Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

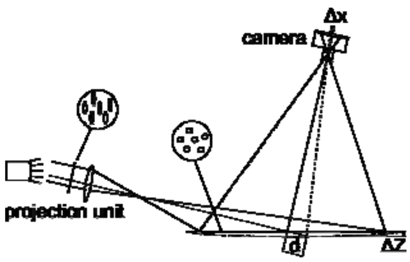
Handout

PROPAC and REPAC – Bumpdetection for production lines

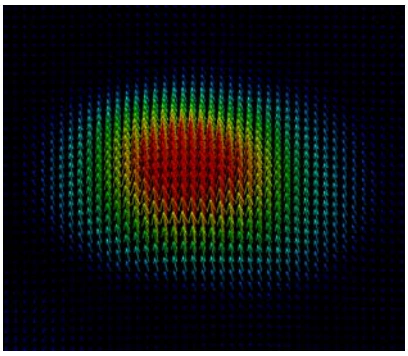
General description

The Projected Pattern Correlation (PROPAC) technique is an optical 3D measurement technique, which is able to measure deformations of diffuse scattering surfaces spatially. The achievable measurement accuracy can be less than one micrometer. PROPAC enables us to determine surfaces of objects in absolute coordinates as a difference to a defined reference surface. The PROPAC technique can be expanded to specular surfaces, which we call the Reflected Pattern Correlation (REPAC) technique.

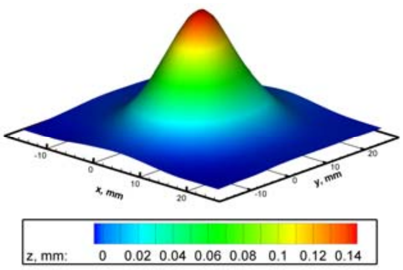
Principle arrangement of the Projected Pattern Correlation (PROPAC) technique.



Result of the cross-correlation algorithm.



Typical measurement example of a bump (displayed exaggerated).



Metrology

The measurement principle is shown in the adjoining sketch: a stationary projection unit projects a random dot pattern under a small angle onto the surface. A stationary camera records the dot pattern under a triangulation angle. Due to the random characteristic of the dot pattern, its cross-correlation is always unique. This allows us to calculate the local cross-correlation between the dot pattern on the deformed surface and on the reference surface and, therefore, the local pattern shift on the surface. For known orientation of the projection unit and the camera, it is possible to reconstruct the orthogonal surface deformation by means of the measured pattern shift. Using high-power light sources enables us to use an exposure time of a few microseconds for image acquisition. This makes real-time measurements of surfaces in production lines possible. Compared to other conventional optical full-field measurement techniques, PROPAC is considerably fast, because it only needs one single measurement image for the calculation of the deformation.

In case of specular surfaces, the stationary camera records an image of an also stationary screen with a random dot pattern indirectly, using the specular surface as a mirror (REPAC). In this case we can use the measured pattern shift to reconstruct the variation in height and also in slope.

Applications and conclusion

For demonstration purposes we applied an artificial bump on the surface of a metal sheet, which was afterwards measured using the PROPAC technique. The spatial dimension of the bump was about 2 x 2 square centimeters and it was about 100 micrometers deep. For the measurement, we used an off-the-shelf LCD projector with 800 x 600 pixels as well as a 1.4 mega pixel CCD camera with 12 bit and active cooling. The recorded image data was processed using our in-house developed cross-correlation software. On the left side, you can see the results of the local cross-correlation algorithm and the final deformation, both color-coded.

Other possible applications are:

- Surface roughness measurement for classification purposes
- Local deformation or velocity measurement of moving or deforming objects
- Determination of the shape and local declination of mirrors, lenses, eyeglasses and head-up displays
- Measurement of glass panes thickness

The presented measurement principle based on cross-correlation of random dot patterns is very modular, since different quantities (deformation, slope, velocity) can be measured on different surface types. In addition, the PROPAC technique is considerably fast, which allows us to handle with moving objects.

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