CEBAF Accelerator Tunnel Robot Project

Chris Tennant | Jefferson Lab

"Robotics Use in Accelerators, Targets and Detectors"

March 23, 2022

Motivation and Goals

Motivation

- <u>d</u>ull: repetitive and/or tedious tasks
- <u>d</u>irty: tasks in unpleasant environments
- <u>d</u>angerous: tasks where potential for physical harm to personnel exists

Goals

- remote inspection
- remote sensing (mobile diagnostic) — *passive*
- telemanipulation — *active*

With the aid of robotics technologies, inspection tasks can be done routinely with the transportation, energy, and communications infrastructure remaining in service, rather than the traditional "take it out of service and then inspect" scenario.

A Roadmap for US Robotics
From Internet to Robotics
2016 Edition

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Remote Inspection Robots from Industry

BRAIN-POWERING AUTONOMOUS ROBOTS

WE DIGITALIZE INSPECTION

REQUEST A DEMO

Meet **ANYmal**, your new inspector

WATCH DEMO

Spot Inspection Solution

LEARN MORE >

Remote detection and localization of gas leaks with autonomous mobile inspection robots in technical facilities

https://www.energy-robotics.com/
https://www.anybotics.com/anymal-autonomous-legged-robot/
https://www.bostondynamics.com/

ROBOTICS/UNMANNED SYSTEMS

How a Robotic Revolution Could Replace Hundreds of Thousands of Drilling and Maintenance Roles

Oslo-based consultancy Rystad Energy sees the potential for robots and automation to replace up to 400,000 roles in North America, Europe, and Russia by 2030. The timeline is not guaranteed, though, and will move at a speed set by human decision making.

March 30, 2021 By Trent Jacobs
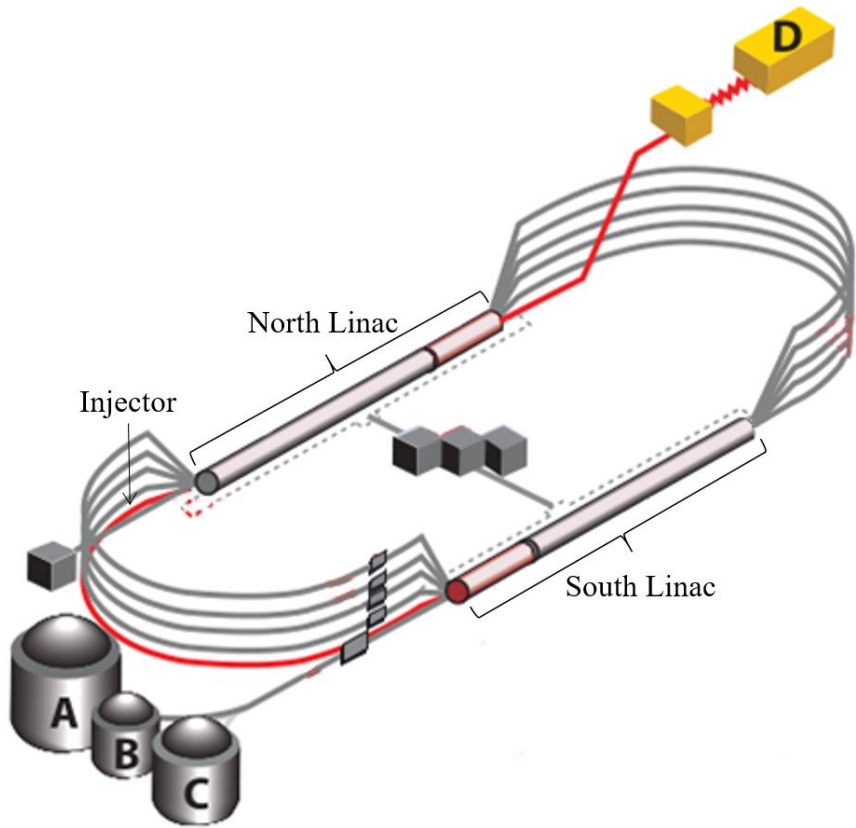Journal of Petroleum Technology

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Challenges

- challenges for deploying robots in an accelerator environment
  - ✓ radiation
  - ✓ communication
  - ✓ long distances
  - ✓ restricted space and/or obstacles
  - ✓ SME in the loop
  - ✓ safety
    - *to robot*
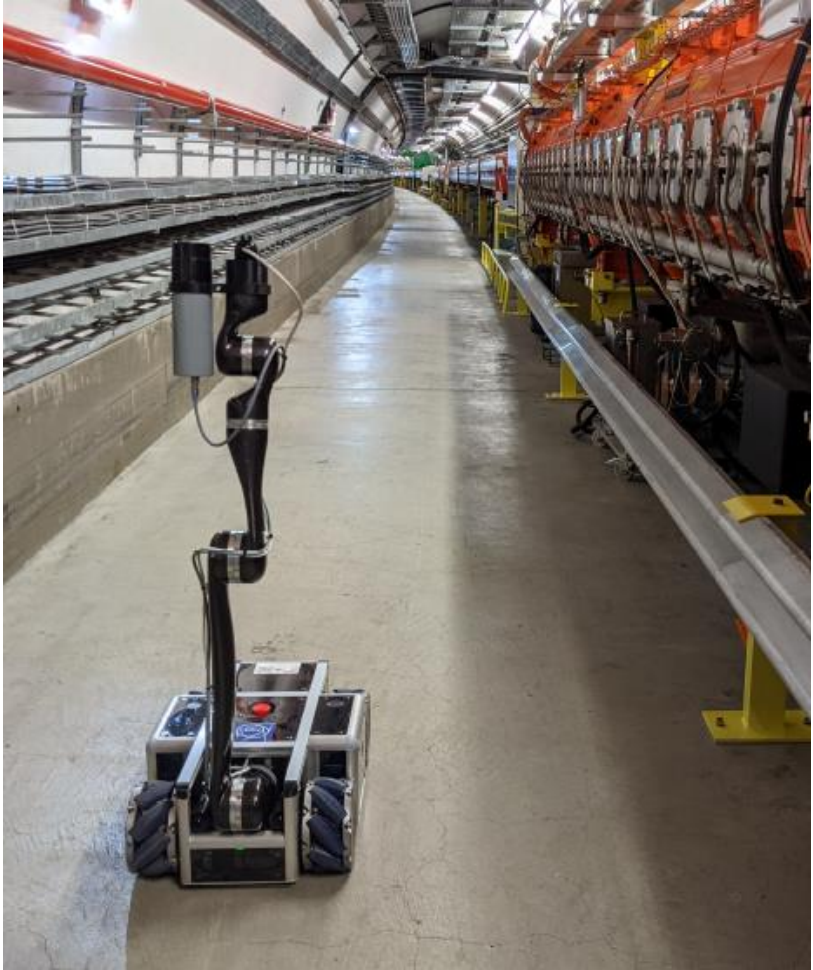   - *to equipment*
    - *to personnel*

CEBAF tunnel construction

CEBAF: Recirculating Linac

North Linac

Injector

South Linac

A
B
C

D

- different accelerator topologies require different solutions

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Other Accelerator Constraints

MARWIN: Localization of an Inspection Robot in a Radiation-exposed Environment

Andre Dehne, Nantwin Möller, Thorsten Hermes

Article

Omnidirectional Robotic Platform for Surveillance of Particle Accelerator Environments with Limited Space Areas

Carlos Prados Sesmero, Luca Rosario Buonocore * and Mario Di Castro

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Areas of Research

- human-robot interaction

  "…robotic products are expected to not only be intuitive, easy to use, and responsive to the needs and states of their users, but they must also be designed with these differences in mind, making human-robot interaction a key area of research"

  ✓ control: teleoperation (passive tasks), haptic feedback (active tasks)

  ✓ advanced control: speech recognition, gesture recognition, brain-computer (robot) interface, virtual reality

  ✓ robot: presence with other personnel in accelerator environment

- training environment

  ✓ deploying a robotic system should be seen as minimizing potential for risk, not exacerbating it

- designing machines/components that are manufactured with easily accessible interfaces (i.e. robot-friendly) for routine maintenance operations

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Advances at CERN

Telemax robot

EXTRM robot with single arm (CERN made)

The TIM (CERN made)

Teodor robot

EXTRM robot (CERN made)

CERNbot (CERN made)

CRANEbot (CERN made)

SPS MKP oilers refill

Remote radioprotection surveys

Cabling status inspection
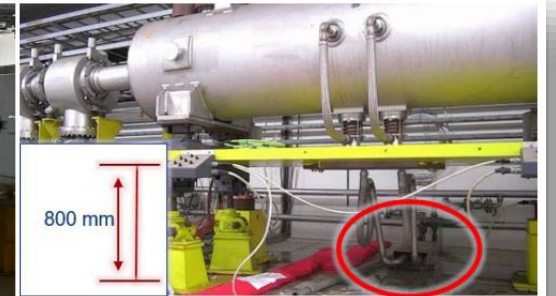
Temperature sensor installation on AD target

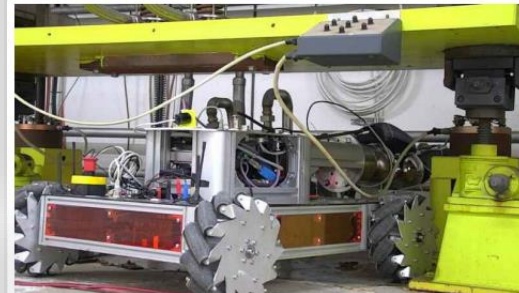Tunnel structure monitoring

Remote Vacuum Leak detection

(a) The two robots in the accelerator tunnel navigating to the water leak location seen from the safe human station

(b) The location of the water leak below the accelerator component

800 mm

(c) The difficult accessibility of the CERNbot robot seen from the support robot

(d) The pouring of the resin in the built metallic box for the water leak fix

FIGURE 20. Different pictures from the water leak in-situ repair intervention.

FIGURE 21. Robots in operation dismounting a beam dump water disconnection at CERN.

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Summary

- in general, the only reliable robotic solutions that exist in industry are for repetitive tasks
  - ✓ there is no single, one-size-fits-all solution
- DOE EM: similar initiative with specific application to scientific user facilities is long overdue
  - ✓ perhaps this workshop will serve as the impetus
- we need to start leveraging robotics "...as a tool [that] should complement, as well as supplement, the current DOE workload"[1]

DOE EM RESEARCH AND TECHNOLOGY ROADMAP
ROBOTICS AND REMOTE SYSTEMS FOR NUCLEAR CLEANUP

2018

U.S. DEPARTMENT OF ENERGY | Environmental Management

[1]W. Chun, "Future of Work with Robotics", 44th Waste Management Conference, (2018).   9

Thank You.