



XPOSURE PHOTOMETRY: INSPECTION UP TO 300 kHz

Unveiling the invisible with high-speed photometric stereo for inline 2D & 3D inspection

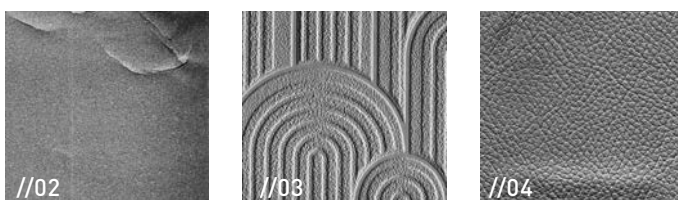
PHOTOMETRIC STEREO

Introduction

Photometric Stereo (PS) imaging is known as a shape-from-shading method for reconstructing the three-dimensional (3D) object shape from planar images taken from multiple illumination directions. It is sensitive to small surface structures, derived as local changes of the surface's local normal vector. PS processing involves the computation of different images of the object's surface under different illumination directions, which allows highlighting small 3D surface structures in the PS output signal (figures //01-//04), including manufacturing defects for instance.

The PS output signal contains quantitative information about the local surface curvature (concave, convex), which cannot be retrieved from conventional two-dimensional (2D) imaging. This quantitative information can then be used by classification algorithms to identify different 3D structures in general, and to distinguish between pseudo defects such as dirt from actual defects like scratches, spikes, pinholes or wrinkles more particularly.

3D inspection of surface structures



Seeing more in 2D & 3D at high inspection speeds

Inspection applications with high-speed requirements are often restricted to 2D imaging, as full-fledged 3D object reconstruction imposes a significant computational effort. At the same time, users are often not interested in measuring the exact shape and absolute dimensions of 3D features, but they rather want to detect and classify anomalies and defects of the inspected parts' surface. xposure:photometry tackles this use case by providing information about the local 3D surface structure simultaneously with classical 2D image data, while operating at very high acquisition rates:

- When one-dimensional (1D) surface gradients are sufficient, xposure:photometry allows for acquisition speeds up to 300 kHz using two lighting directions – e.g. 30 m/s @ 0.1 mm spatial resolution.
- When full 2D surface gradients are required, xposure:photometry allows for acquisition speeds up to 200 kHz using three lighting directions – e.g. 20 m/s @ 0.1 mm.
- When 3D information of the surface structure is targeted, xposure:photometry allows for acquisition speeds up to 150 kHz using four lighting directions – e.g. 15 m/s @ 0.1 mm.

//01 Albedo & gradient image of a 20 Euro banknote – detail

//02 Battery foil (sample size approx. 2x2 cm²)

//03 Wallpaper (sample size approx. 6x6 cm²)

//04 Leather (sample size approx. 7x7 cm²)

XPOSURE:PHOTOMETRY unveils the invisible ...

600 MILLION POINTS/S

xposure:photometry enhances a high-speed line scan camera to solve inspection tasks, where high-resolution 3D surface structures are of interest and standard 3D imaging is too slow. xposure:photometry, which captures local 3D surface structures (albedo and surface gradient in 600 million points/s) at high inspection speeds, is a novel solution for demanding surface inspection tasks with applications in many fields of industrial production. xposure:photometry is a fast inline 3D surface scanner acquiring texture and structure information by providing and offering

- simultaneous grayscale images (albedo) and gradient images (surface normal vector field),
- plug-and-play features: easy to integrate using standard interface,
- smart camera features: FPGA with free resources for additional customized processing tasks, and
- flexible design: easy to be adapted for different accuracy/speed configurations.

XPOSURE:PHOTOMETRY – THE INNOVATION

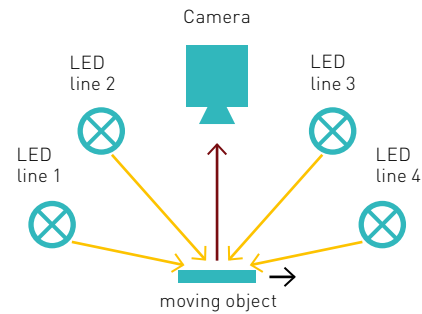
- Detection of microscopic 3D defects at high speed with inline photometric stereo
- Multi-directional lighting revealing 3D surface defects
- Single camera – multiple strobed illuminations
- Photometry processing inside camera disburdening CPU/GPU
- Camera extracting relevant image information for subsequent image processing task

APPLICATION FIELDS

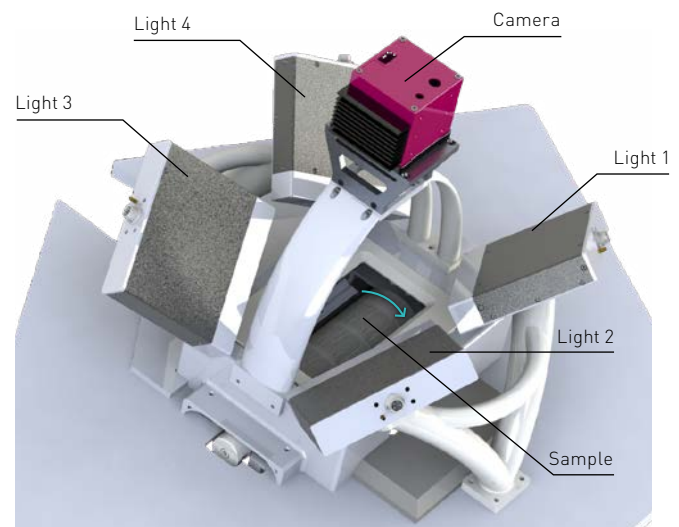
- High-quality metal surface inspection
- Wire surface inspection
- Inspection of printed material with tactile features (e.g. intaglio print, braille embossing)
- Inspection of battery electrode foils
- Inspection of infrastructures (rail surface, road surface, etc.)

XPOSURE:PHOTOMETRY IN A NUTSHELL

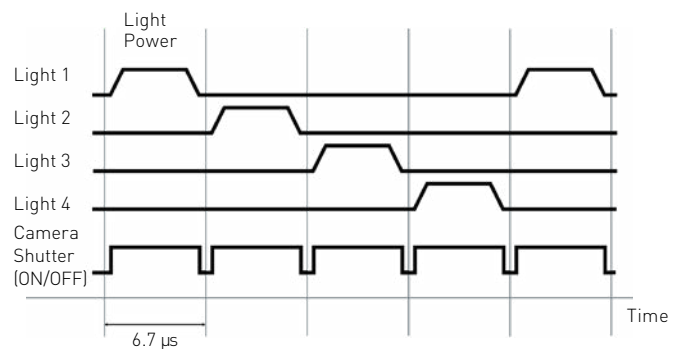
- High-speed inline inspection
- High sensitivity to small surface defects
- High-quality data for subsequent defect classifiers
- 3D surface information by smart combination of image acquisition and time-multiplexed illumination



xposure:photometry – working principle



xposure:photometry – AIT test set-up



LED and camera timing; frame period = 6,7 μs.

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... at highest inspection speeds.