Using 3D Game Engines to Build Digital Twins for Industrial Machine Simulation and Testing

Bachelorarbeit

Graduate

Silvan Kisseleff

Isaia Brassel

Advisor
Prof. Dr. Christoph Gebhardt

Co-Examiner
Dr. Sammy Christen, The Walt Disney Company (Schweiz) GmbH

Subject Area
Software Engineering

Project Partner
AVM Engineering AG, Dietfurt, St. Gallen

Initial Situation: Developing control software for industrial machines requires careful planning. However, it is still crucial to test the software before deploying it on a physical machine. To create meaningful tests, a digital twin that can simulate the behavior of the real machine is required. Yet, creating such digital twins can be both costly and complex – and often, they still fall short when it comes to offering realism. In light of these challenges, AVM Engineering AG approached us with the task of evaluating whether modern game engines are suitable for developing digital twins of their industrial systems. Our objective was to design a workflow for creating such digital twins and to demonstrate it using parts of a package distribution machine.

Approach / Technology: Research into digital twins and 3D simulation highlighted the potential game engines provide with their advanced physical simulation capabilities. To determine the most suitable platform for implementing digital twins, we analyzed and compared the leading game engines – Unity and Unreal Engine 5. Based on performance, visual fidelity, extensibility, and licensing terms, we chose Unreal Engine 5. For reliable and standardized data exchange with industrial equipment, we used OPC UA, the de facto communication standard in industrial automation.

To enable communication between Unreal Engine 5 and industrial controllers, we required a bridge between the OPC UA server and the game engine. For this, we integrated open62541, an open-source OPC UA implementation in C, into the game engine. To simplify the communication with the server we created custom Blueprint functions, the visual scripting language of Unreal Engine, for a simple drag-and-drop experience when building a digital twin. These building blocks enable read, write and subscribe operations from the game engine to the OPC UA server. In addition, we investigated the process of converting existing CAD models into assets suitable for use in Unreal Engine 5. This allows for highly realistic representations of industrial components within the digital twin.

Result: The integration of modern game engine technology with industrial automation tools enables the creation of highly customized digital twins. In this case, it allowed for a real-time simulation of the control logic developed for the package distribution machine, providing a safe and efficient environment to test and validate the software under realistic operating conditions—without the need for the physical system.
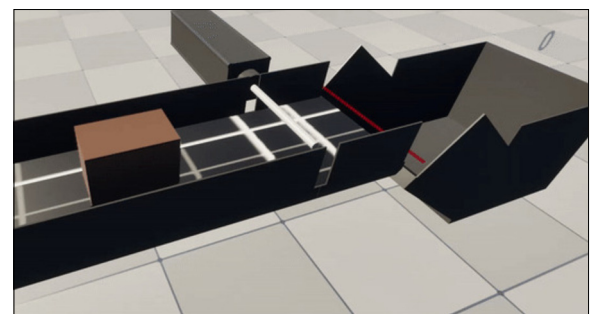
To showcase the capabilities of our Blueprint functions and to make our approach to digital twin development more accessible, we designed and implemented custom models inside Unreal Engine 5.

These models were specifically created to replicate key elements of the package distribution system—most notably, the conveyor belt mechanism. The components not only illustrate common use cases when it comes to OPC UA communication but also incorporate realistic physics simulations to closely mimic real-world behavior. User testing confirmed that our construction-based approach is intuitive and effective, significantly supporting the understanding and development of digital twins for complex systems.
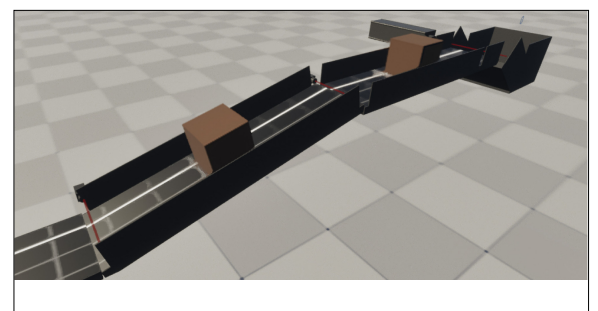
Example Blueprint configuration that subscribes to data changes of a certain field.
Own presentment
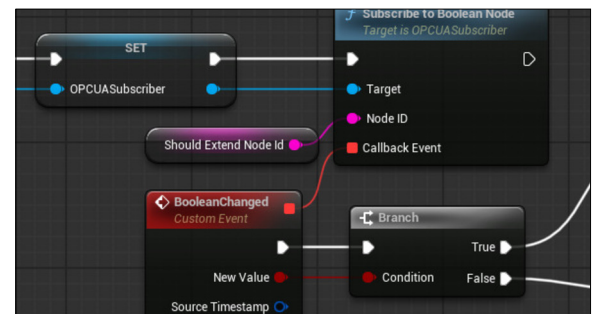
Close-up of the machine showing a pneumatic cylinder blocking packages before they descend a slide.
Own presentment

Conveyor belt construction with two packages on it, several sensors, a pneumatic cylinder and a slide at the end.
Own presentment