European Metrology Programme for Innovation and Research

Delivering Impact

A low-cost 3D Large Volume Metrology system for the factories of the future

Many industries utilise components that are too large to fit within conventional measuring machines or too bulky to transport to a calibration laboratory. These require measuring in situ, but current systems used in warehouses or factory floors are often off-line, slow, expensive or lack metrological traceability. Cheaper, more accurate methods are required to enable more companies to benefit from the 'digital' factories of the future.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Even relatively small passenger planes have wingspans and fuselages exceeding 35 m in length, and larger, more modern aircraft can exceed 50 m or more. Due to the size of components in aviation, and many other industries, these must be correctly assembled, tracked and error mapped or 'calibrated' in situ. To do this requires the use of Large-Volume Metrology (LVM).

One of the most common LVM tools are laser trackers which can determine dimensions and distances to within micrometres. These systems are expensive however, and most typical industrial applications can tolerate a measurement uncertainty of tenths of millimetres. In addition, tools such as laser or radar trackers are time-consuming, expensive and undertaken only occasionally, leading to downtime issues.

Industry is increasingly turning to using Automatic Guided Vehicles (AGVs) and robotics in factories to achieve the positioning and alignment accuracies required in production, often in conjunction with artificial intelligence (AI). However, in these the control systems are usually integrated into the AGV itself and not with the plant in which it is operating.

Cheaper, simpler and metrologically validated AGV systems would allow more European industries to increase quality and reduce costs when manufacturing large, high value components.

Solution

During the EMPIR project LaVA, partner TEKNIKER developed a 3D Large Volume Metrology system for large part assembly and positioning control of AGVs based on photogrammetry, a technology that interprets data from images. Ten prototype active targets were manufactured, slightly larger than a Euro coin, containing three 850 nm near-infrared (NIR) LEDs powered by a compact Lithium-ion battery cell. Along with a temperature control to prevent overheating, the system was provided with wireless communication to allow the targets to be switched on and off from a remote computer.

In the validated scenario, these emitters were placed on AGVs operating in a 10 m × 10 m × 5 m shop floor and low-cost cameras, with fisheye lenses to increase the field of view, were positioned at points around the factory to track the NIR targets. The measuring system was calibrated using static targets previously measured with a commercial Laser Tracker with a certified metrological traceability.

The system was then validated in a real industrial environment with an active target on top of a moving AGV. The images for the photogrammetry measurement, obtained in real-time, were filtered for all wavelengths except for the 850 nm NIR light band to help identify targets in open air or solar light conditions. Calculated position data of the active targets were uploaded in real-time to an external server.

Impact

TEKNIKER is a private Research & Development foundation with more than 40 years of experience in Advanced Manufacturing, Surface Engineering, Product Engineering and Information and Communications technologies. The company's involvement in the project provided them with the opportunity to collaborate with world-leading metrology institutes to advance the state-of-the-art of large-scale metrology solutions and help increase the competitiveness of the European industry sector.

Since the end of the project, TEKNIKER has developed the 3D Large Volume Metrology system further to include an autocalibration feature to remove the need for expensive laser trackers in the calibration step. With the sub-millimetre accuracy required by industry, using low-cost components, the scalable tracking system developed in the project is already helping the company provide new measurement solutions for their customers.

The development of these types of solutions for large volume metrology applications, such as aviation and aerospace, will not only help decrease costs for European companies, but also help the introduction of the Digitised Factories of the Future using Industry 4.0 approaches.

Large volume metrology solutions for industry

The LaVA project produced novel systems capable of simultaneously providing metrology at different scales and accuracies.

Three photogrammetry systems, for extracting 3D information, were developed:

- A robot-compatible close range photogrammetry system that uses particle swarm approaches for camera calibration.
- A software-driven, scalable infrared system that was demonstrated in a 10 m × 10 m × 5 m shop floor environment.
- A calibration artefact comprising a carbon fibre shaft with well-defined targets to provide traceability for existing camera systems.

In addition to the photogrammetry systems, the project also developed a telemeter with over 22 m range and a Frequency Scanning Interferometry (FSI) setup that was produced in the EMRP project LUMINAR was further developed into a state-of-the-art system termed 'OPTIMUM'. FSI obtains traceability from reference gases and the system included hydrogen cyanide (HCN) spectroscopy data produced in the project that is several orders of magnitude more accurate than the previous published work.

Work continued in the project DynaMITE to further provide European industries with large volume metrology solutions.

EMPIR EURAMET

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