EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-s11**
Version: 1.0

Title: Optical bidirectional measurements

Abstract

An optical Coordinate Measuring Machine (CMM) is a 2D device that provides non-contact measurements of the physical and geometrical characteristics of an object, using optical probes. Bidirectional measurements are measurements of the distance between two different types of sample with opposing edges e.g. measurements of the width of a line structure or the diameter of an aperture or a cylindrical structure. There are currently no validated standards for optical bidirectional measurements and consequently optical CMMs used for bidirectional measurements in quality control systems are calibrated using a standard, which has been certified by other means (e.g. CMM with mechanical probing system or Scanning Electron Microscope). This approach limits the uncertainty of bidirectional measurements to approximately 0.5 µm and typically introduces systematic measurement errors due to probe-sample interactions. Therefore traceable optical bidirectional measurements are required for accurate optical measurements of 2D features using optical CMMs.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 13 and 38.

Keywords

Bidirectional measurements, optical microscopy, optical coordinate measurement machines, ISO 10360-7, probe-sample interactions

Background to the Metrological Challenges

Although bidirectional measurements are as important as unidirectional ones, no validated standards or calibrants for optical bidirectional measurements currently exist. The only calibrations that are available are for special photomasks, but due to the small dimensions of photomasks (approximately 150 mm x 150 mm) they are not well suited for the calibration and testing of most optical CMMs. Consequently the requirement to perform acceptance and verification tests of bidirectional measurements has been removed from ISO standard 10360-7 [1] and optical CMMs have to rely on being calibrated by a standard, which has been certified by other means. This approach leads to an uncertainty for optical CMMs, which is significantly larger than for tactile CMM and typically introduces measurement errors due to probe-sample interactions into the system. The situation is very similar with bidirectional measurements using an optical imaging (vision) system, i.e. due to missing metrological infrastructure for optical bidirectional measurements, instruments using an optical imaging system must be calibrated by means of standards certified in another way, and in industry this missing measurement capability impedes the development of products based on microparts and microstructures.

One possible solution is CMM data fusion, i.e. a method for obtaining agreement between the measurement results of tactile and optical sensors and computer tomography. However, agreement between these methods is currently poor, and this limits the uncertainty to several micrometres rather than achieving the required uncertainty of less than 0.1 µm. The use of more advanced optical sensors, such as confocal or white light interferometer based microscopes or different types of illumination may help but in these optical methods probe sample interactions are known to be greater and more complicated. Therefore such interactions need characterising and integrated into data fusion evaluations.

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Scientific and Technological Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the JRP-Protocol.

The JRP shall focus on traceable optical bidirectional measurements to enable accurate optical measurements of 2D features, such as needed for optical coordinate measurement machines.

The specific objectives are

1. To develop traceable optical bidirectional measurements from 0.5 μm to 1 mm with measurement uncertainties of 0.1 μm that are applicable to a wide range of materials.
2. To determine threshold values for optical bidirectional measurements for various materials, material combinations and imaging systems, including using simulations of the microscopic images,
3. To develop accurate, user friendly software capable of calculating the threshold value for different illumination and imaging modes.
4. To produce guidelines on achieving measurement uncertainties of 0.1 μm with optical bidirectional measurements over a wide range of materials.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (e.g. letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the industrial sector, particularly users of optical Coordinate Measurement Machines.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] ISO 10360-7:2011 Geometrical product specifications (GPS) -- Acceptance and reverification tests for coordinate measuring machines (CMM) -- Part 7: CMMs equipped with imaging probing systems