JARVIS

INTEGRATED ROBOT CONTROL FOR ADVANCED HUMAN-ROBOT COLLABORATION

Funded by the European Union

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The control method of a robot is critical to completing its task. Simple control methods have been available for a long time, but transitioning from 'moving like a robot' to moving with the same (or better) dexterity and adaptiveness as a human is no easy task.

The complexity of robot control can be built up, with each layer required for added functionality to perform the next stage of useful tasks. Starting with joint space control for repetitive actions, moving onto inverse kinematics for automated positioning at specific locations, then path planning and dynamics control allowing a robot to follow specific trajectories. Following these fundamental control methods come more advanced methods allowing interaction with the world, such as force-based control to maintain force in specific directions, or compliance control to allow some dynamic movement when experiencing external force. Active research is also ongoing into cutting-edge topics such as how the robot may autonomously decide which control method to use, or actively adjust parameters to achieve the desired task.

Many advanced control methods are available in isolation for specific platforms and use cases, often in research environments. To be practical in real-world applications, advanced control methods must be easily adaptable and implementable across diverse use cases. This requirement is complicated by the variety of robot architectures, brands and accessories available. Developing a toolkit of control methods easily adapted to various use cases across different platforms is key to the Robot Control Module (RCM) developed as part of the JARVIS project. The module development is led by Tampere University.

RCM: ROBOT CONTROL MODULE

The Robot Control Module will bring together a variety of controllers for use in one toolkit. It will integrate various advanced methods for robot arm control, mobile robot navigation, manipulation and inspection of objects, and direct control from humans to robots in intuitive ways. The RCM will then be applied across the four JARVIS use cases, demonstrating the advantages of centralising the control of robots in

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one toolkit, allowing varied applications to access the specific controllers required.

COLLINS: AIRCRAFT SEAT PRODUCTION

The aircraft seat production use case requires a robot arm on a mobile base to autonomously navigate an environment, pick up a sheet of flexible fibre material in collaboration with a human and place it on a mould. This requires careful motion planning and navigation to ensure safe movements synchronised with a human user. The robot must then use force-based control to smooth out the ply by following the contours of the mould, further using advanced methods from the RCM.

TOFAS: VEHICLE BATTERY PACK PRODUCTION

In the battery pack assembly scenario, a robot arm on a mobile base will collaboratively assemble a hybrid vehicle battery with a user. The robot must place and screw in screws as well as manipulate flexible cable assemblies while interacting with a user. This will require various control methods including impedance and compliance control to manipulate complex objects.

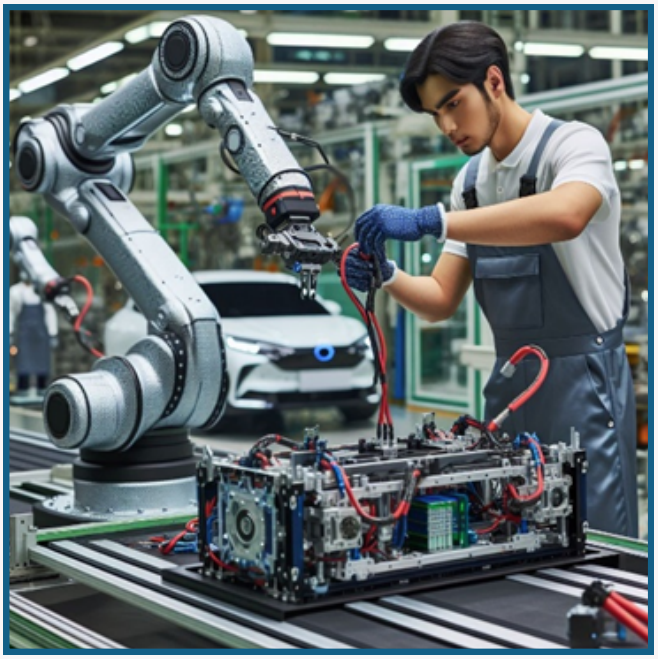

Fig. 1- Vehicle battery pack production by human-robot collaboration. Image generated by Microsoft Copilot.

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EDF: NUCLEAR PLANT DECOMMISSIONING

The EDF use case focuses on the teleoperation of a mobile robot to disassemble a nuclear facility. Positioning and localisation in complex and tight spaces is key, with force feedback and contact detection to reliably and safely cut and manipulate objects.

EQUINOR: INSPECTION & MAINTENANCE OF OFFSHORE ENERGY PLANTS

The semi-autonomous inspection and maintenance of an offshore energy plant requires the mobile robot to navigate an environment, inspect specific areas and manipulate valves and buttons. Human-in-the-loop control methods will be developed, ensuring safe and reliable completion of complex navigation, inspection and manipulation tasks.

Fig. 2- Inspection & Maintenance of Offshore Energy Plants by mobile manipulator. Image generated by Microsoft Copilot.

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CONCLUSION

The adoption of advanced control methods in widespread use cases, and the ability to develop further intelligent strategies using them, requires centralisation and easy access to a whole suite of different control methods. Intelligent selection and tuning of controllers are core to the future of autonomous and intuitive robots. The Robot Control Module developed as part of JARVIS is a key step in demonstrating the value of bringing together a toolkit of different controllers, readily available for different robot platforms and scenarios.

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