MODAPTO [101091996]: Modular Manufacturing and Distributed Control via Interoperable Digital Twins

9.1.1 Virtual environments for testing robot setups and production scenarios

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The creation and utilization of virtual environments for testing robotic systems and production scenarios represents one of the most powerful applications of virtual commissioning technology. These digital environments serve as comprehensive testing grounds where engineers can validate, optimize, and perfect their systems before any physical implementation occurs.

Modern virtual environments for robotics testing are sophisticated digital ecosystems that accurately replicate the physics, kinematics, and dynamics of real-world systems. The basic idea is to create a simulation or digital twin of your automation solution. This is a virtual model showing how the machine (or machines) will work in your process. You use this virtual model to test out different scenarios to see how this will affect the automation solution. This helps you to optimize the solution before you take it to the physical environment.

The MODAPTO project leverages the RF::SUITE tools to create these comprehensive testing environments. RF::ViPer serves as the behavior simulation engine, capable of modelling complex logical sequences and control flows. RF::YAMS provides the 3D visualization component, allowing engineers to observe robot movements, collision detection, and spatial relationships in an intuitive visual format. These tools work in concert to create a virtual environment that is virtually indistinguishable from reality in terms of functional behavior.

The process of creating a virtual testing environment begins with importing or creating 3D models of all relevant components. This includes not just robots, but also workpieces, fixtures, conveyors, sensors, and any other equipment that will be present in the physical system. Modern CAD integration allows these models to be imported directly from design software, maintaining geometric accuracy and reducing modelling time. The virtual environment must also include accurate representations of the workspace, including floors, walls, safety barriers, and other spatial constraints.

Once the geometric environment is established, the next critical step is implementing accurate physics simulation. This includes modelling gravity, friction, inertia, and collision dynamics. For robotic systems, this means accurately representing joint limits, motor characteristics, and payload handling capabilities. The virtual environment must faithfully reproduce how objects will behave when grasped, moved, and released by robots. This level of physical accuracy is essential for validating pick-and-place operations, assembly tasks, and material handling scenarios.

Control system integration represents another crucial aspect of virtual environment creation. The virtual robots must be controlled by the same programs that will run on physical systems. This is achieved through virtual controllers that emulate the behavior of real robot controllers. Tools like RF::KUKAConnect and RF::SiemensRead establish connections to these virtual controllers, enabling the testing of actual robot programs and PLC logic in the simulated environment. This approach ensures that the control logic tested virtually will behave identically when deployed to physical systems.

The testing capabilities within these virtual environments are extensive and powerful. Engineers can test normal operational scenarios to verify that robots can reach all required positions, complete tasks within cycle time requirements, and coordinate effectively with other equipment. More importantly, they can test edge cases and failure scenarios that would be dangerous or impractical to test physically. This includes simulating sensor failures, testing emergency stop procedures, and exploring the limits of system performance.

Virtual environments also excel at testing complex multi-robot scenarios. Modern production lines often feature multiple robots working in shared spaces, requiring sophisticated coordination to avoid collisions while maintaining productivity. Virtual commissioning allows these interactions to be thoroughly tested and optimized. Engineers can experiment with different robot placement options, modify motion paths to eliminate interference, and optimize task allocation between robots. The ability to quickly test multiple configurations accelerates the design process and results in more efficient final systems.

The RF::Recorder v2 tool adds another dimension to virtual environment testing by enabling detailed data capture and analysis. This tool can record thousands of signals at millisecond intervals, creating a comprehensive record of system behavior. Engineers can replay these recordings to analyze specific events, compare different scenarios, and validate system performance. This data-driven approach to testing ensures that optimization decisions are based on objective metrics rather than subjective observations.

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