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The Use of VR to Analyze the Profitability of the Construction of a Robotized Station

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Abstract

The development of software applications and the use of VR (Virtual Reality) techniques allow to improve the company's financial result. The construction of models of robotic stations with robots using Virtual Robot technology allows to determine the time of the machining process. It allows its optimization through the selection of accelerations, tools, tooling strategies, and so on. Determining the time of a technological operation translates into savings. This allows you to decide on the purposefulness of the investment. In addition, modern software add-ons, for example, Signal Analyzer in RobotStudio, allow you to monitor the electricity consumption of a robotic station. The article presents a solution showing how, based on the construction of digital models and the use of VR, we can conclude about the profitability of the investment.

Keywords

: virtual reality, RobotStudio software, signal processing, real robot, programming robot, robot-operated quality control

1. Introduction

The Polish aviation industry, which is a supplier of subassemblies to all of the leading aviation companies, is concentrated in a cluster called Aviation Valley. Aviation Valley is located in south-eastern Poland, and today it connects over 160 companies in the aviation industry. The factor that links the companies is their production profile. Although it is diverse from the aviation industry point of view, it can be seen as a coherent whole from a global perspective. Joint operation on the global market offers great opportunities but involves the need for cooperation between companies of various sizes and different levels of technological advancement. The cooperation of many diverse companies is possible, thanks to the creation of collaborative networks [1, 2]. As part of the cooperation, it is possible to exchange data in robotic systems using Internet connections. Robotization in the aviation valley companies mainly concerns quality control [3–5] and processing [6–14].

The application of the philosophy of collaborative networks and the exchange of data of robotic systems can be used to improve the economic performance of the companies in Aviation Valley.

The development of software that uses virtual reality, working with previously used tools for programming robots such as RobotStudio, gives new possibilities to analyze procedures, robot movements and whole robotic lines, as well as the analysis of results from different perspectives.

So far, the software for working with robots has enabled the writing of motion codes, estimating process times, and checking kinematic motion limitations. We are currently observing a tendency to develop robot programming applications focused on building virtual models and to expand the possibilities of remote control of process parameters. This is confirmed by the increasing number of new software add-ons, for example, the signal analyzer package allows the monitoring of robot work parameters. Monitoring the operation of a machine using the Internet allows the collection of information from stations or robotic lines from different manufacturers, from different, geographically distant, factories, and it gives very large possibilities for data analysis in terms of time, economy, and technology.

Another type of add-on that uses virtual robot technology allows the generation of a digital twin of the real station. Thanks to this approach, we have the opportunity to test programs in near real time and to export and import software, movement of robot paths, and so on. This add-on allows the estimation of process time, which is very important from an economic point of view.

In recent years, we have noticed a very large development of virtual reality systems, which are increasingly being used not only in entertainment but also in industry. The best example of that

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is the VR add-on for RobotStudio. Growing computing power, especially for graphics, allows the programmer or technologist to be in the virtual world, where we have reconstructed not only robots but also transport system machines. It all depends on the available computing power and the detail and availability of real object models. This approach can already be used to train operators at the modeling stage.

Every digital representation has defects resulting from simplifications. This mainly concerns the modeling of physical phenomena, motion dynamics, and so on. Companies in their solutions introduce modeling of some of them, such as the dynamics of wire movement, modeling of falling phenomena, and modeling of some contact phenomena. However, there is no modeling of tool wear, heat generation, or the susceptibility of arms to noise.

In my opinion, the widening of modeling phenomena, better visualization with the use of VR, and the improvement of the ability to provide information at a distance are the main directions of the development of computer applications for programming robots.

2. Collaborative Network

The collaborative network is a model of cooperation between companies, research and education units, and cluster associations. It is characterized by dynamics allowing the creation of a structure resulting from the goal being pursued. Changes may involve various components from legal relationships to a change in the way the tasks are carried out. The proposed combination of all network participants is implemented to achieve financial benefits and to develop new products. Exploiting the potential of collaborators and networking brings benefits and connects all of the parties in a new and innovative way. In short, a collaborative network is an organization that links entities that have the capabilities and resources needed to achieve a specific goal.

An example of the adaptation of an organization pursuing a defined goal is the production of the Boeing 787 passenger aircraft. Distributed production in plants around the world requires an efficient network of cooperating partners and suppliers. Boeing has built a global cooperation network of over 50 partners operating in over 130 locations around the world [2].

In Poland, the Aviation Valley companies are part of the global supply system of such companies as Safran or Pratt&Whitney. The proposed solutions consisting of the construction of a collaborative network require appropriate tools in the legal financial area, but also communication, IT, and financial controlling. The development of software for programming robots by adding new modules and improving communication capabilities is becoming a very useful tool to support collaborative networks. Figure 1 illustrates the possibilities offered by the RobotStudio software in the context of data

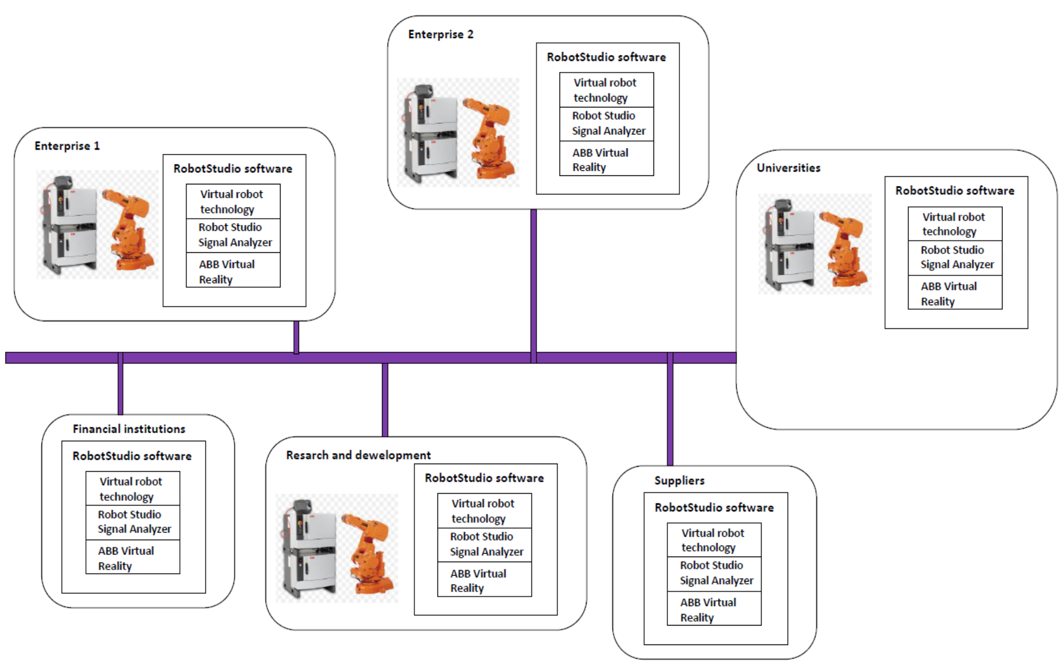

Figure 1. Diagram of an information exchange that can be implemented with RobotStudio software.

exchange, analysis of production times, programming possibilities, and construction of virtual models.
The solutions and possibilities of modern and constantly evolving software allow users to control the time of carrying out robotic processes, monitor the loads on machines or stations, control the manufacture of a robotic product at every stage, schedule tool database management, anticipate servicing activities and thus control downtime, carry out remote programming and operator training, work visualization, and presentation of solutions using virtual reality. Thanks to communication using the global Internet network, all of these activities can be implemented by any company or organization forming part of a collaborative network.

3. RobotStudio Software

All virtual robot environments are applications that enable modeling and programming of robots and simulation of their work in offline and online modes, using a standard PC. The RobotStudio environment made available by ABB, in the online version, is delivered with an industrial robot and supports the configuration and programming of real devices. The offline version is available for a fee and allows the design of robotic production stations and simulation of their operation without the use of real robots (Figure 2).

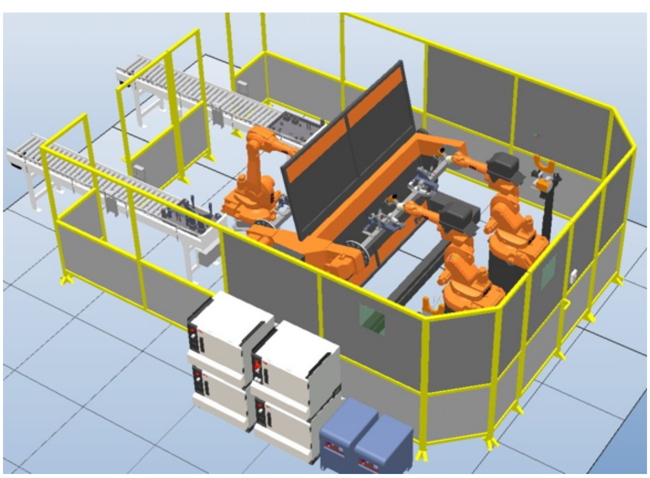

Figure 2. Model of robotic station in RobotStudio.

Individual software versions (educational and commercial) are made available on different terms. Every year new modifications appear as well as modules supporting the programming of selected technological processes (e.g., welding – ArcWelding PowerPac, cutting – Cutting PowerPac, machining – Machining PowerPac or painting – Painting PowerPac), which after installation are fully compatible with RobotStudio. On the other hand, additional programming tools are integrated with the environment. One example is the built-in ScreenMaker, which allows users to create windowed operator interfaces on FlexPendant panels.
RobotStudio is a fully comprehensive environment that allows users to design complex graphic objects, define their degrees of freedom, and conduct motion simulations. Despite having its own CAD design module, it is possible to import geometries created in various formats (including: *.stp, *.igs, *.sat, *.rsgsx, *.stl).
Virtual controller technology is implemented in the environment, allowing for a precise reflection of the actual work of a controller, and hence, among others, accurate determination of the actual work cycles of a device. If the user is in possession of a real robot, the environment allows them to work online, with the option of depicting the robot on the computer screen. In this mode, it is possible, among others, to program the robot, its operation and system configuration, and to configure and analyze the integrated vision and software safety controller – SafeMove. With real robot backup, a system can be created that can be successfully programmed and run on a computer offline. As a result, the user has at his disposal a system with all its possibilities and limitations. According to the manufacturer, the simulations are reproduced 1:1. After the design has been completed, the station can be saved as an interactive *.exe file, ready to be viewed in the free RobotStudio Station Viewer. This solution is very useful (a simulation of the work can be played, changing the views of the scene), especially for presenting a proposed option to a final recipient. The connection of a PC to a robot takes place through an Ethernet network (Ethernet or service connection) and appropriately defined IP devices. Among the innovations of the latest version of the environment, we should point out: support for integrated vision, transferring of an image from a camera to the FlexPendant panel, the possibility of software configuration of the SafeMove safety driver and the connecting of Oculus 3D glasses and a real robot in 3D technology.

3.1. Virtual robot technology

The technology named by the manufacturers Virtual Robot is based on emulating a robot controller on the computer (Figure 3). The real controller has its own RobotWare operating system; the use of back-up files help us to map the real operating system of a robot on a PC computer. Although the operating systems of most computers are not real-time systems, Virtual Robot solutions strive to reproduce the real controller's work as faithfully as possible. The use of offline software, and the emulation of the actual work of a robotic station, saves time and funds. We can build a robot station in the simulation or recreate an existing station, program it, analyze its operation, and optimize the operating parameters.
In addition, it is an excellent tool to minimize training costs through training in simulation environments.

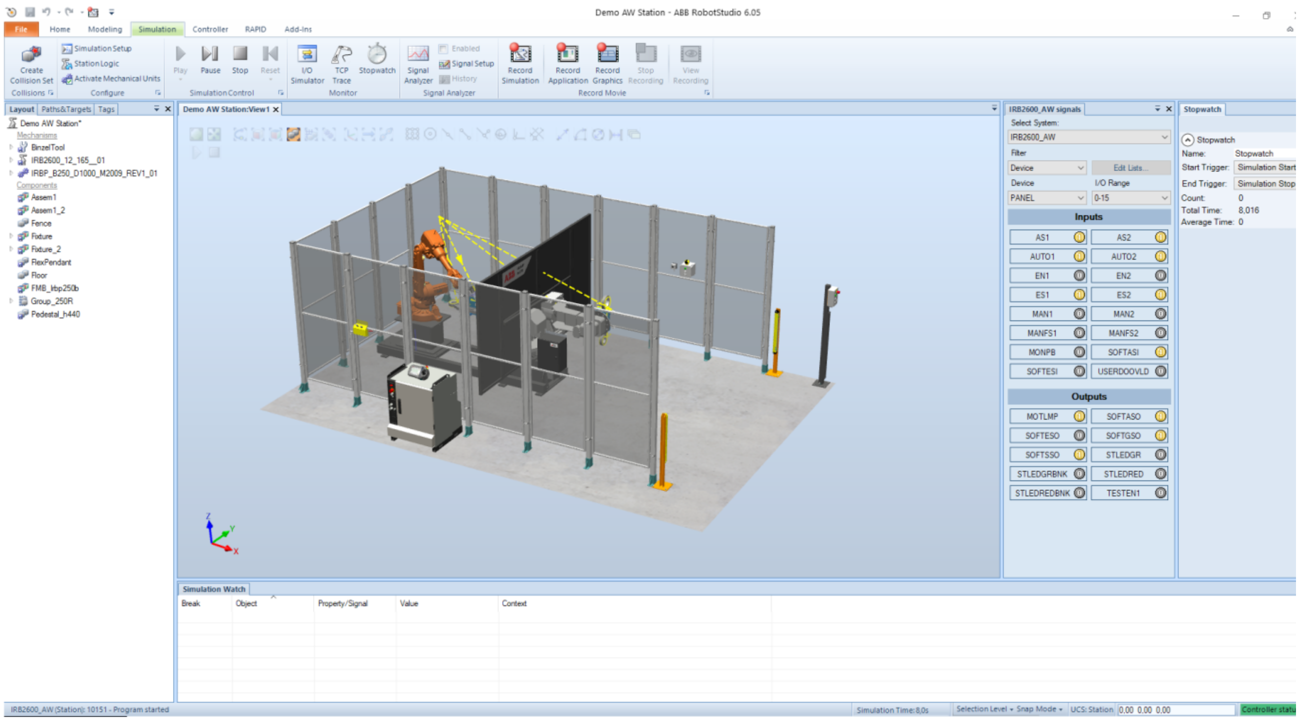

Figure 3. The work-time modeling process in VirtualRobot technology.

3.2. RobotStudio signal analyzer

Monitoring of system parameters and kinematic parameters of ABB robots with an IRC controller is possible through the use of RobotStudio software, which includes the Signal Analyzer application. This is a tool that allows users to record a number of defined values at a rate of 40 per second. The values of the recorded parameters can be observed in the on-line mode on scaled graphs or saved in the form of text or *.xls files. An exemplary application window is presented in Figure 4.

Thanks to the possibility of connecting to the robot controller through the Internet, we have access to information about the work of robotic stations in any place. We can remotely track event logs, power consumption, tool speed, acceleration, states of digital inputs and outputs defined in the robotic system, work time, downtimes, and workpiece tool-changing times.

3.3. ABB virtual reality

The development of information systems, the growing computing power of computers and graphics cards have made it possible to use virtual reality in ever new areas [15–18]. Systems based on VR solutions are also used to program robots. An example of such a solution is the RobotStudio product from ABB. The use of VR creates new opportunities and simplifies the work of the programmer or engineer [19]. The operation of robotic stations built from 3D models and their software can be tracked using goggles. Computer programming in the 2D dimension enters the 3D phase. The application allows the programming of robot movements in the virtual world. The use of handheld controllers allows users to interact with models, add markers and move the robot arms. A person may be inside a three-dimensional model and move around it to observe the work of a robotized station from different angles. In addition, the VR is reflected on a computer screen, so that many experts can work together. It is also possible to work over long distances through an Internet connection, and then we can visit a robotic station and check the system from a distance.

The addition of physical relationships and interaction models in the software is very helpful in understanding the work of the station. For example, in a materials application, if the robot drops a box, the box will fall and bounce like in the real world. For conveyor belts or other things in which product movement must be simulated, this is excellent because the user can see exactly how the robot moves in coordination with the movement of cables and hoses, and so on. The ability to provide cable simulation is very helpful to ensure that cables do not interfere with the process and do not create unnecessary risks. During welding or sealing, experts can examine the working sequence near the model and then make adjustments to improve the robot's performance. In the case of painting applications, users can virtually paint and create a robot path from hand control movement.

The use of the VR technology in learning programming allows for its acceleration, learning in conditions of lower stress, with a better understanding of the emerging program because it

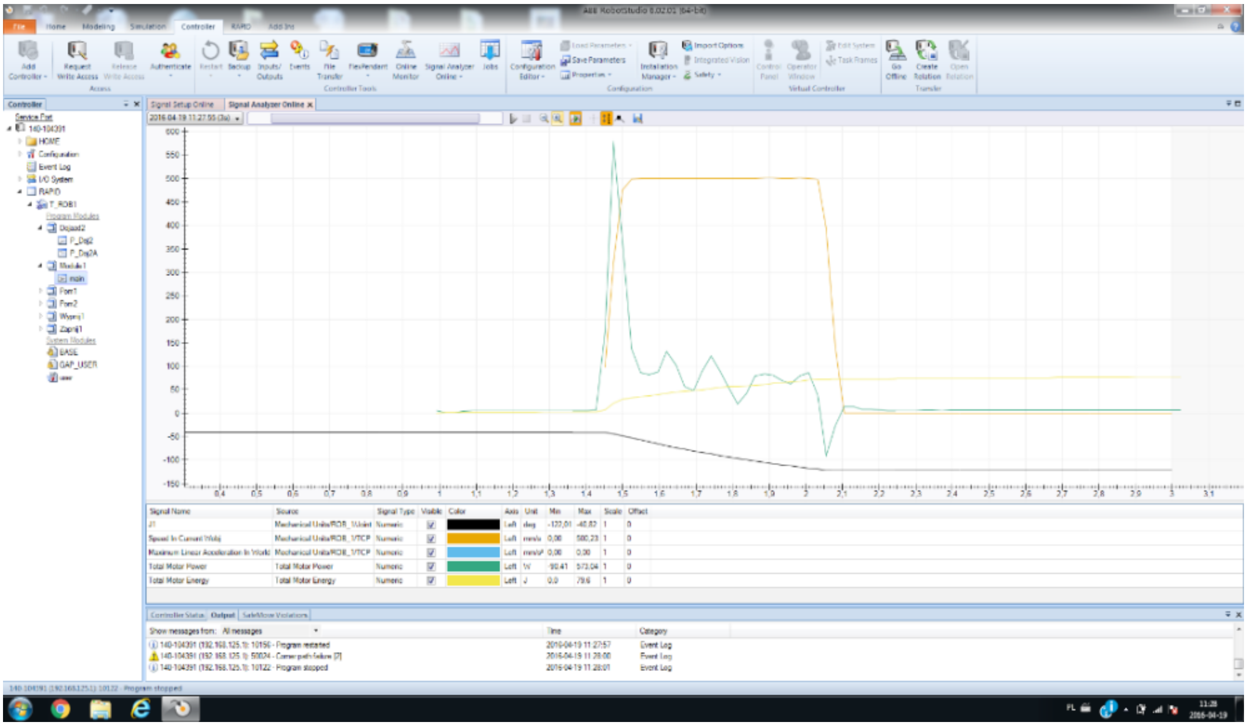

Figure 4. Signal Analyzer application window.

brings the user closer to the real activity (Figure 5) [20–22]. The presence of the VR technology in robot programming is something new, and applications of this type will grow strongly with the development of personal computers.

Figure 5. An example of the use of virtual reality in a robotic application.

4. Conclusion

The use of the capabilities of modern computer applications for programming robots allows their implementation in various areas. We can use them as a tool for data exchange communication, modeling, and visualization of a process. Thanks to the use of a global network, the communication modules included in the software allow for the remote work of many entities, companies, or members of an organization. The presented capabilities of the RobotStudio software can be used as a tool in an existing or newly built collaborative network. The capabilities of the presented application allow for minimization of costs, management of product flow, and management of production.

References

[1] L.M. CAMARINHA-MATOS, H. AFSARMANESH: Collaborative networks: a new scientific discipline. *J. Intell. Manuf.*, **16**(2005)4-5, 439-452.

[2] J. SHUMAN, J. TWOMBLY: Collaborative networks are the organization: an innovation in organization design and management. *Vikalpa*, **35**(2010)1, 1-14.

[3] A. BURGHARDT, et al.: Robot-operated inspection of aircraft engine turbine rotor guide vane segment geometry. *Tehnicki Vjesnik-Technical Gazette*, **24**(2017)Suppl. 2, 345-348.

[4] A. BURGHARDT, et al.: Software for the robot-operated inspection station for engine guide vanes taking into consideration the geometric variability of parts. *Tehnicki Vjesnik-Technical Gazette*, **24**(2017)2, 349-353.

[5] A. BURGHARDT, et al.: Robot-operated quality control station based on the UTT method. *Open Eng.*, **7**(2017)1, 37-42.

[6] P. GIERLAK, et al.: On-line manipulator tool condition monitoring based on vibration analysis. *Mech. Syst. Signal Process.*, **89**(2017), 14-26.

[7] P. GIERLAK: Hybrid position/force control in robotised machining. In: Solid State Phenomena. Trans Tech Publications, 2014, 192-199.

[8] A. BURGHARDT, et al.: Monitoring the parameters of the robot-operated quality control process. *Adv. Sci. Technol. Res. J.*, **11**(2017)1, 232-236.

[9] A. BURGHARDT, et al.: Experimental study of Inconel 718 surface treatment by edge robotic deburring with force control. *Strength Mater.*, **49**(2017)4, 594-604.

[10] P. GIERLAK, et al.: Eliminating the inertial forces effects on the measurement of robot interaction force. In: International Workshop on Modeling Social Media. Springer, Cham, 2018, 67-76.

[11] K. KURC, et al.: Non-contact robotic measurement of jet engine components with 3D optical scanner and UTT method. In: International Workshop on Modeling Social Media. Springer, Cham, 2018, 151-164.

[12] P. OBAL, et al.: Monitoring the parameters of industrial robots. In: International Workshop on Modeling Social Media. Springer, Cham, 2018, 230-238.

[13] D. SZYBICKI, et al.: Robot-Assisted Quality Inspection of Turbojet Engine Blades. In: International Workshop on Modeling Social Media. Springer, Cham, 2018, p. 337-350.

[14] D. SZYBICKI, et al.: Calibration and verification of an original module measuring turbojet engine blades geometric parameters. *Arch. Mech. Eng.*, **66**(2019)1, 97-109.

[15] C. BURDEA GRIGORE, P. COIFFET: Virtual reality technology. John Wiley & Sons, New York, 2003.

[16] M. MIHELJ, D. NOVAK, S. BEGUS: Virtual reality technology and applications. Springer, German 2014.

[17] F. SHAO, A.J. ROBOTHAM, K.K. HOK: Development of a 1: 1 scale true perception virtual reality system for design review in automotive industry. 2012.

[18] A.G. GALLAGHER, et al.: Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Ann. Surg.*, **241**(2005)2, 364-372.

[19] E. MATSAS, G.C. VOSNIAKOS: Design of a virtual reality training system for human–robot collaboration in manufacturing tasks. *Int. J. Interact. Des. Manuf. (IJIDeM)*, **11**(2017)2, 139-153.

[20] M. KOŹLAK, A. KURZEJA, A. NAWRAT: Virtual reality technology for military and industry training programs. In: Vision based systems for UAV applications. Springer, Heidelberg, 2013. 327-334.

[21] S. ORTIZ JESSICA, et al.: Virtual training for industrial automation processes through pneumatic controls. In: International Conference on Augmented Reality, Virtual Reality and Computer Graphics. Springer, Cham, 2018. 516-532.

[22] F. DE PACE, et al.: An augmented interface to display industrial robot faults. In: International Conference on Augmented Reality, Virtual Reality and Computer Graphics. Springer, Cham, 2018. 403-421.