Sort and Disrupt with Reconfigurable Autonomy

Introduction

The Reconfigurable Autonomy project is developing an autonomous computer architecture for a sort and disrupt scenario to enhance robotic waste processing in nuclear decommissioning.

The developed system identifies and classifies incoming waste using information, from cameras, processed using computer vision algorithms. Using artificial intelligence, for example a rational agent, can then make decisions on the optimal ways to process the waste material. The system then manipulates and disrupts the waste using an intelligent control system. This will be tested in the laboratory using a Kuka IIWA robotic arm (depicted in Fig. 3). This will then be scaled to operate on an industrial robot, the Kuka KR-180 in Fig. 4, capable of lifting 180kg.

Sort and Disrupt

In the sort and disrupt scenario (shown in Fig. 1) canisters start within an import container. They must first be safely moved to a processing table, avoiding collision with obstacles. A decision to disrupt using an appropriate tool is then made based on the nature of the canister and whether it is already free from voids. Once disrupted it can be grouted to ensure voids are removed.

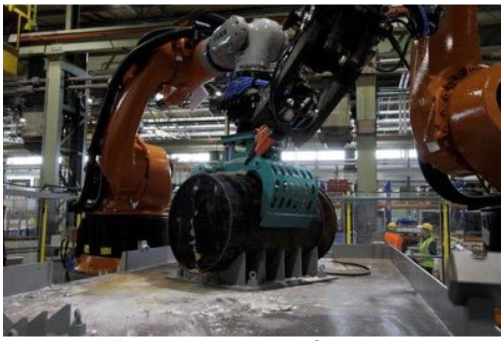

Fig. 1. Disrupting a Canister

Realising an Intelligent System

The sort and disrupt scenario process can be defined as a set of operations, enacted by a set of components as shown in Fig. 2:

Vision System: Responsible for identifying the canister and providing information about its state, aiding the decision making process of the agent, and localisation of objects for manipulation by the robot arm.

Agent: Responsible for taking decisions on the steps needed to process the canister, for providing instructions to the arm on how to deal with objects, which tool to use and where disruption should occur.

Robotic Arm: Responsible for providing information about the weight of the object. Enacts the agent instructions for moving the objects, selecting appropriate tool and indication of the disruption location.

Reconfiguration options: Multiple cameras around the system provide on-board and surrounding options. Redundancy in processing allows re-allocation of tasks.

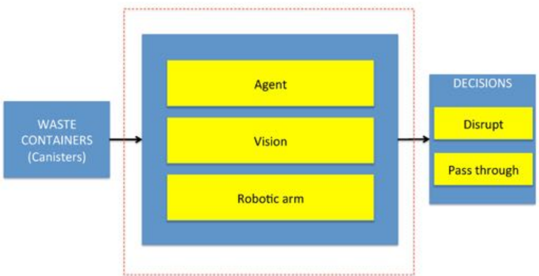

Fig. 2 Computing Components

Laboratory Scenario

The laboratory scenario, shown in Fig 3, uses a Kuka IIWA arm, redundant computer stations and two camera systems: A kinect on the arm itself and a set of surrounding cameras. The canisters are simulated using smaller consumer tins.

The agent makes decisions about the disruption tool and the selected site. This is shown by the selection of different coloured laser pointers which are then tracked across the canister.

Separate computing nodes provide redundancy in processing which can be switched as required by the rational agent.

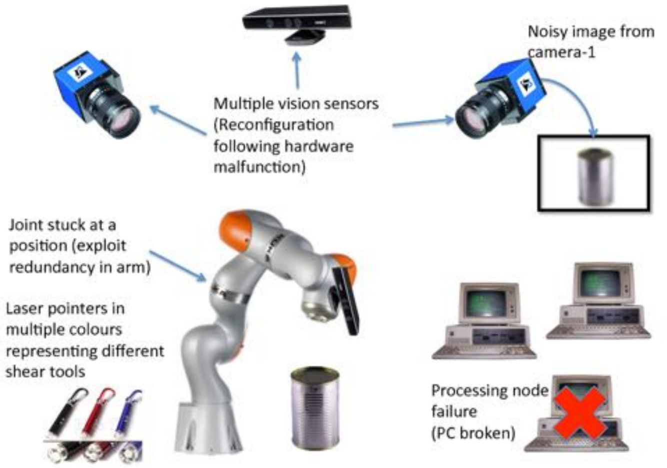

Fig. 3. Sort and Disrupt Laboratory Scenario

Scaling to Industrial Robots

NNL has a Kuka KR-180 (shown in Fig. 4), controlled by a KRC4 controller with a smart pad interface.

Control Interface: The computing components will be created using the Robot Operating System. This allows a distributed network, facilitating reconfiguration (Shown in Fig. 5). This will interface to the KRC4 through a network interface to a controller written in the Kuka Robot Language (KRL).

Identical protocol for communication between vision system and agent, and agent and arm for demonstrator and industrial applications.

Fig. 4. Kuka KR-180

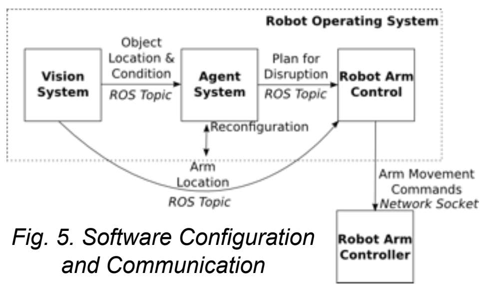

Fig. 5. Software Configuration and Communication

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