Automatic Teach Point Optimization

When objective data analysis enables autonomous program adjustments

ArtiMinds Robotics. Modern industrial robots produce an enormous amount of data during ongoing production. By using intelligent software, this data is automatically collectable and can be used to calculate program optimizations. Thus, the robot is able to independently adjust to changing workpiece properties. ArtiMinds Robotics has developed a novel approach where a PLC serves as gatekeeper between robot controller and analysis software. The supervision of the PLC permits a safe autonomous change of the robot´s teach points.

Quick changes of suppliers, a high number of variants in high-mix/low-volume production, production on short notice and ever-shorter product life cycles pose great challenges for classical automation. The typical automation is mechanically tuned to perform a very specific task that runs without major changes over a long period of time. Frequently changing processes can thus often not be mapped to automation. Hence, in many cases it remains the domain of manual work to this day.

Sensor-adaptive industrial robots and cobots in combination with intelligent software can fill this gap and bring those previously manual work steps into automation. This includes the robot being able to perceive changes in its immediate environment via force-torque sensors or cameras. In addition, this perception must be collected over many production cycles. Based on this knowledge of the current process, intelligent software can calculate program optimizations that adapt the robot task to current workpiece or system properties.

The analysis tool ArtiMinds LAR can be used to determine the best possible joining point for different workpiece carriers with tolerances, thereby improving the cycle time

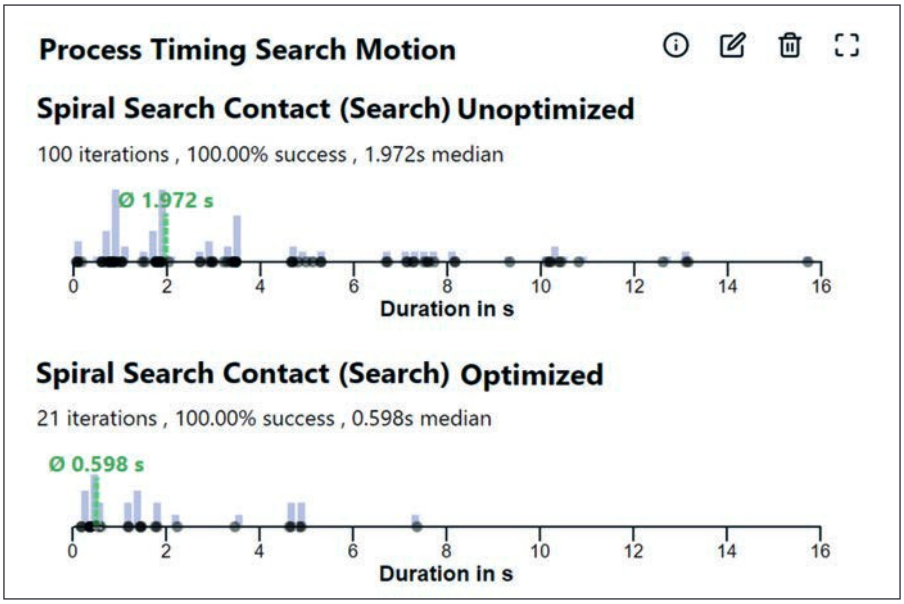
Data-driven adjustment of robot poses

Teach points or individual robot poses form spatial key elements for robot programs with sensor-based operations. This can be, for example, the starting point for a force-sensitive joining operation or the direction of a contact motion. In the past, such key poses must be manually fine-tuned in exhaustive teaching processes. In the case of small-scale variances or stochastic scatter over a large number of workpieces, manual adaptation is often not even possible at all. The same applies to short-term post-optimization during operation.

Data-driven automatic adjustment can manage these challenges. During operation, motion data is collected from the robot at a high sampling rate. Due to sensor adaptive motions, this data can provide insights into actual geometric arrangements during operation, simply by analyzing motion adjustments based on sensor measurements. Typical sensor sampling rates are around 250 data points per second with spatial resolutions down to 50µm and forces down to less than 0.1N. Using semantic structuring of a robot program, the data can be assigned to clearly defined motion elements once collected which is crucial for focused optimization. Based on the collected runtime data from a set of work cycles - from a few to a few thousand - a recalculation of teach points can be performed using statistical fitting methods.

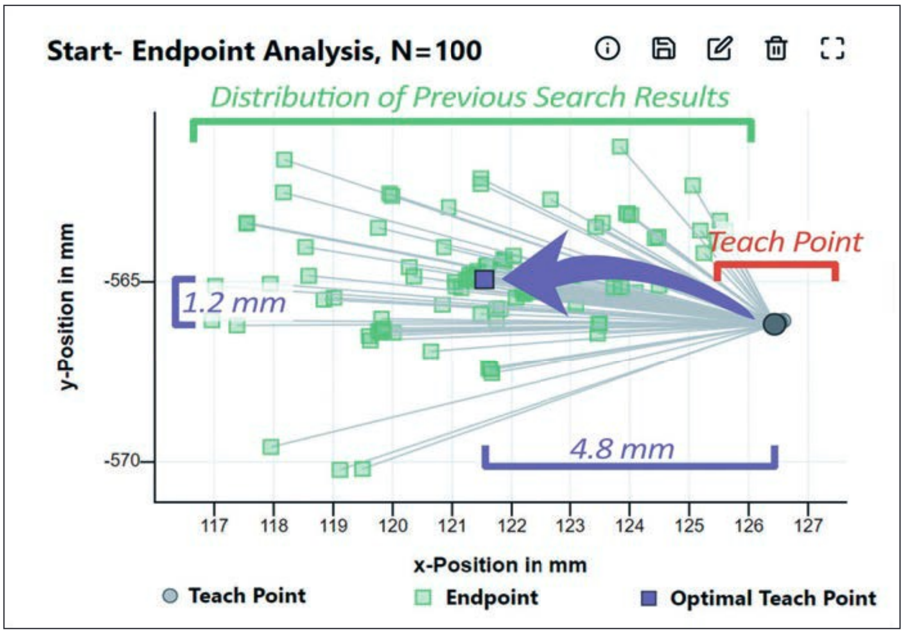
Objective data analysis and process monitoring

ArtiMinds Robotics with its software tool Learning & Analytics for Robots (LAR) has developed a solution to specifically adjust relevant points of a robot program with regard to runtime and robustness and to continuously monitor processes. For this purpose, an analysis of the process data generated during operation of the robot is created on a time-decoupled edge PC. This data can be automatically collected and annotated without additional programming effort by using the low-code programming software ArtiMinds RPS. Therefore, for example, the best possible starting point of a sensor-based search for a join-



The segment timing diagram shows the cycle time before and after the adjustment. An improvement of 70 percent was achieved

ing process can be determined very efficiently and transparently. The results can then be transferred offline to the adjusted RPS program.
In order to integrate the adjustment fully automatically without stopping production, ArtiMinds has recently established the use of a PLC for this method. This PLC acts as a gatekeeper between the LAR database backend and the robot controller, since both have different requirements regarding their communication protocols. Furthermore, the PLC takes over the role of an additional safety instance that ensures that automatic adjustments can only take place to a safe degree and that guarantees an interruption-free robot operation even if the database is not available. The PLC temporarily stores optimization results and checks them for unauthorized limit violations using independently stored safeguarding rules. The motion program in turn actively requests teach points adjusted by the PLC. In this way, temporal synchronization anomalies can be ruled out as well as unauthorized outliers, which can occur in untested special cases in more complicated optimization procedures. Last but not least, an HMI on the PLC allows manual intervention in the optimization parameters or (de)activation of the adjustment after successful user authentication.
"The robot program can regularly request the new, optimized poses from the PLC and apply them. The fact that the robot program queries the poses ensures that the process is correctly synchronized in time via the network," Dr. Sven Schmidt-Rohr, CEO of ArtiMinds Robotics, explains. "Our approach is the interaction of the process-critical robot controller, our software ArtiMinds LAR and the in time securely coupled PLC."



A data-driven shift of the teach point reduces the search paths of the robot program

Self-improving system

Using the described approach of robot, PLC, and data-driven adjustment, there are not only general improvements feasible. The system is able to learn optimizations per specific component or workpiece carrier and to use these appropriately at runtime and for the present situation. A reliable, self-optimizing system consisting of established industrial components can thus be realized from a single source.
"Sensor-adaptive robot programs reliably compensate for even major process deviations. With our system, however, the cycle time buffers required for this can be drastically reduced, as the process is automatically adjusted based on the optimization results. This increases the robustness of the robot system and the quality of the process," says Schmidt-Rohr, explaining the advantages of ArtiMinds Robotics' approach. "In addition, employees are of course strongly supported by the software and thus gain new capacities to take care of other tasks."
As a result, the future execution of sensor-adaptive robot programs will be faster, better and more robust.
The automatic teach point adjustment can be used during system development, commissioning, post-optimization in continuous operation as well as during changeovers. It is suitable both for different types of processes and for every conceivable type of robot.

Outlook

In automatic teach point optimization, the main intelligence runs on the time-decoupled edge PC with the ArtiMinds LAR analysis tool. But here the development is not finished yet. Plans are already underway to use deep learning or deep neural networks to optimize complex relationships of parameters in the robot program that go beyond teach points. "This will enable processes to adjust to even more complicated changes or occurring wear and tear on workpieces independently and automatically," says Schmidt-Rohr, giving an initial outlook.

►► 62822 at www.ien.eu