Research Article
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Digital twin of ABB IRB-120 robotic cell based on the industry 4.0

Abstract

The evolution of virtual commissioning has enabled significant advances in analysis, safety testing, programming and failure anticipation in projects involving industrial robots. To make this possible, a virtual model equal to the real one is needed and our research objective is to develop the Digital Twin of the ABB IRB-120 process and robot to digitally validate the robotic cell and minimize installation and project implementation time in the "shop floor" in the context of I4 .0 Currently, a major problem related to Virtual Commissioning activities is the lack of precision between the virtual model and the physical model (digital twin), due to difficulties related to mechanical fabrication after model generation 3D The use of the Process Simulate software (SIEMENS PLM), allowed more accurate and real results to commission the robotic cell of the Robotics Advanced Institute - I.A.R. The main analysis tools are shown in this study.

Keywords: ABB IRB-120, digital twin, process simulate, industry 4.0, roboticist, virtual commissioning

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Introduction

Digital design techniques promise to revolutionize the way we create products. As product complexity increases, classic design methodologies will not suffice. With the ability of Digital Twins to model and simulate across the entire product lifecycle, they have become a requirement for modern product development.[1] At the same time, artificial intelligence (AI) accelerates the power of product developers to take full advantage of new design capabilities. With these innovations, the design universe invites increased intelligence and the possibility of emulating your design or system in the lab. In this session, industry leaders discuss the definition and types of digital twins and how they increase clarity throughout the design space.[2] The experts share their views of digital twins, how they shape design today, and the changes expected with AI's growing role to innovate design and manufacturing. With the precision enabled by these capabilities, designers welcome a transformed workflow and design cycle.[3] Digital Twin calibration and virtual commissioning to digitally validate robotic mechatronic cells in the context of I4.0. Industrial robotics and the complexities of 4.0 processes are rapidly reshaping the manufacturing industry. Succeeding in this new scenario means adopting this complexity and using it as a market advantage over competitors who implement legacy and less sophisticated processes. The increasing use of Virtual Commissioning during the development process of automated factories, paired with the growing demand for better quality control leads to the need for improved virtual plants that systematize the necessary configuration procedures for the realization of their processes. Common plant simulation techniques based on the concept of virtual commissioning of robotic cells go beyond the need to validate control algorithms, that is, new approaches need to be developed to meet the demand for reconfiguring your operational resources in a systematic way, compatible with the flexibility that these autonomous resources currently have.[1-4]

The need for new solutions in Robotic Engineering for the design of complex projects involving physical systems and the virtual part associated with them, has never been more present. Virtual commissioning technology can be considered as one of the established trends in automotive assembly.[5] Among other benefits, it promotes a more efficient treatment of the complexity associated with assembly systems, capable of causing a reduction in the acceleration time of the system itself and a reduction in the development time of the product capable of meeting the market's competitiveness.[6]

By its general definition, a digital twin is a real-time virtual digital representation that mimics a physical object or process. Industries such as the aerospace and defense industry have been developing strategies to implement such solutions for years. In its simplest form, the digital twin concept seems almost obvious-but as it is unpacked and understood, it becomes deceptively complex. The ability to model a single function over time as it is being stimulated, although it requires deep thought and meticulous construction, is not impossible. How about the possibility of tens of thousands of interdependent functions happening over time with power and frequency changes over various environmental conditions, all happening independently and possibly randomly? That's the definition of complexity.[7,8]

The biggest benefit of virtual commissioning is the savings. It is possible to test an investment in advance, which could be hundreds of thousands or even millions of dollars in equipment, since a single robot could cost you around $50 to $70,000. So, five robots, equipment, clamp systems, accessories, different products, and all that together in one manufacturing cell is a significant investment. Companies do not intend to develop projects without knowing if it can satisfactorily perform at the expected levels and results. Process reduction Standard operating. Possibility of carry out part of this process in a more convenient environment (no necessarily on-site) combined with the opportunity to use the emulation model for training workers. Parallel development and optimization of mechanical parts, especially mechanisms mechatronics. Programming and debugging simultaneously from the control software. The Companies aim to implement sustainable manufacturing of robotic cells, in order to improve profitability, reducing resource consumption, global expenses, as well as satisfying the regulatory input of ecological impacts. In addition, the widespread adoption of industrial robots, necessary to satisfy the ever-increasing requirements in terms of manufacturing quality, customization and flexibility, further increased the need to improve the energy efficiency of robotic cells.[9,10]

Analysis of experimented data

The network digital twin should accurately represent the target network's topology, i.e., the devices of different types in the network, locations of the devices (for wireless networks), and the connections between them. The network digital twin should also replicate how the devices communicate at different layers of the protocol stack. The research has as a solution with the *Siemens Digital Industries Software* commercial *called "Tecnomatix Process Simulate version 15.1.2"* so that it is possible to test: the quality of the researched solutions and algorithms; computational complexity and proper scaling of the necessary automation resources. We also intend to create a proof of concept containing all parts of the simulation system. This initial step will allow us to accurately estimate the needs for robotics, automation, IT resources, the quality of the algorithms and the overall feasibility of the proposal. The objectives of this project in terms of scientific and technical challenges to be overcome will be to propose a procedure for validation of the digital twin for which it is feasible to validate the virtual commissioning at 100% for a simple loading and unloading application. It will also demonstrate that Digital Twin calibration and virtual commissioning of industrial robots are reliable, feasible and useful for key advanced industry applications. The value proposition is to show that the investment of companies in projects that make use of the methodology to be developed from the initial phase of the project, can significantly reduce their costs with tryout time, start-ups, engineering, prototypes, implementation on the floor of factory and third-party costs for programming rework (Figure 1).

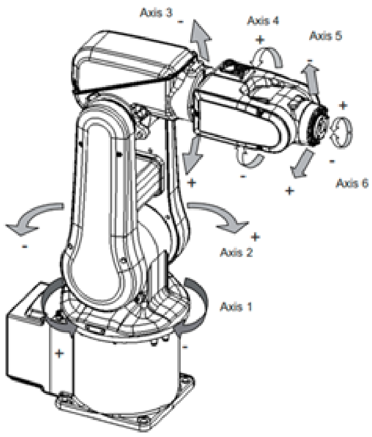

Figure 1 ABB IRB-120 robot.

Topology converters: These tools import a network topology specified in a standard format and create a simulation model of the network based on the topology information. These utilities can handle Layer 2 and Layer 3 switches, VLAN configurations, hubs, gateways, bridges, routers, servers, firewalls, and many more network objects. TC-Nmap can import topology information generated by Network Mapper (Nmap), which is a free, open-source utility for network discovery and security auditing. TC-XML can import topology information contained in XML files. Interfaces with Network Managers: These tools interface with commercial network managers to extract topology information and create equivalent EXata models of the networks. TC-NA is an interface to the Network Automation (formerly Hewlett-Packard Network Automation) server that extracts device, topology, and configuration information on the network being monitored. TC-SolarWinds extracts information on networks managed by the SolarWinds network configuration manager and creates EXata models using that information (Figure 2).

Figure 2 Real robot for testing (ABB IRB-120).

For the handling applications present at the Advanced Robotics Institute – IAR, in Brazil (São Paulo), the real industrial robot that was used in the research have their respective initial positions (HOME POSITION) changed in relation to the original factory values where all the joints have values equal to zero. Digital twins can be created not only of physical networks, but also of constructive networks, i.e., networks represented in other simulators and Computer-Generated Forces (CGF) tools, such as VR- Forces. One application of such a network digital twin is its use in a co-simulation with the constructive network where the digital twin and the constructive network simulate different aspects of a system. In addition to the confined and narrow environment for handling parts, the fixing and screwing of the base of both are not perpendicular and also not parallel to the XY plane of the work table, which increases the programming difficulty by 30%. Other differentials of this research are that all analyzes of potential elastic energy for the study of communication cables from the sensors and pneumatic connections leaving the central handle of the manipulator to the midpoints of the grips will be studied in depth. Such an analysis is important because on the shop floor it is relevant to predict trajectories that interpolate excessively and points with singularities that cause the connection cables to break. The fact that the proposed methodology allows the delivery of robotization projects using virtual commissioning and digital twin with an assertiveness of approximately 100%, demonstrates that it is feasible. However, we would have a very high technological risk if we opted for a direct implementation on the shop floor (Figure 3).

Figure 3 Example of a digital twin tool robotic gripper developed at the advanced robotics institute – IAR.

In many cases, the goal of network analysis is to study the performance of applications running on the network. But performance of an application depends not only on the configuration of the network and the application itself, but also on other applications that may simultaneously run on the network and compete for network

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resources. Therefore, for actionable analysis, the network digital twin should accurately represent the mix of network traffic flowing over the physical network.

It is a mistake to imagine that this proposed project does not involve technological research and that it is only obtaining processes using existing *software*, and that the use, mastery and handling of the *software* tools called *Process Simulate by Siemens Digital Industrie Software* takes us clear and intuitive to an understanding of the digital twin calibration. The development of a virtual robot calibration and commissioning methodology using "absolute zero", so that it can be applied directly to real robots on the shop floor and can also be used by different types of industries is quite complex. To confirm this complexity, the IAR team carried out several projects in the Brazilian industry in recent years under the responsibility of the responsible researcher together with the team of specialists from *Siemens Digital Industrie Software*, integrators, systemists, robotic engineering offices, realizing this way, the complexity of the topic and the opportunity for contribution reported by the *software* manufacturers themselves in the calibration of all phases of the study. In Brazil there is still no consulting company that researches and uses absolute zero in its real implementations with robots in the industry (Figure 4).

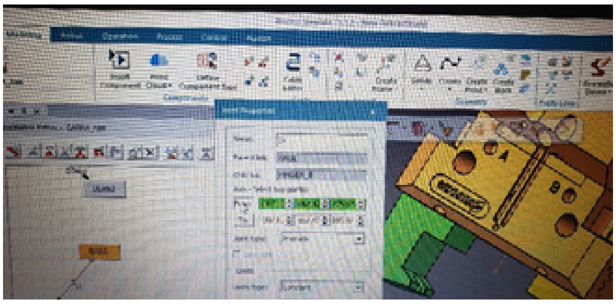

Figure 4 Final example of task modeling with the ABB IRB-120 robot in a robotic cell.

The PCAP (Packet CAPture) files, which can be created using networking sniffing tools such as Wireshark, provide a convenient way to import network traffic into network digital twins. A PCAP file records IP packets received at and sent from a monitored interface. PCAP files can be used in a network digital twin in the following ways: 1-) PCAP playback in the scenario: IP packets are injected into the scenario in the same timeline in which the packets were recorded. Each packet is injected at the node specified by the source address in the IP header, travels along the network, and is delivered at the network layer of node specified by the destination address in the IP header. 2-) Aggregating flows in PCAP file(s): Flows can be aggregated into a PCAP file and scaled to generate different traffic profiles. This feature is useful when the recorded PCAP file represents only a small fraction of the entire network traffic but can still be used to produce larger, meaningful traffic profiles (Figure 5).

The digital twin of a robotic cell allows to parallel the mechanical, electrical and automation design as well as systems engineering tryouts. Waiting times for phases of information exchange between equipment can be avoided in this way. Through the simulation of industrial robots, extensive tests allow the detection and correction of errors in the design and functions, making real commissioning very fast. With simulation, perceptions of virtual tests can improve engineering quality at an early stage. Testing the PLC code during virtual commissioning increases confidence that the interaction of the electrical, mechanical and the robot controller is working as intended by the analyst and robotist. This helps to avoid high costs and minimizes errors. Problems during actual commissioning take time and increase labor and material costs, especially with international projects. To overcome these difficulties, everything can be tested safely virtually without the need for the operator of the robotic cell. Industrial robots are designed to work constantly, with no downtime.

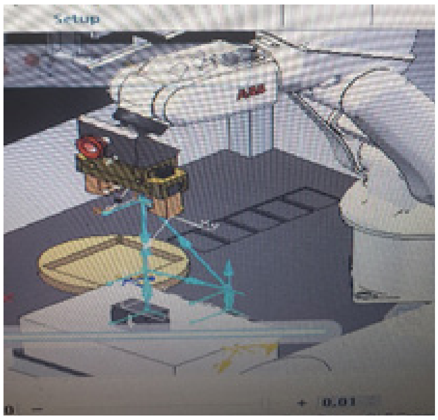

Figure 5 Virtual commissioning and digital twin of robotic cell.

Conclusion

The digital product twin is used to test a certain product, structure or part that has not yet been produced, simulating the characteristics to which it will be exposed. In this way, it is possible to predict possible design problems and correct them even in the simulation phase, avoiding numerous wastes.

The fact is, not all tests are created equal when looking across an enterprise and/or workflow. Not everyone develops a test strategy and simulates its effectiveness and efficiency on the product the same way. The idea of a digital twin strategy has been around for years in the mechanical world and is starting to gain traction in the electrical world to minimize the gap between theory and reality. These same principals now can be applied to the test and measurement world. Such a strategy can lead to greater accuracy, repeatability, and utilization of test strategy. It will also allow test or design changes to be made before designs are frozen for technical and/or performance reasons. This Design and Test (DaT) process would not only change the way design and test flows work, but how overall programs change the way they do business from concept through support.

The results for the ABB IRB-120 robot were satisfactory because we performed all the robot modeling, tool kinematics, TCP calibration and we managed to generate the programming code in RAPID language. After this result provided by the digital twin, it was possible to "download" the code to the real robot from the cell and it performed the block grip without problems.

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Conflicts of interest

The author declares that there was no conflict of interest.

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