AI-Powered Waste Intelligence: Enhancing Environmental Remediation Through Autonomous Robotics and Data Fusion
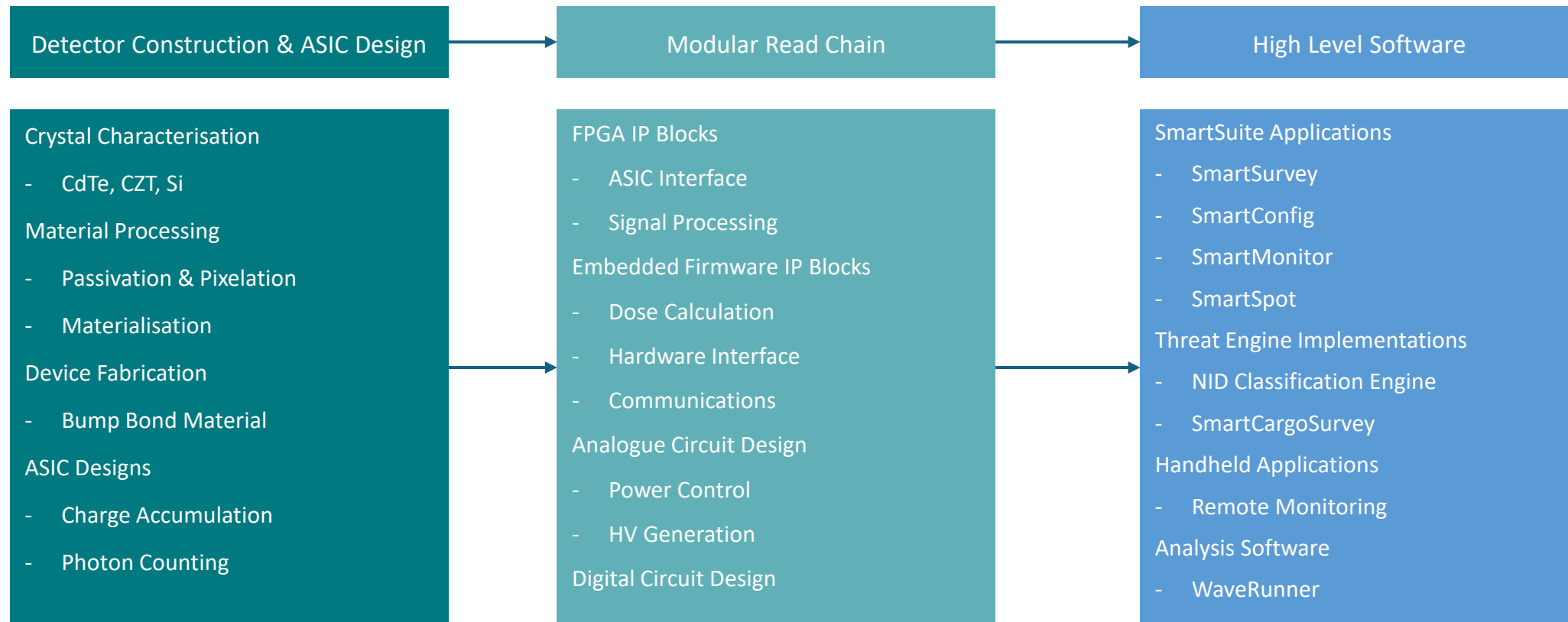
About Us

- Research & Development

- Founded in 2008

- Privately Owned

- Headquarters in the United Kingdom

- Offices in Japan, United States and South Korea

Capabilities

Detector Construction & ASIC Design	Modular Read Chain	High Level Software

Detector Construction & ASIC Design

Crystal Characterisation

- CdTe, CZT, Si

Material Processing

- Passivation & Pixelation

- Materialisation

Device Fabrication

- Bump Bond Material

ASIC Designs

- Charge Accumulation

- Photon Counting

Modular Read Chain

FPGA IP Blocks

- ASIC Interface

- Signal Processing

Embedded Firmware IP Blocks

- Dose Calculation

- Hardware Interface

- Communications

Analogue Circuit Design

- Power Control

- HV Generation

Digital Circuit Design

High Level Software

SmartSuite Applications

- SmartSurvey

- SmartConfig

- SmartMonitor

- SmartSpot

Threat Engine Implementations

- NID Classification Engine

- SmartCargoSurvey

Handheld Applications

- Remote Monitoring

Analysis Software

- WaveRunner

The Global Landscape:

- **150+ Nuclear Reactors** worldwide set for decommissioning in the next 20 years.

- **Massive Nuclear Waste Accumulation** – handling and sorting are expensive and hazardous.

- **Worker Safety Risks** – Radiation exposure during manual sorting.

- **Current Methods Are Costly & Inefficient** – Manual sorting slows down the process and increases operational costs.

- **Regulatory Compliance Challenges** – Need for precise sorting to comply with safety standards.

The Problem:

- Human exposure to radiation

- Manual handling = slow + expensive

- Growing volume of legacy waste
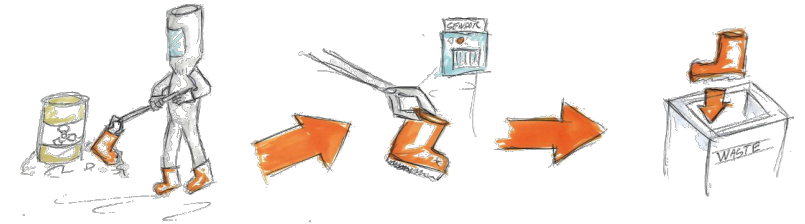
Humans assess and sort contaminated into the appropriate stream for disposal.

Challenges in Manual Waste Handling:

- **Radiation Exposure:** Workers are at risk of radiation exposure during manual sorting.

- **Inefficiency:** Manual sorting is slow and prone to errors, especially with complex waste materials.

- **High Costs:** Labor-intensive processes increase operational costs in nuclear decommissioning.
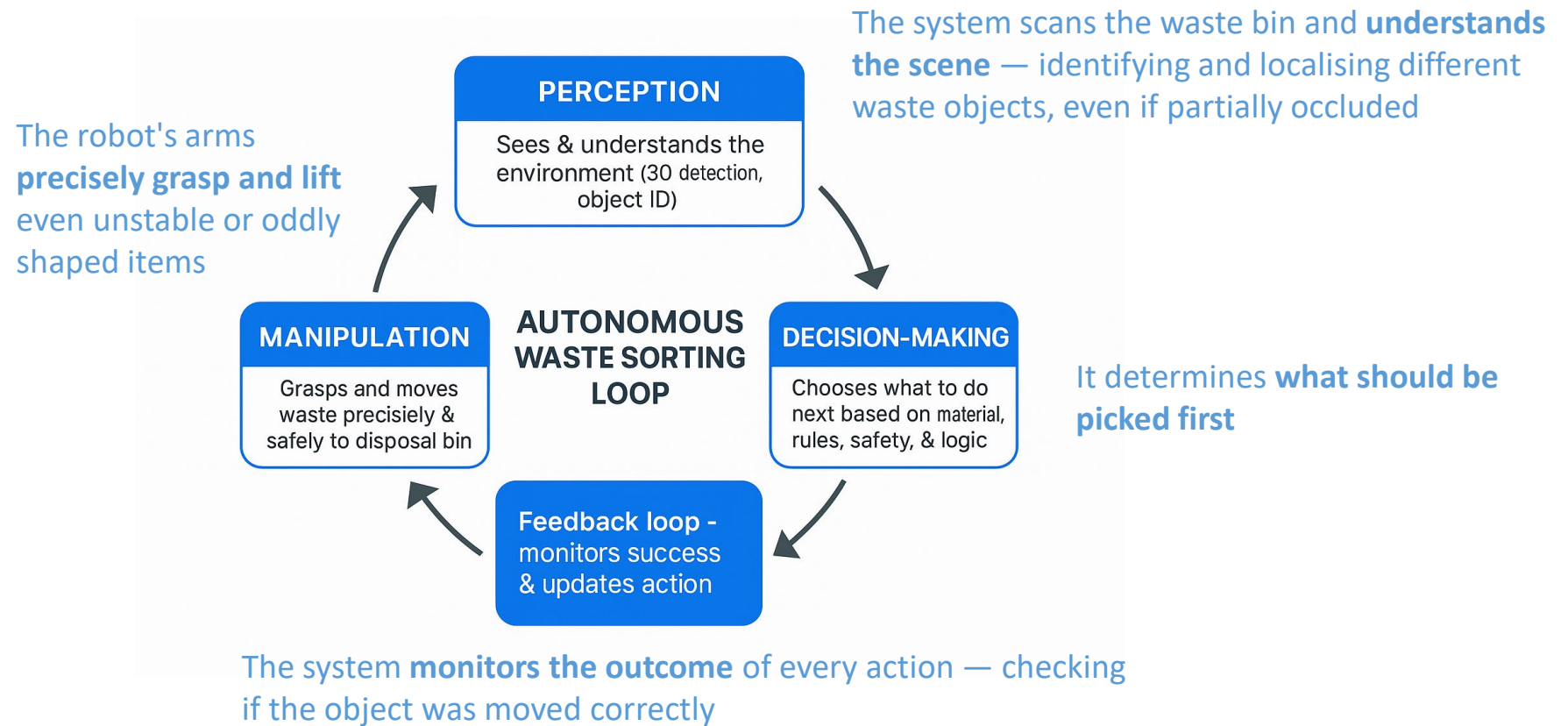
Role of Robotics & AI:

- **Safety:** Robots handle hazardous materials, reducing human exposure to radiation.

- **Efficiency:** AI and robotics enable faster and more accurate sorting of waste materials.

- **Scalability:** Automated systems can handle large volumes of waste.
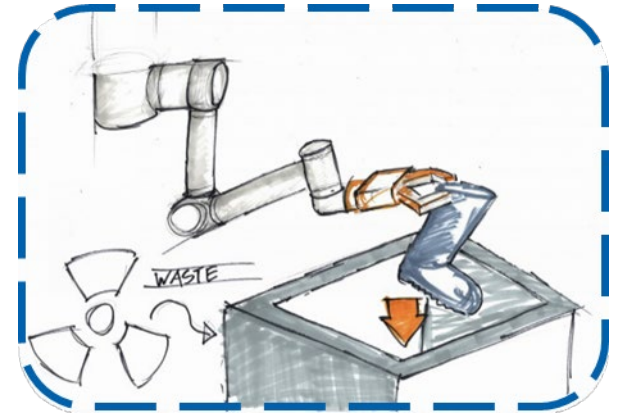
A robot can mimic human activity via machine learning and allocate the waste the appropriate stream.
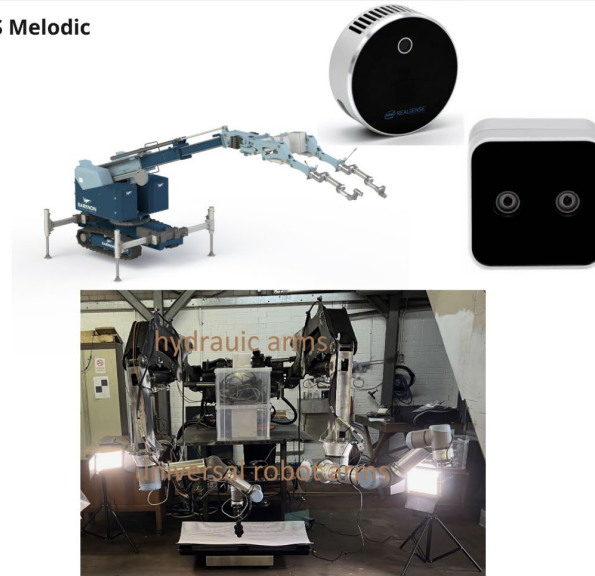
Working Overview

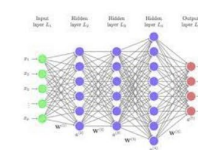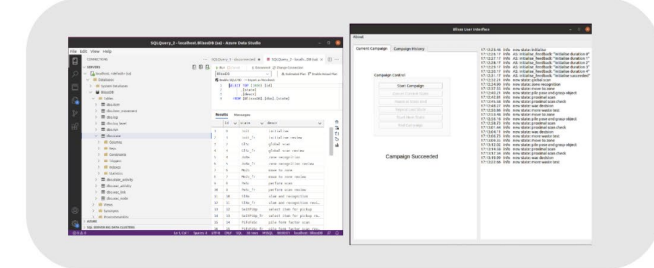The system scans the waste bin and **understands the scene** — identifying and localising different waste objects, even if partially occluded

The robot's arms **precisely grasp and lift** even unstable or oddly shaped items

PERCEPTION

Sees & understands the environment (30 detection, object ID)

MANIPULATION

Grasps and moves waste precisiely & safely to disposal bin

AUTONOMOUS WASTE SORTING LOOP

DECISION-MAKING

Chooses what to do next based on material, rules, safety, & logic

Feedback loop - monitors success & updates action

It determines **what should be picked first**

The system **monitors the outcome** of every action — checking if the object was moved correctly

Approach

ROS 18.04

ROS Melodic

hydrauic arms

universal robot arms

ROS 20.04

ROS Noetic

SQL database   **State Machine**

Deep learning recognition

Computer vision
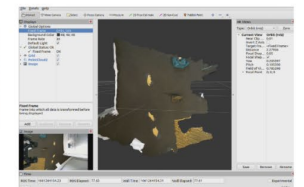
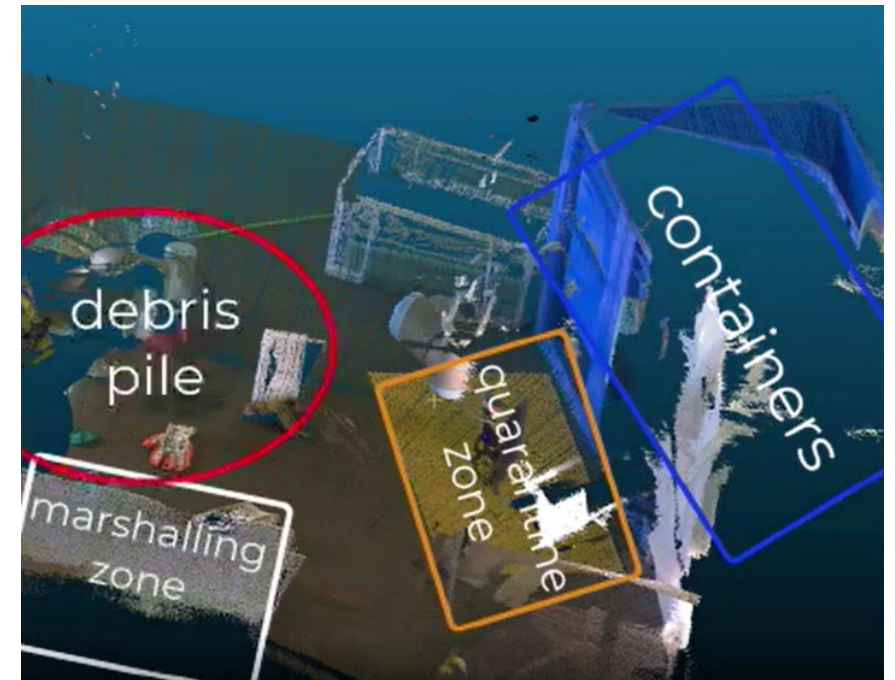**SLAM (simultaneous location and mapping**

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Sort & Segregation of Nuclear Waste: The Need

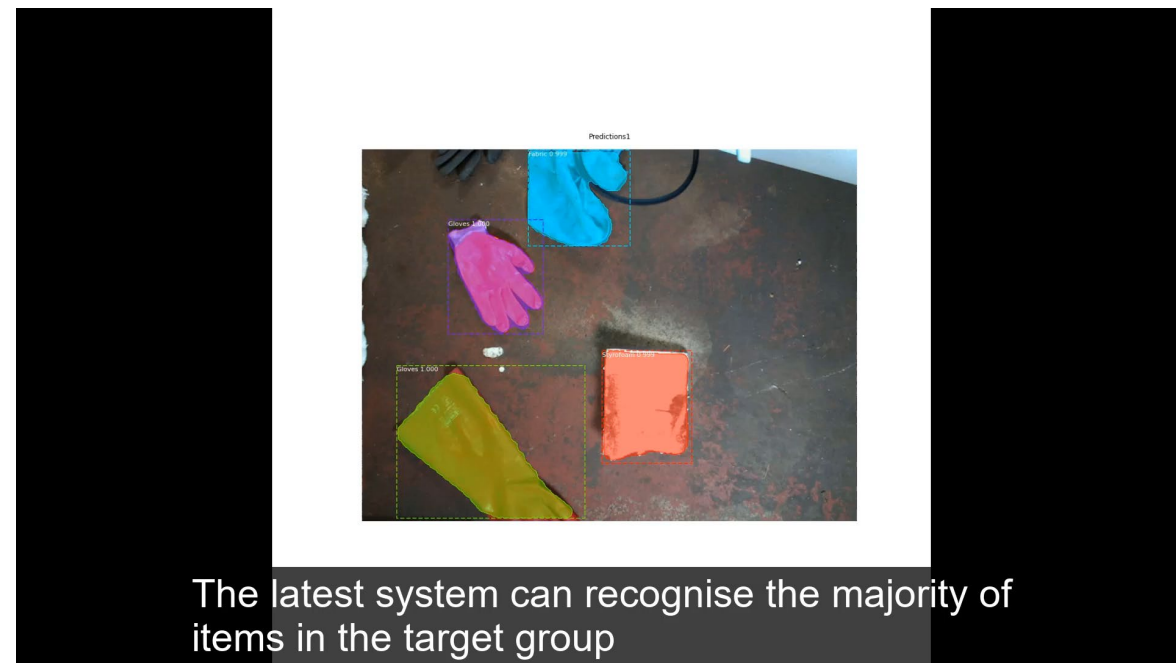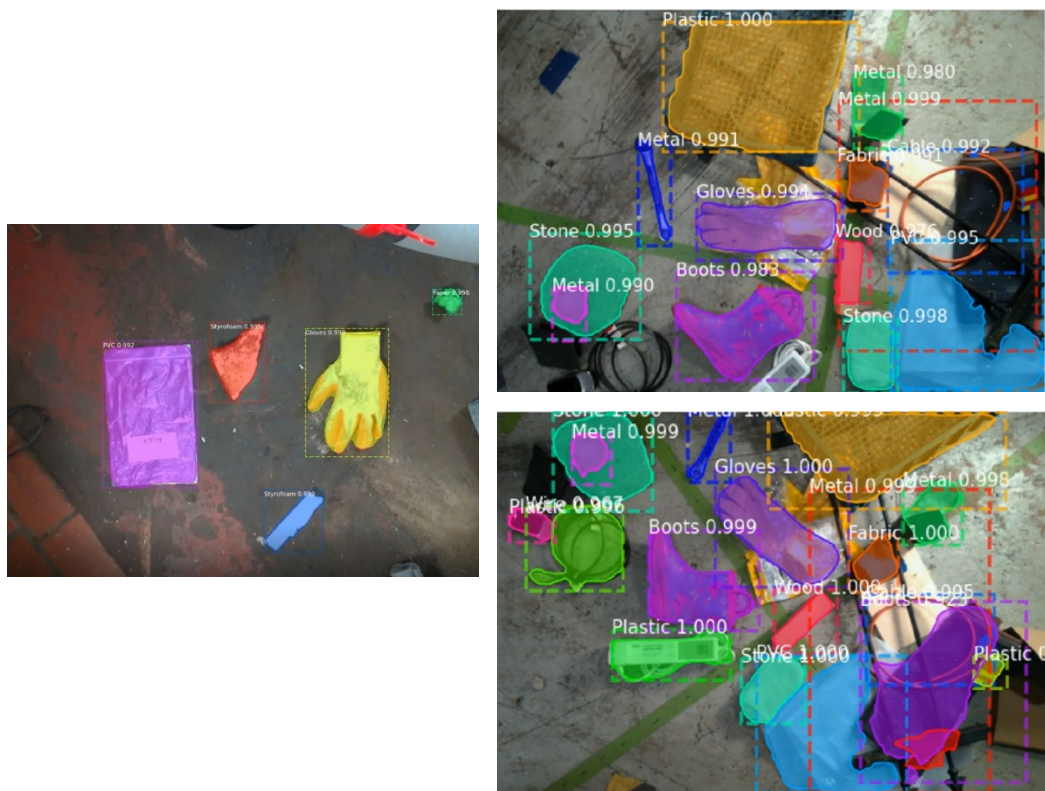**How to Automate Nuclear Waste Disposal and Storage?**

Key Requirements

- Reduce waste, recycle

- Reduce the manual sorting & segregation process

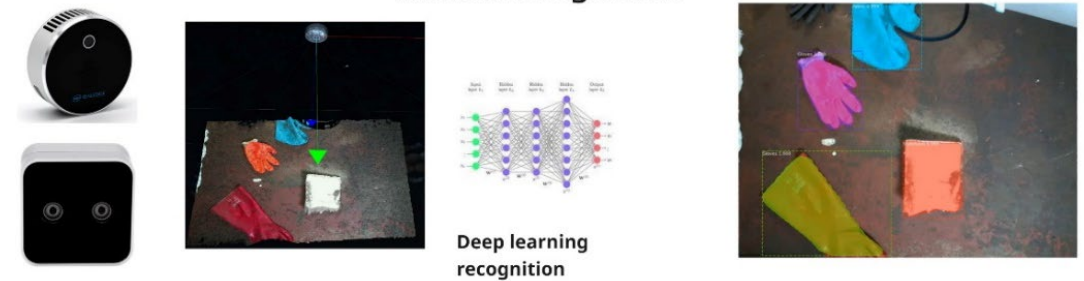# Sort & Segregation of Nuclear Waste: Object & Material Detection

The latest system can recognise the majority of items in the target group

Sort & Segregation of Nuclear Waste: Material Identification

- Initial identification via Machine Learning (deep learning CNN)

- Orthogonal datasets for mass and paramagnetic materials.

- Laser ablation techniques

- Hyperspectral imaging techniques
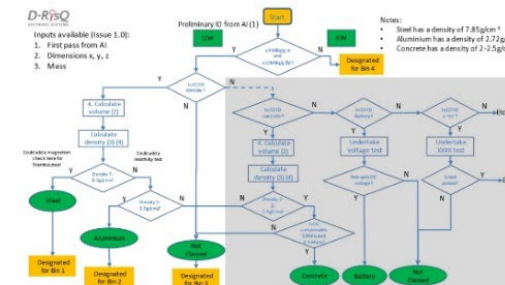

Material identification

Initial Recognition

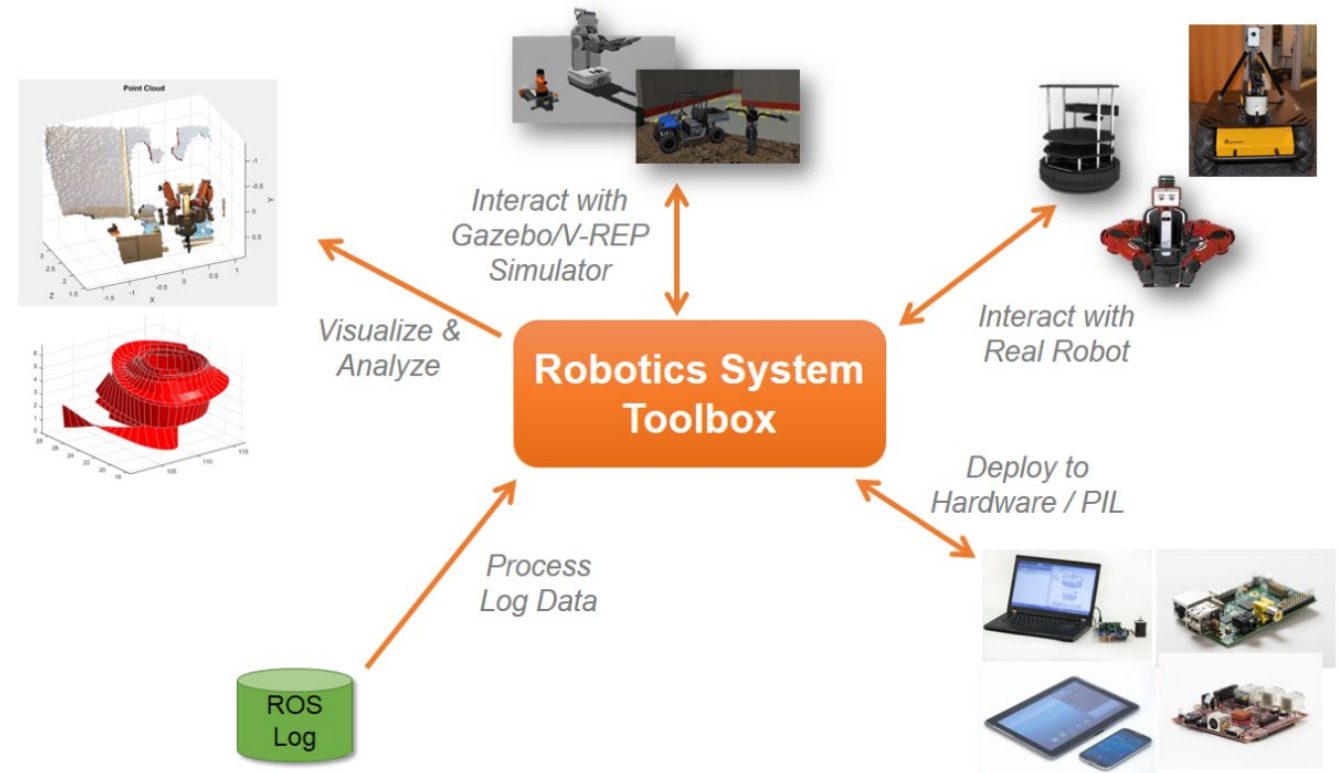Deep learning recognition

Orthogonal Data   ✓ now   ✓ future

- ✓ density
- ✓ ferro-magnatism
- ✓ voltage test
- ✓ compressable
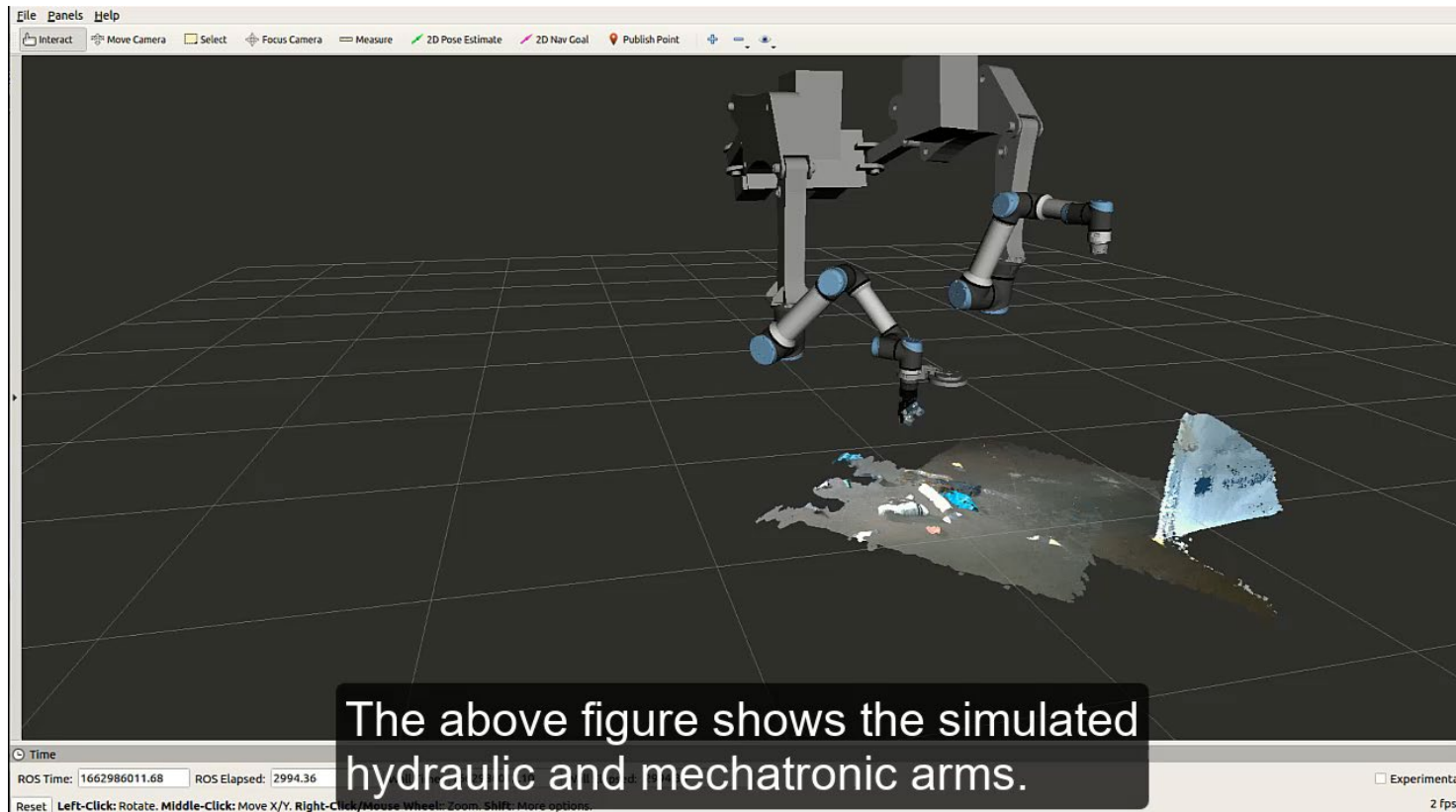- ✓ laser-induced breakdown spectroscopy (LIBS)

Sort & Segregation of Nuclear Waste: Sensing & Interpretation

- Pose and Grasp Estimation
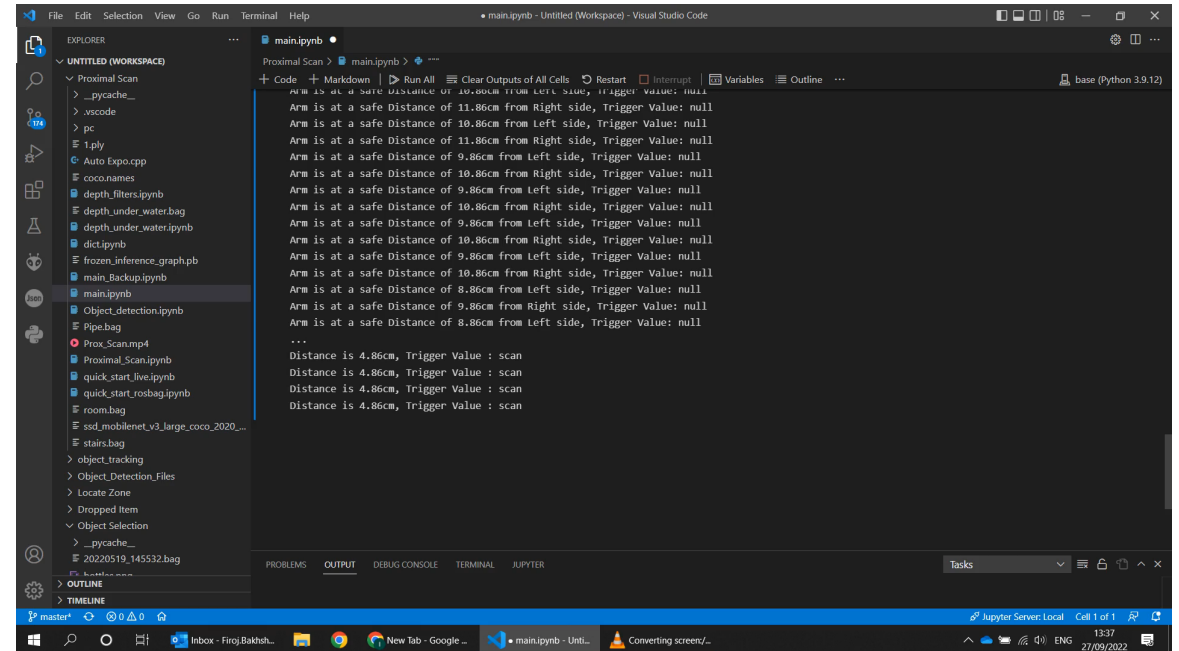
- Proximal Tracking

- Form Factor Scanning

Sort & Segregation of Nuclear Waste: Pose & Grasp

Sort & Segregation of Nuclear Waste: Contamination Mapping

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Sort & Segregation of Nuclear Waste: BLISSS

- Autonomous sort and segregation of waste

- Verified autonomy

- Identification of materials, radiation

  - levels and ability to document findings

- Mobile platform

Thank You

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