European Metrology Programme for Innovation and Research

Delivering Impact

A new instrument for large volume metrology and advanced manufacturing

Many industrial sectors, including aerospace, automotive, and energy production, utilise autonomous manufacturing. Capable of producing products more efficiently at reduced cost, it is essential that production processes are continually monitored in real time to ensure they are flexible and can respond to changes. This requires state-of-the-art metrology in large, dynamic environments, where measurements require sub-millimetre accuracy.

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

Many modern factories contain highly dynamic environments where robots work autonomously to assemble products. This presents a problem for those industries where individual components need to be tracked in real-time with high precision. Laser trackers can determine distance and position of single targets with sub-millimetre accuracy but can only handle multiple targets sequentially, and whilst multiple trackers could be used, this increases both time and comes at considerable expense.

In the project LUMINAR (2013-2016), the National Physical Laboratory (NPL), the National Metrology Institute of the UK, developed a prototype instrument based on divergent beam Frequency Scanning Interferometry (FSI). This utilised a single laser beam which was spread out over multiple targets equipped with retro-reflectors, allowing multiple measurements simultaneously. An internal hydrogen cyanide (HCN) gas absorption cell provided a spectral signal which could be probed by the laser, providing SI traceability. Although the initial instrument's range was limited to a couple of metres, in the subsequent LaVA project (2018-2022) this was extended to over 10 m with a 50 µm accuracy using improved HCN spectroscopic data and task-specific measurement uncertainty evaluation for every measurement.

However, whilst a great improvement over commercial laser trackers, the prototype system was still limited to stationary or slowly moving targets.

Solution

During the DynaMITE project (2021-2024) NPL continued to develop the new FSI system to provide dynamic target capability. To achieve the faster scan rate, a commercial laser with multiple emitters was used, and Four Wave Mixing was employed to overcome the errors that can occur if the target changes position during measurements (termed a "Doppler shift"). To quickly identify targets for the laser and track them whilst moving, cameras were added as a photogrammetric solution. The multilateration algorithm used to precisely determine the position of the tracker heads was also updated, as was the patented beam steering mechanism which uses a holographic diffraction grating to steer individual laser beams to follow the motion of each target.

Impact

Following DynaMITE, the company K3 Metrology Ltd was formed in 2026 to commercialise the new ***Metralis*** instrument. It is the first system that can simultaneously track 6 or more targets with SI traceability at speeds encountered during precision robotic manufacturing operations, and coverage can be extended by adding more sensors to the network. Capable of real-time measurements in a 10 m x 10 m x 5 m volume, capturing both position and orientation (using multiple targets), it has an accuracy of 50 µm (0.05 mm) comparable to, or exceeding, current commercial systems. The new instrument also contains an automated calibration feature - eliminating the need for periodic checks or factory recalibration.

Aimed at advanced high-value manufacturing sectors it has demonstrated a robot control application at the Advanced Manufacturing Research Centre and in early trials during structural testing at an aerospace manufacturer. A timing study with a major manufacturing partner found that using Metralis can result in efficiency gains of 40%-60% over current processes and multiple aerospace primes are investigating its use for manufacturing next generation aircraft products.

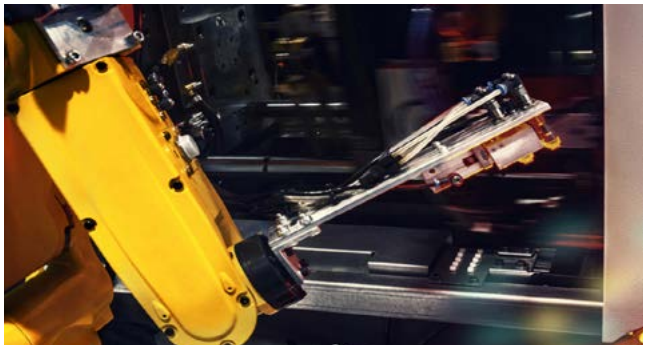
Capability now exists in Europe to support Industry 4.0 automation and advanced manufacturing. In the long-term it will support advanced products such as lighter aircraft, efficiently manufactured vehicles, and the assembly of critical infrastructure such as next-generation power stations.

Developing the instruments for advanced manufacturing and the factories of the future

Building on the work of LUMINAR and LaVa , the DynaMITE project:

- Upgraded a novel FSI system to enable multiple object tracking in large factory floor environments
- Developed a low-cost and dynamic photogrammetry system consisting of 18 cameras, simultaneously tracking 50+ objects with live 6-degee-of-freedom at 100 Hz and 10 m/s in a 10 m × 8 m × 2 m volume. The system was tested in scenarios including on an aircraft wing, a reference table, 4 aerospace drills, and multiple joints on 2 robots, before delivering 3 systems to manufacturing organisations
- Further developed a photogrammetry camera calibration process which was used to measure aircraft performance at a Polish airfield
- Designed a new fast self-tracking interferometer with multiple-wavelength coaxial beams
- Completed multiple copies of a telemeter measurement head, to form a multilateration telemeter system

The new instruments and systems devised will provide the tools required for the next-generation of factories of the future.



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