THE ROLE OF DIGITAL TWINS IN MODERN MANUFACTURING

BRIDGING THE GAP BETWEEN PHYSICAL AND DIGITAL WORLDS

In the rapidly evolving landscape of modern manufacturing, the integration of digital technologies has become a cornerstone for enhancing efficiency, reducing costs, and improving product quality. One of the most transformative innovations in this domain is the concept of digital twins. Digital twins are virtual replicas that leverage real-time data to mirror the behaviour and performance of the physical asset. Digital twins typically provide features such as performance optimisation, task planning or process optimisation.

Applied more specifically to robotics, the digital twin is usually a means to plan, simulate and visualise the robot's actions. It becomes a key element for robotic applications in changing or unknown environments, which is the standard for low-volume / high-mix manufacturing activities, as well as inspection & maintenance applications. Indeed, for these use cases, dynamic perception and adaptation to the environment are mandatory for the robot to perform its task, and – as illustrated in the following schematic – the digital twin becomes the link between the 3D perception, the decision layer, and the robot. It also becomes naturally the main interface for the user.

THE CHALLENGE: FROM EXPERT SYSTEMS TO OPERATOR-FRIENDLY TOOLS

However, Digital twins are still expert systems, which usually rely on heavy scene-preparation work, and are not intended or ready for use by non-software-skilled operators. It leads to situations where, despite the potential added value of the digital twin environment, the overhead of setup and operator mental load is often too heavy for satisfactory results and actual deployment.

This is the main challenge that we aim to solve in JARVIS, with the Intelligent Digital Twin (IDT) module development.
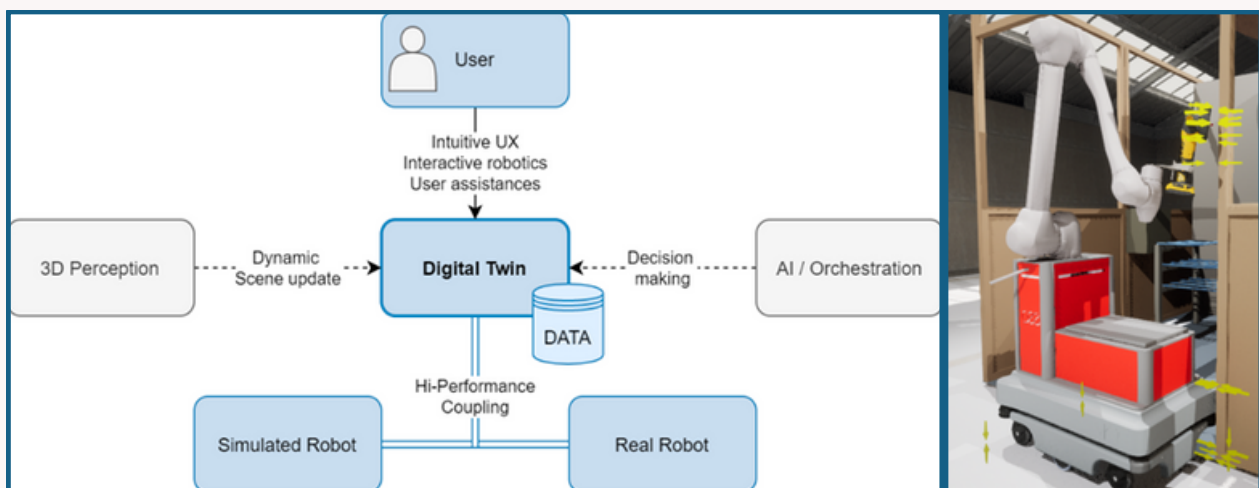
Figure 1 - Left: Simplified view of IDT ecosystem. Right: Visualisation of collision avoidance feature.

IDT: INTELLIGENT DIGITAL TWIN

JARVIS project has a heavy focus on user interaction, whether be it collaborative robotics applied to manufacturing, or remote operation for inspection & maintenance. As such, the core positioning of the IDT module is about user interactive applications and aims at providing a seamless and simple workflow for the operator.

The starting point of the IDT development is the real-time coupling with the robot controller, which enables operator-in-the-loop workflow via hand guiding or teleoperation, and user-friendly robot-control features such as collision avoidance (as illustrated before) and virtual guides.

These features provide practical assistances that improve robot displacement efficiency and accuracy, and thus allow for easier and faster teaching of points of application, which can in turn be used to trigger robotic skills on-the-fly, for fast and no-code semi-automation.

To enable this workflow, a seamless User Experience is critical. Our goal is to provide an interactive and intuitive use. For this, we plan the IDT to provide an intelligent adaptive interface to the user, based on the semantics of the scene. That way, the user can simply select an object in the 3D scene, and be guided by the IDT about which virtual guides or

skills can be applied to this object, depending on the context.

As previously mentioned, the IDT is at the centre of the software stack and shall provide adequate modularity and interfacing capabilities for versatile coupling with other modules. For the JARVIS project, we aim at coupling modules such as MSP (Multi-sensory perception), VRT (Virtual-Reality & MoCap-based Teleoperation), OFO (OpenFlow Orchestrator), etc. It should also be emphasised that given the rapid evolution of technologies and frameworks, modularity and compatibility with 3rd party frameworks such as Unreal Engine or Isaac Sim is mandatory, in order to maintain added value while leveraging their available features.

At JARVIS, we are confident this approach is the best recipe for a successful and pragmatic solution, and we strongly believe that IDT, in synergy with other JARVIS modules, will be a key enabler for larger acceptance and deployment of interactive robotics, both in Manufacturing and I&M sectors.