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Technology Offer

Reducing phase singularities in speckle interferometry

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Background

Speckle interferometry is an established metrology technique for the characterization of rough objects. Deformations of rough objects under a load can be determined, as well as – with the help of an additional second wavelength – the surface shape of the object under test. As an illustration, Figure 1 (left) shows the so called raw phase as a result of a deformation measurement on a metal plate. The shape and the density of the fringes indicate the response of the metal plate to the load.

Owing to the monochromaticity of the illuminating light, the raw phase is given only mod 2π, leading to a discontinuous, saw tooth structure. Unwrapping, i. e. eliminating the 2π-discontinuities, is however greatly impaired by the presence of phase singularities in the raw phase. Such phase singularities are a consequence of the multiple beam nature of the interference phenomenon on rough surfaces. Using a standard unwrapping algorithm suited for smooth surfaces then leads to the result of Figure 2 (right). No traces of the systematic phase distribution generated by the deformation can be seen.

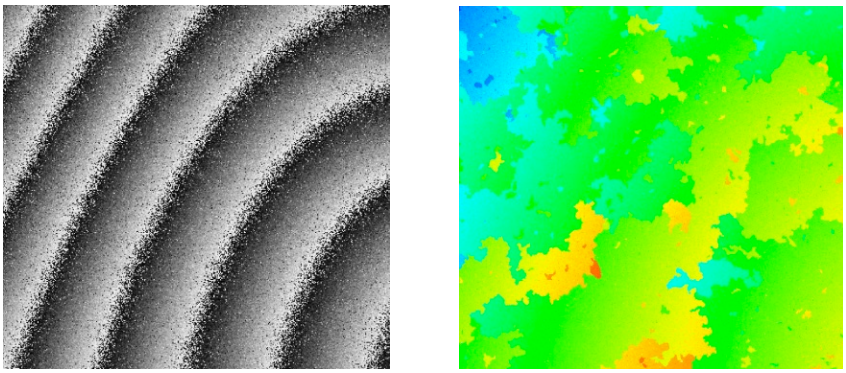

Figure 1. Result of a speckle deformation measurement. Left: Raw phase. The huge number of phase singularities makes the raw phase appear noisy. Right: Unwrapped phase, obtained via a standard, unsophisticated unwrapping algorithm. The errors during unwrapping completely mask the systematic phase from the deformation.

Motivation

Much more sophisticated unwrapping algorithms than the one used in Figure 1 have been developed, trying to deal with the huge number of phase singularities. Nevertheless, it is highly preferable to reduce the number of phase singularities appearing in the raw phase in the first place. This should be done by a physical mechanism, and not by software.

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To this end, a physical averaging of many independent speckle fields has been realized, each giving the same deformation phase, while their combination leads to a much reduced number of phase singularities in the resulting raw phase.
Figure 2 shows the raw and the unwrapped phase for a similar deformation after the physical averaging was applied. Comparing with Figure 1, the raw phase now looks much cleaner and less noisy. Apart from a few, small regions, the unwrapped phase has been correctly unwrapped even by the unsophisticated, standard algorithm used.

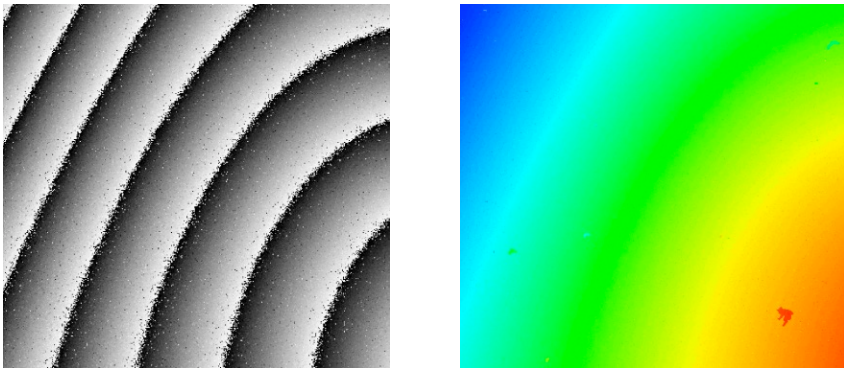

Figure 2. Result of a speckle deformation measurement, physical averaging applied. Left: Raw phase. Right: Unwrapped phase, obtained via the same standard, unsophisticated unwrapping algorithm.

Summary

- Speckle interferometry is routinely used to determine shape and deformations of rough objects
- The evaluation process is however impaired by the presence of phase singularities
- Here, a physical averaging mechanism is applied to reduce the number of phase singularities in the raw phase
- The resulting, averaged raw phase can then be unwrapped even with standard algortihms

Patent Information

German patent has been filed on 02.08.2016