European Metrology Research Programme

Delivering Impact

Precision robotic movements

Manufacturers of cars and planes rely on automated industrial robots to assemble parts with great precision. The EU produces 30 % of these robots - an industry which generates 140 billion euro and employs 2 million people. To stay competitive, as manufacturers develop smaller and more precise parts, the robotics industry needs to measure 3D movements with increasing accuracy in order to develop more precise motion control.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Precision manufacturing industries, such as aerospace, mechanical engineering, and automotive all rely on automation to produce quality products. Industrial robots making complex movements in 3D follow engineering designs to manufacture and assemble parts on the production line.

Robots are fitted with angle encoders, devices used to convert the angular position of a rotating shaft into an electrical signal. To ensure correct assembly, robotic arms must move through pre-described angles around rotating shafts, in a three-dimensional environment. Software delivers the required instructions according to the design need, as a series of small electrical signals. These signals are processed by controllers and matched with angle encoder's, to drive the motors that translate them into the precision robotic movement required.

As manufacturing requires ever greater automation precision, angle encoder design and calibration must also develop greater accuracy. A particular challenge for angle encoders is that their angle measurement performance is heavily influenced by the rotation errors of the mechanisms that they are fitted to during calibration and use. An understanding of this and other sources of potential errors would improve measurement practices and support the development of the greater angle encoder precision demanded by the robotics and automation industry.

Solution

The EMRP project, *Angle metrology,* investigated performance and sources of measurement error for angle encoders to increase knowledge on the factors that affect calibration and operation, thereby improving traceability to the SI unit for angles – the 'radian'.

This included a focus on emerging multiple scanning head angle encoders and the development of a self-calibration method for the fast and precise in-situ calibration of multi-head encoders with optimised numbers of reading heads. This method was validated using computer simulations and does not rely on external reference standards. The project also investigated various methods for calibrating angle encoders and identifying sources of measurement error. The measurement best practice information generated is now available to users as a EURAMET calibration guide for angle encoder calibration.

Impact

Fagor Automation, a manufacturer of machine automation technologies – in a collaboration with non-profit technology centre IK4-Tekniker – has used project knowledge and understanding to design and commission a new angle encoder assessment machine fitted with a special multiple reading head angle encoder. This new test machine acts as a reference device and uses the project derived self-calibration principle to achieve more precise calibrations for Fagor Automation's angle encoders. Fagor Automation have also developed new software for assessing calibration result spread therefore increasing confidence in measurement results.

With these improved assessment tools, Fagor's R&D department can better evaluate the performance of new and improved prototype encoders. This is enabling the company to develop angle encoders with increased accuracy and improved repeatability, leading to a 100 % improvement in product performance. These advances in angle encoder precision will allow robotics companies to develop the more precise 3D movement capabilities needed to underpin the next generation of automated machine tools. Providing greater precision for robotic arms carrying process tools, such as those used for cutting, drilling, welding, or spraying paint, has the potential to boost the competitiveness of Europe's major manufacturing industries.

Improving precision angle measurements for industrial applications

The EMRP project *Angle metrology* improved the precision of angle measurements and developed devices for checking the quality of complex optical components used in fundamental research at Synchrotron and Free Electron Laser (FEL) facilities and also the angle encoders that control industrial robotics and automated machine tool movements.

Project results include new calibration methods now published in two EURAMET calibration guides; one on angle encoder calibrations important for robotics, and another on autocollimators performing surface profile measurements. For the first time 2D autocollimator calibrations are possible that meet requirements for inspecting highly curved optical surfaces. Whilst project investigations into angle encoder performance produced a self-calibration method for the fast and precise in-situ calibration of multi-head encoders so improving robotic machine tools movements.

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Tanfer Yandayan

TUBITAK, Turkey
+90 262 679 5000 | tanfer.yandayan@tubitak.gov.tr

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