The Future Metrology Hub

EPSRC Engineering and Physical Sciences Research Council

Fully Funded EPSRC PhD Case studentship.

Project Title: Integrated self-aware sensors for manufacturing

Improving in-situ integration of sensors on manufacturing platforms to provide embedded measurement is a longstanding aim for the surface and dimensional measurement community. As the concepts developed by the Industry 4.0 movement around digitalised 'smart' manufacturing are realised, a proliferation of sensors will be required to yield increased demand for data at all stages of the manufacturing process. The traditional role of metrology for the assessment of part quality has now been subsumed by a need to provide (near) real-time data on all aspects of processes. Sensor integration poses may challenges including the need to reduce the size/cost of sensors and enhance their flexibility where possible. However it is also important to consider the *adaptability* of sensors across changing measurement scenarios e.g. lighting conditions, spectral response, measurand material/texture/form or environmental conditions. Calibration is also another difficult to address problem for in-situ sensors because a well-controlled environment and carefully designed metrology frames, as relied upon by dedicated ex-situ metrology instrumentation, are not present. Furthermore, calibration procedures must be rapid in order to reduce downtimes, particularly as the overall number of sensors in a given manufacturing process is anticipated to increase.
The concept of the self-monitoring sensor came about in the early 1990s when advances in microprocessor technology enabled the development of the self-validating (SEVA) sensor concept [1], where a quality index is attributed to a measurement which additionally enables fault detection/correction. Such concepts have been extended to multifunctional self-validating sensors [2] but have yet to be applied to metrology systems assessing dimensional/surface properties in manufactured components except for some initial work on optimal sensor positioning in fringe projection [3, 4].

This self-validation of measurement data is in itself useful because it gives the ability to assign a 'quality index' to measurement data. Furthermore, it allows for the application of adaptive signal processing as well as the possibility of adjustment of input parameters e.g. light intensity. Finally, calibration activity can also be minimised by being deployed 'as needed' rather than strictly periodically i.e. the system can 'self-calibrate'.
For example, in a single analysed point (pixel) in an areal wavelength scanning interferometer is in fact hundreds of parallelised interferometers each at a specific wavelength. The primary measurement (surface height) is determined by monitoring rate of linear phase change with wavelength. However errors in wavelength due mis-calibration, signal intensity variation due to source/measurand material properties can be detected the deviation of the generated phase from that implied by the constraints imposed by the optics.

Aim:
This aim of this project is to develop fundamental concepts behind a 'self-aware' sensor that can holistically evaluate the full gamut of information contained within an acquired signal in order to determine not only the primary information e.g. height/distance but also to track changes in other secondary parameters such as alignment, calibration status, environmental/measurand variation. The initial work will develop analytical techniques for broadband interferometry e.g. wavelength scanning interferometry (WSI) in order to establish methods for separating secondary parameters from the primary measurement.
Once the ability to effectively separate secondary parameters has been established, signal processing techniques will be expanded be adaptive based on the nature of secondary parameter variation. The possibility of adapting input parameters to the system will also be considered at this stage.

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Evaluation of the efficacy of the adaptive sensor will be done through practical demonstration within a suitable in-situ measurement application, for instance on a diamond turning machining centre.

Eligibility: The student must have a high-grade qualification, at least the equivalent of a UK 1st or 2:1 class degree or MSc with distinction in Physics, Engineering or related disciplines. The student must be proficient in both written and spoken English, and possess excellent presentation and communication skills.

Salary: £15,285 (2020/21 EPSRC Standard)

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