A General Architecture for Flexible Autonomous Systems

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Introduction

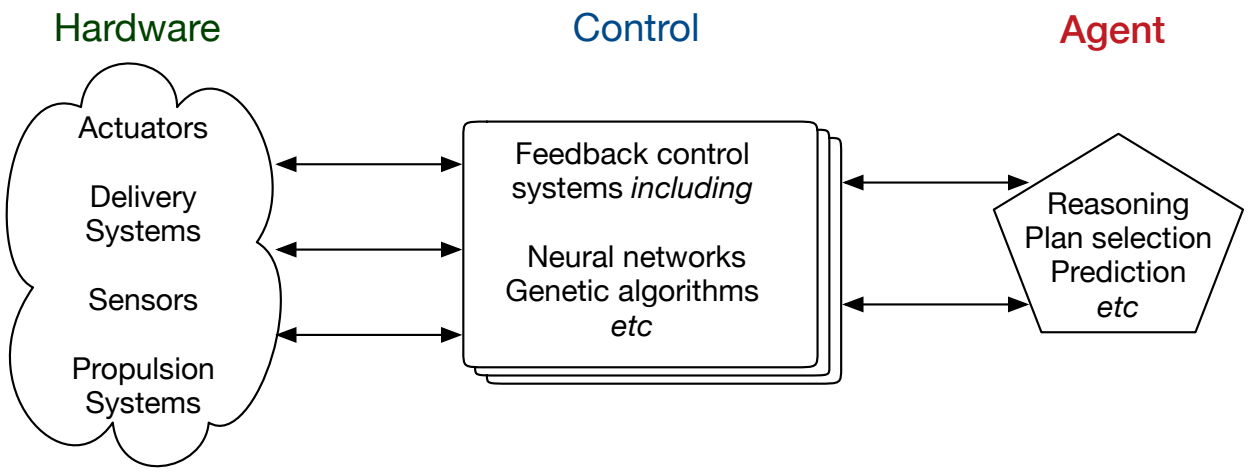
Autonomous systems are increasingly popular in different scenarios:

- Working environments dangerous and hazardous for humans.
- Industrial environment where the operator might need to be physically remote, or control a large number of robots, or perform a repetitive task.

The basic tasks include deciding:

- what are the appropriate action for a particular scenario
- what is the appropriate object to be acted on
- what is the appropriate order of action executions
- what is the appropriate way of performing every action

Hybrid Agent Architecture



In the hybrid architecture continuos control systems are overseen by the rational agent.

- The agent takes high-level and discrete decisions.
- The control systems are engaged in continuous feedback with the environment and carry out the decision taken by the agent.

Rational Agent

The rational agent make decisions about what action to perform, given its *beliefs*, *desires*, and *intentions*.

A rational agent is also able of:

- Have explicit reasons for choosing an action instead of another.
- Be aware of the system components and their expected behaviour.
- Monitor the system's performance.
- Reconfigure its software to overcome deficiencies.

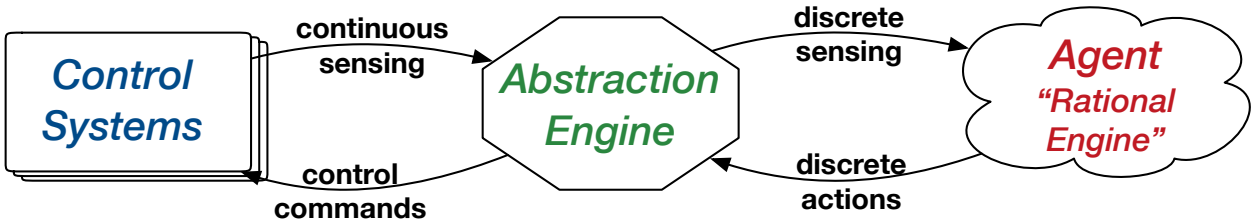
Reconfigurability

The reconfiguration process is required when the systems need to cope with changes, in the hardware or in the environment, or to adapt to failures or damages of some of the sub-system, potentially allowing the agent to still achieve its goal.

Different reconfiguration possibilities:

- Reconfiguration due to the hardware.
- Reconfiguration due to the control.
- Reconfiguration due to the agent.

Architecture of the Rational Agent: Abstraction



The abstraction engine is responsible of:

- translating the continuous data coming from the continuous system into discrete abstractions of this (**perceptions**), understandable to the agent.
- translating all the decisions and action invocations coming from the agent into proper commands for the control subsystems.

Architecture of the rational agent: Knowledge base

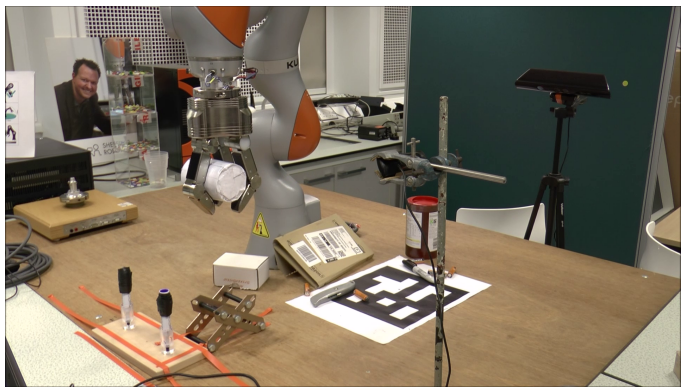
All the information that need to be shared by both the high-level systems and control systems are stored in the knowledge base.

- A section for perception, describing information about the external world.
- A description of the system components and their capabilities.
- Program data (route plans, maps, metrics, models,...).

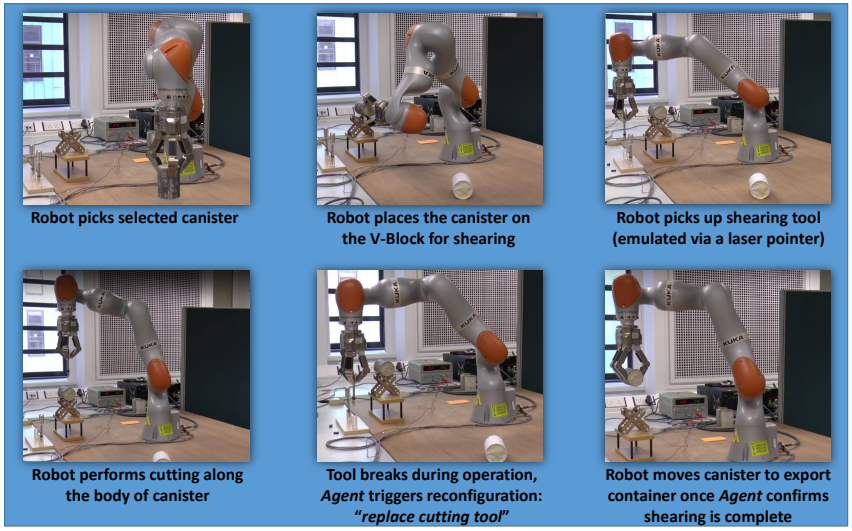
The agent can register an interest in particular beliefs and will be notified when those beliefs change, or it can query the knowledge base for additional information.

Autonomous Industrial Robotic System

We implemented an agent-based system able to assist an autonomous nuclear waste management process, which is dangerous for direct human intervention and also very repetitive task.

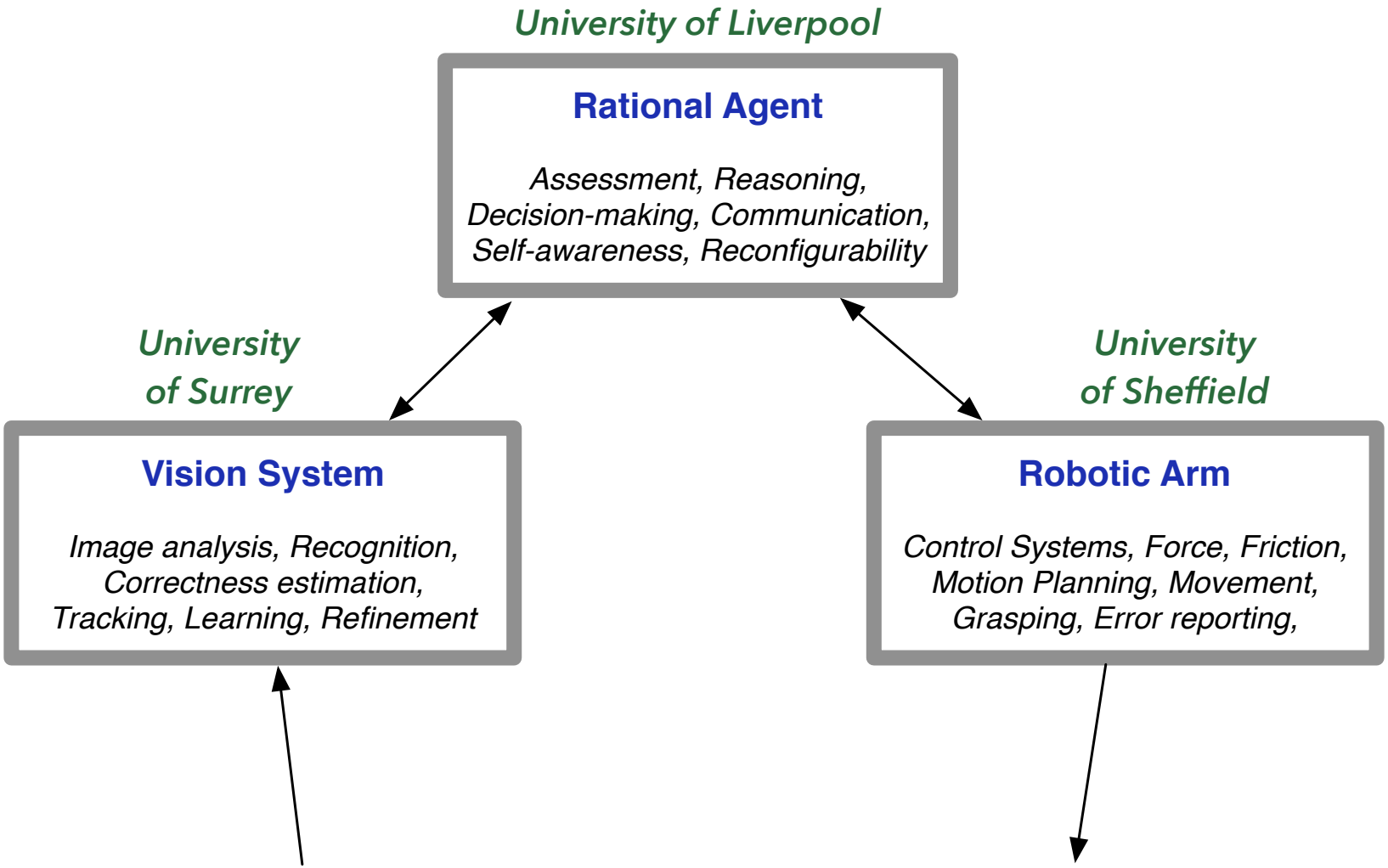


Autonomous Industrial Robotic System



The system has to perform a "sort and disrupt" task. As well as handling the main task the agent can also reason about faulty equipment or better control systems, and if needed the reasoning engine can reconfigure the system's architecture (switch to a different equipment or to a more updated control system).

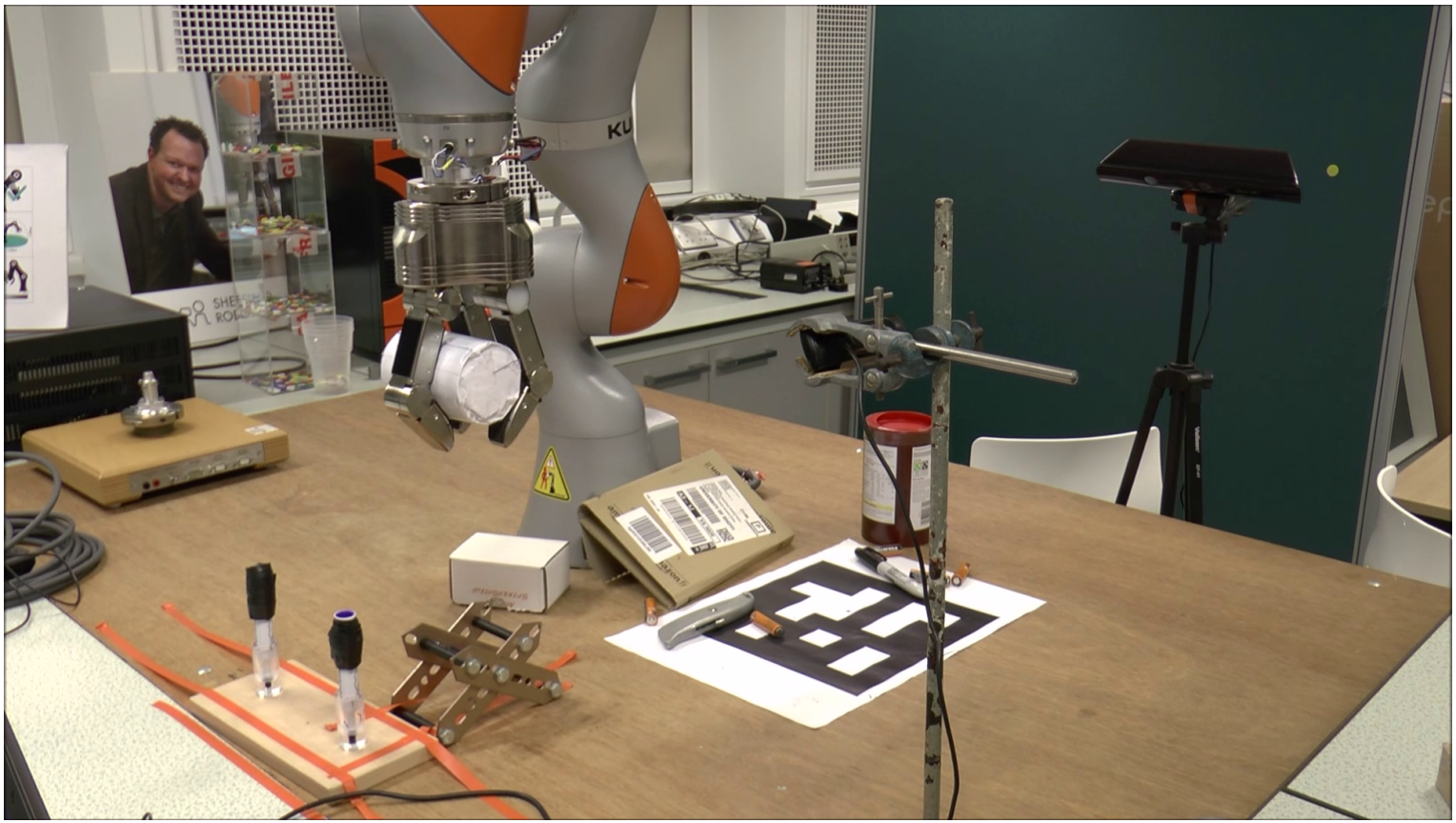
System



Nuclear Decommissioning "Sort and Segregate" Scenario

[National Nuclear Laboratory and Sellafield Ltd]

Video



Conclusion

Th key benefit of the hybrid agent architecture is that there is an identifiable entity which can provide reasons for the decisions it make, which is important to define the responsibility for decisions and to provide a system which is verifiable.

Moreover this system architecture allows the reconfiguration of mission goals, capabilities and control sub-systems at run time. Such ability is crucial also to overcomes failures and deficiencies in areas where the human intervention is not feasible.

THANKS!