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Zero-crossing detection algorithm for arrays of optical spatial fi ltering velocimetry sensors

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This paper presents a zero-crossing detection algorithm for arrays of compact low-cost optical sensors for measuring e.g. minor fl uctuations in angular velocity of rotating solid structures. The algorithm applies to signals with low signal-to-noise ratio, and delivers a “real time” output (0-1 kHz). The sensors use optical spatial-fi ltering velocimetry on the dynamical speckles arising from scattering off a rotating solid object with a non-specular surface. The technology measures rotation of a target, without being biased by any linear translation of the object. The calibration of the sensors is independent of the radius of the target, the wavelength of the light, and the distance to the object. No preparation of the surface, as in the case of an indexer, is necessary. Furthermore, any thermal dependency of the calibration factor is directly related to the thermal expansion and refractive-index coeffi cients of the optics (> 10-5 K-1 for glass). By cascade-coupling an array of sensors, the ensembleaveraged angular velocity is measured in “real-time”. This allows the instrumentation to signifi cantly reduce pseudo vibrations, and to gain high performance measurement of angular velocity. The traditional zerocrossing detection is extended by 1) inserting an appropriate band-pass fi lter before the zero-crossing detection, 2) measuring time periods between zero-crossings and 3) doing peak searches in histograms of time-period to allow measuring at low signal-to-noise levels. The algorithm will be compared with time-resolved Fourier analysis.