Wrapping of soft items for power grasp

- Design robust and modular following nuclear standards
- Different fingers can be mounted

Final Application Scenario

Sorting of Mixed Waste

- Processing of mixed nuclear waste with semi-autonomous robotic sorting cells
  - Waste comprises low and medium radioactive material
  - Presence of material with different size (small to large)
  - Presence of compressible material (always low radioactive and soft items such as garments, gloves, wires)
- Challenges
  - Properties of objects unknown e.g. geometry, material.
  - Significant clutter.
  - Harsh environment.
- Targets
  - Improve sorting speed compared to fully manual processing

Final Application Scenario

Sorting of Mixed Waste

- Envisaged Results
  - Demonstration of grasping of previously unseen objects from a heap.
  - Demonstration of grasping of objects of different size and compressibility (e.g. garments).
  - Evaluation of radioactivity resistance of gripper.
  - Use of tactile cues (tactile sensors embed on grippers) to assess grasp stability.
  - Demonstrate dual-arm manipulation capabilities for picking long objects (e.g. ropes)

More Info

- Project web-page: http://radioroso.ciirc.cvut.cz/
- Project videos: Youtube channel.
- Contact:
  - Project coordinator:
  - Sotiris Malassiotis (malasiot@iti.gr)

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