
CERN

Robotics and application techniques for remote inspection and survey

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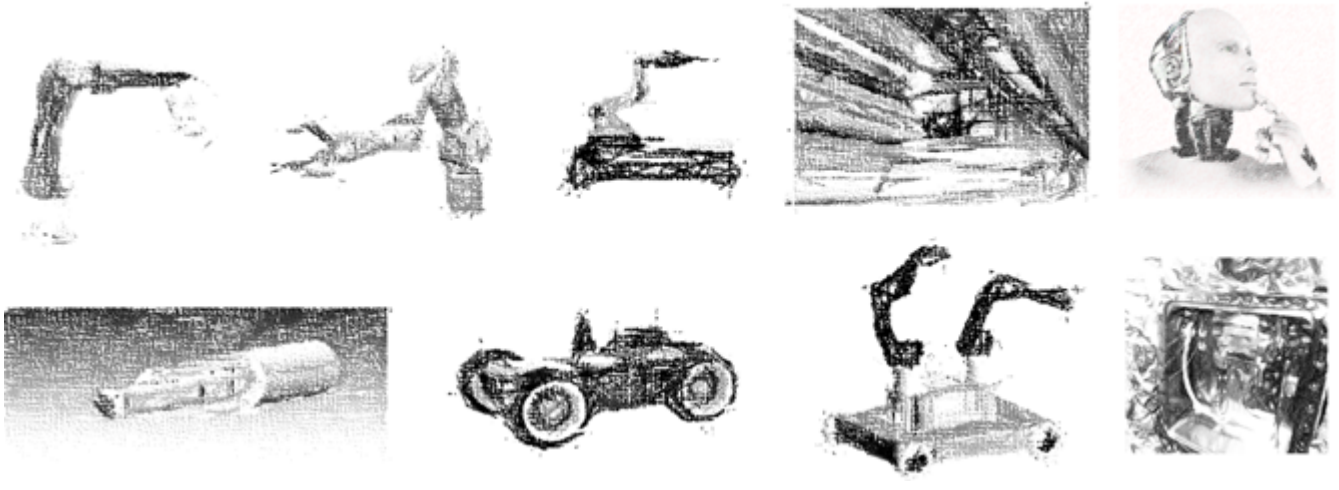
CERN



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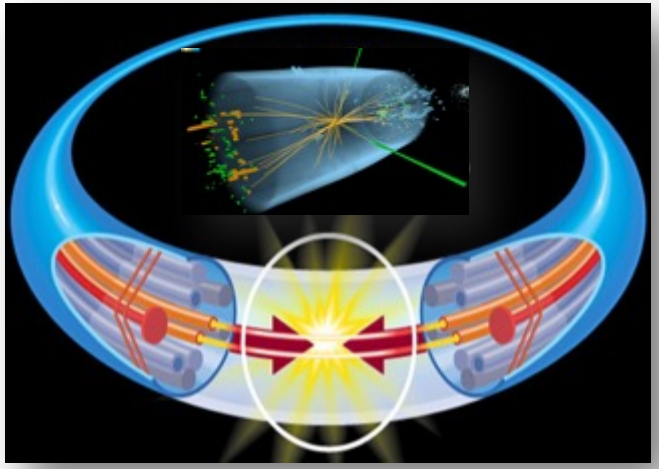
Robotics mandate at CERN

- The “mission” of tele-robotics at CERN may be resumed in the following:

Ensuring safety of Personnel
improving availability of CERN’s accelerators



Main needs for robotics in Big Science Facilities

- Non-destructing testing and inspection, remote operation and maintenance of **dangerous equipment and zones**
- In many particle accelerator facilities, areas and objects are **not designed and built to be maintained remotely**
  - ✓ Any intervention may lead to **"surprises"**

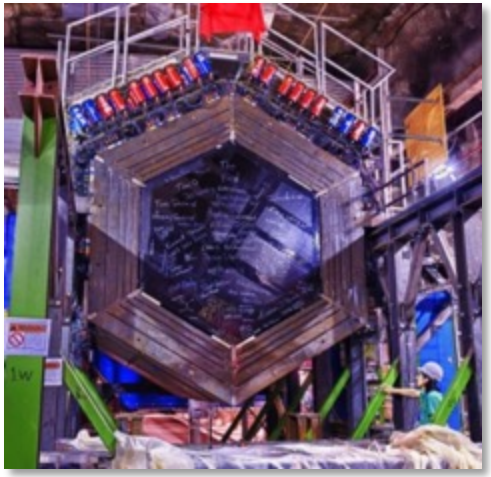
The Thorium nuclear reactor

North Area experimental zone at CERN

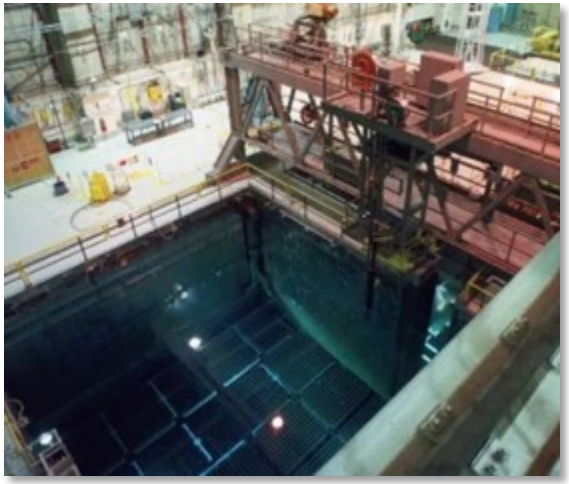
The European XFEL accelerator tunnel

Main difficulties for robotics in Big Science Facilities

- **Accessibility**, radiation, magnetic disturbances, delicate equipment not designed for robots, big distances, temperature, explosive atmosphere, communication, **time for the intervention**, **highly skilled technicians required** (non robotic operators), etc.



Antineutrinos experiment at FERMILAB

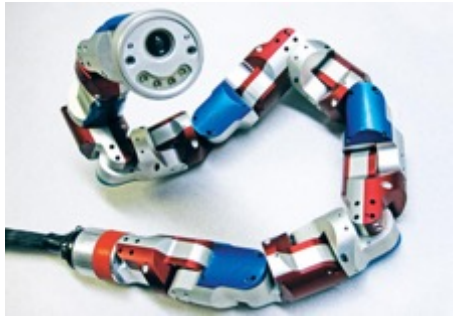


Clinton nuclear power plant

Compact Muon Solenoid experiment at CERN

Robotics for Big Science Facilities

- No single robotic solutions can fulfill the needs
- Mobility and manipulation capabilities are required
  - ✓ A “fusion” of several type of robot is needed



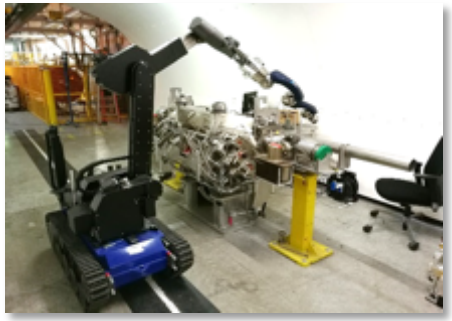
Robotics technologies are mainly used at CERN for:

- Safety
- Human intervention procedures preparation
- Environmental measurements and inspection
- Maintenance
- Quality assurance
- Post-mortem analysis
- Reconnaissance
- Search and rescue
- ….

Robotic Support for CERN [5] [19-22]

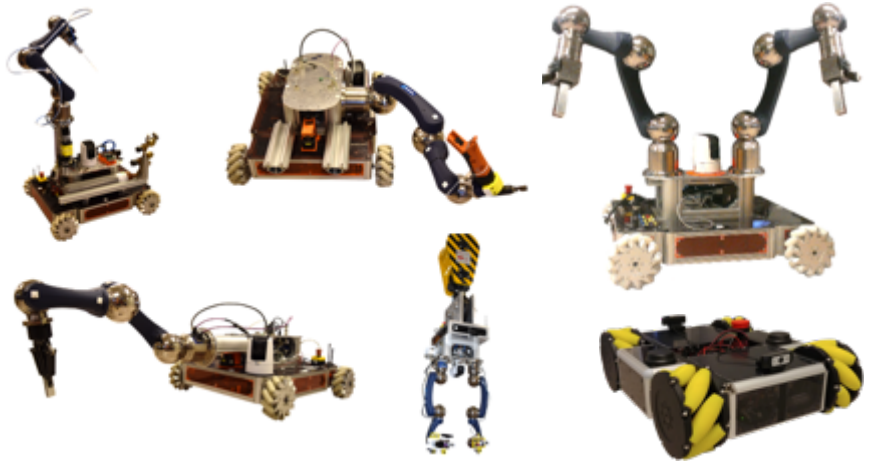
Telemax robot

Train Inspection Monorail (CERN made)



Teodor robot

EXTRM robot (CERN made)



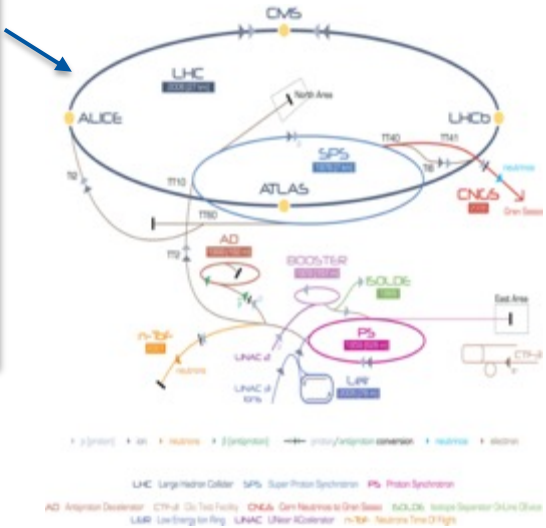
CERNBot in different configurations (CERN made)

[Mario Di Castro, Alessandro Masi, Luca Rosario Buonocore, Manuel Ferre, Roberto Losito, Simone Gilardoni, and Giacomo Lunghi. Jacow: A dual arms robotic platform control for navigation, inspection and telemanipulation. 2018.]

[Di Castro, Mario, et al. "i-TIM: A Robotic System for Safety, Measurements, Inspection and Maintenance in Harsh Environments." 2018 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR). IEEE, 2018..]

Main Robots integrated/controlled within facilities at CERN

Train Inspection Monorail

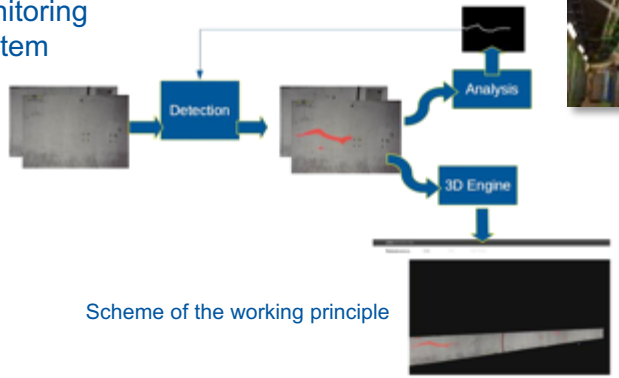


Main Robots integrated/controlled within facilities at CERN

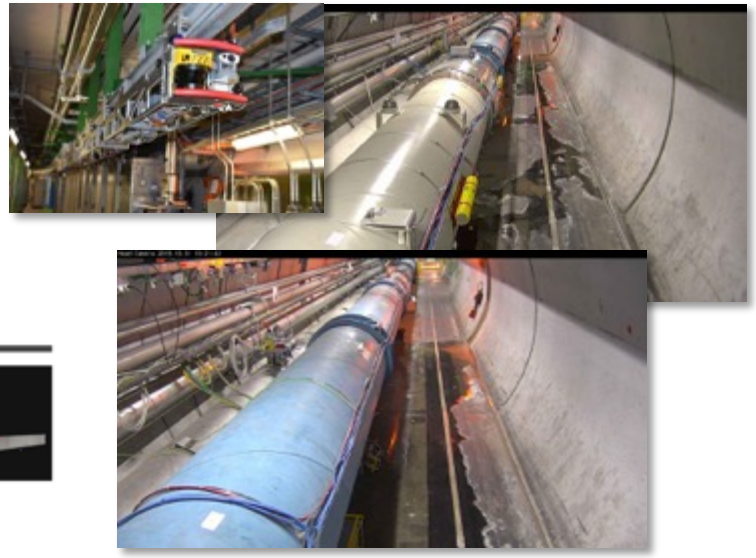
Online Tunnel Structure Monitoring

- Detects defects (cracks, water leaks, changes [13-14]) using a Mask-RCNN network.
- High-definition picture collection using TIM and CERNBot
- 3D reconstruction of wall using Structure from Motion techniques to compare time evolution of defects (available on web browser or virtual reality headset)
- **HL-LHC condition survey of existing infrastructure carried out with TIM to monitor impact of new civil works**

Structural Health Monitoring System

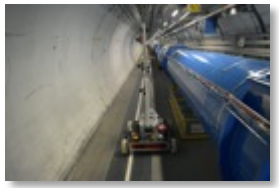


Scheme of the working principle



Example of water leak found by TIM2 during TS3 2018

HD camera system for tunnel dome view



System integrated also on other robots

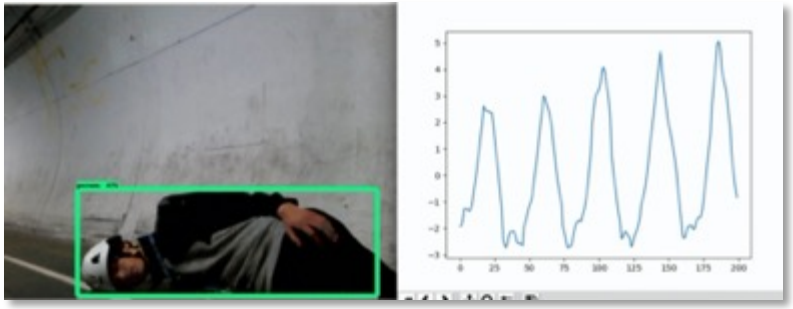
HD cameras mounted on TIM

Example of crack found using vision based machine learning techniques

People recognition and vital monitoring #1

- Machine learning techniques enhance people detection and vital signals monitoring at distance
- People search and rescue is of primary interest in disaster scenarios
- People monitoring during rehabilitation

Vision system (2D Laser, radar, thermal and 2D-3D camera)



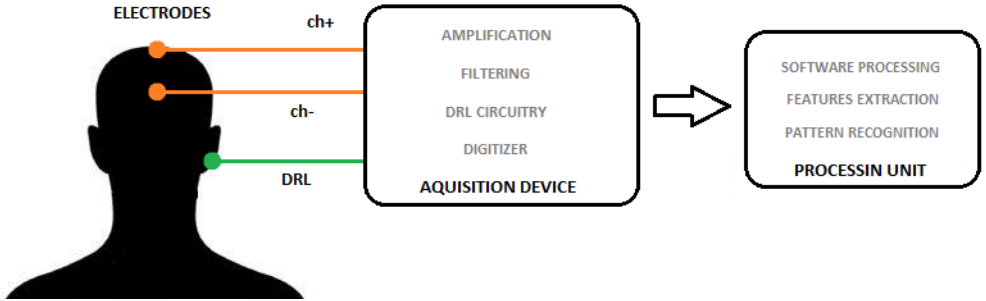
Online respiration monitoring

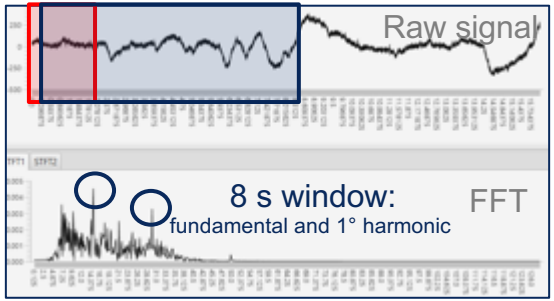
Online people recognition and tracking

Brain-Robot Interface for robot arm control

- Online analysis of brain signal
- Augmented reality glasses used for commands display
- Eyes focus point detected by CNN processing Steady State Visual Evoked Potentials (SSVEP [15]) which are synchronous responses produced in the visual cortex area when observing flickering stimuli

Hardware used for the brain monitoring





Example of brain activity monitoring

Brain-Robot Interface for robot arm control

Thank you for your attention

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