Fibre-optic shape sensing

Fibre-optic shape sensing (FOSS)

- Tracking of lateral movements of a structure and its direction without external access
- Based on the measurement of curvature-induced differential strain within a multicore fibre or a fibre arrangement
- Applications include structural health monitoring, vibration analysis and object tracking, such as medial endoscopes
- Unlike accelerometers, FOSS measures vibration/displacement in the structure's own frame of reference, a key advantage for non-stationary measurements

Our approach to FOSS

- Based on Fibre Segment Interferometry [1,2], an approach pioneered at Engineering Photonics in Cranfield University, which measures strain integrated over fibre segments
- Simple, cost-effective and robust interrogation system based on standard telecoms laser diodes
- Fast and highly sensitive measurements (nanostrain resolutions at multi-kHz bandwidths result in µm lateral displacement resolutions)

Example application: helicopter blade vibration mode measurement

A current project investigates vibration monitoring of a helicopter blade in airborne conditions as shown in Fig. 1. The use of flexible support structures, such as a Teflon (PTFE) rod, allows high-resolution measurements with a robust sensor mounting. Ultimately, the use of multi-core optical fibre would permit low-protrusion measurements and embedding into composite blades.

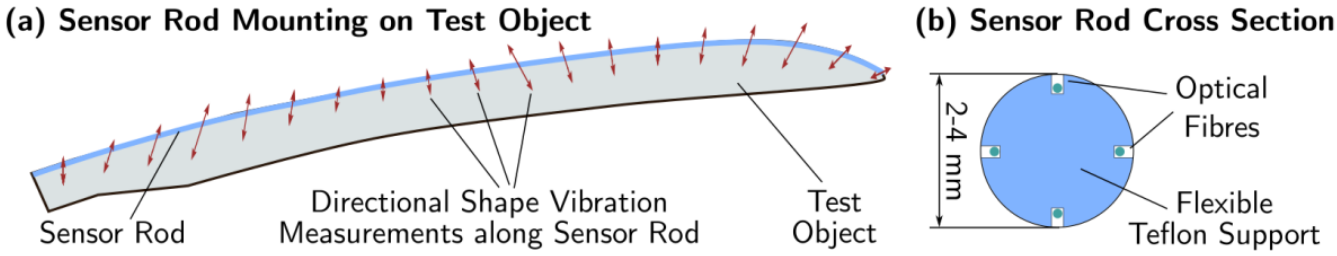

Figure 1: FOSS concept for directional, lateral vibration measurements on a helicopter blade (a). Fibre arrangement on the Teflon sensor rod (b) Teflon sensor rod cross section

Further to applications in structural vibration monitoring, we also envisage potential of the approach for the online measurement of lateral displacement without external access, for example for precision manufacturing stages and healthcare applications.

Further information:

[1] T Kissinger, R Correia, T O H. Charrett, S W James and R P Tatam, "Fiber segment interferometry for dynamic strain measurements", *J. Lightwave Technol.*, **34**, pp. 4620-4626, 2016.

[2] T Kissinger, T O H Charrett and R P Tatam, "Range-resolved interferometric signal processing using sinusoidal optical frequency modulation", *Opt. Express* **24**, pp. 9415-9431, 2015.

Centre for Engineering Photonics

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About Cranfield University

Cranfield is an exclusively postgraduate university that is a global leader for transformational research in technology. Cranfield is focussed on the specialist themes of aerospace, defence and security, energy and power, environment and agrifood, manufacturing, transport systems, and water.

Cranfield has the largest number of engineering and technology postgraduates in the UK, awards over five percent of the UK's engineering and technology PhDs each year and currently works with over 1,500 companies and organisations worldwide.

Cranfield is ranked in the top five of UK universities for commercial research income, with 81% of Cranfield's research classed as world-leading or internationally excellent by REF (Research Excellence Framework, 2014). Cranfield University was formed in 1946 as the College of Aeronautics, the first postgraduate college of its kind.

The Centre for Engineering Photonics

Engineering Photonics at Cranfield is recognised internationally as a leading centre for optical sensing and instrumentation, which, since its inception in 1989, has been led by Professor Ralph Tatam. Engineering Photonics undertakes research ranging from blue skies concepts to the development of prototype instrumentation that is used by us and our academic and industrial collaborators in real environments. Further information about the Centre and a full list of publications and links can be found at openoptics.info.

Research areas

Engineering Photonics applies advanced photonic technologies to solve challenging measurement problems. Our research underpins measurements across a wide range of industrially important areas such as: aerospace, healthcare, manufacturing, transport, automotive, environment and agrifoods. We work in collaboration with academia, SMEs and major international companies both nationally and internationally.

Technologies

Optical interferometry; optical fibre sensor technology including interferometry, FBGs and LPGs; optical imaging and image processing; optical gas sensing; speckle interferometry and metrology.

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