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Rivet hole inspection

Utilising a 3D laser profiler from LMI Technologies, a German research institute has developed a rivet inspection system which has reduced assembly errors in the aerospace sector, as MEPCA found out.

Aircraft production presents various technical challenges, such as large product dimensions, complex joining processes, and the need for proper organisation of assembly tasks. Overcoming such challenges while enforcing tight tolerances and ensuring small batch sizes is often difficult to achieve with a high degree of cost efficiency.

In the assembly of the aft section of an aircraft, the pressure bulkhead is typically mounted to the section barrel. To achieve this, two operators must work collaboratively in uncomfortable, non-ergonomic positions, while having to maintain exacting assembly quality standards.

Based in Saarbrücken, Germany, ZeMA, The Center for Mechatronics and Automation Technology, has devised a semi-automated approach to optimising aircraft section assembly. This was achieved through an innovative riveting process for solid rivets, using Human-Robot-Collaboration in combination with an intuitive Human-Machine-Interaction operational paradigm.

Zema's solution leverages collaboration between humans and robots to complete the task more efficiently. First, the solution involves placing a robot inside the section barrel. The robot's workspace is then expanded by mounting it on top of a lifting unit, which enables it to position the anvil properly in front of the bulkhead. In the meantime, a human performs the more complex tasks of inserting the solid rivets and operating the riveting hammer from outside the sectional barrel.

To create the robotic system used in this application, a Gocator 3D laser line profile sensor from LMI Technologies is mounted and calibrated to the robot flange using built-in hand-eye calibration. The sensor is then able to provide 3D coordinates of every measured point. With onboard data processing and built-in measurement tools, Gocator detects the holes in the frame or shell of the aircraft, enabling the riveting process to be done with maximum accuracy and efficiency.

Tasks in the riveting process are divided between human and robot. The human detects the designated hole, inserts the rivets, positions the riveting hammer and starts the collaborative process by activating the hammer. In parallel, after ascertaining the position of the holes, the robot positions the anvil and bucks it against the rivet during the execution of the process.

"We picked the LMI sensor because it can be integrated very quickly and flexibly into our robot applications and enables onboard data processing, which is a great advantage for the rapid implementation of research ideas and feasibility studies. In addition to onboard data processing, access to the sensors raw data is an important factor for us - and this is also made possible by LMI. All in all, we have the perfect scope for research and industrial applications with Gocator sensors, " explained Tobias Masiak, Research Assistant (Robotic & Human-Machine-Interaction) at ZeMA

With the introduction of the Gocator laser triangulation sensor, the distance between rivet and anvil no longer depends on human judgement, but on the measurement precision of the laser line, the robot positioning, and the calibration of the tool (such as the anvil and additional production equipment). As a result of automating this complex process, assembly errors and deviations have been significantly reduced.

Refinement of this solution is ongoing, including long-term stress testing of the developed process tools and the integrated robot system. Furthermore, the test series includes quality inspection using data fusion from Gocator, camera and force-torque data, as well as information gathered from operator experience. Combining the data with Artificial Intelligence algorithms will be introduced in future iterations.

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