Technical Report – Industrial cameras optimize shape from shading applications

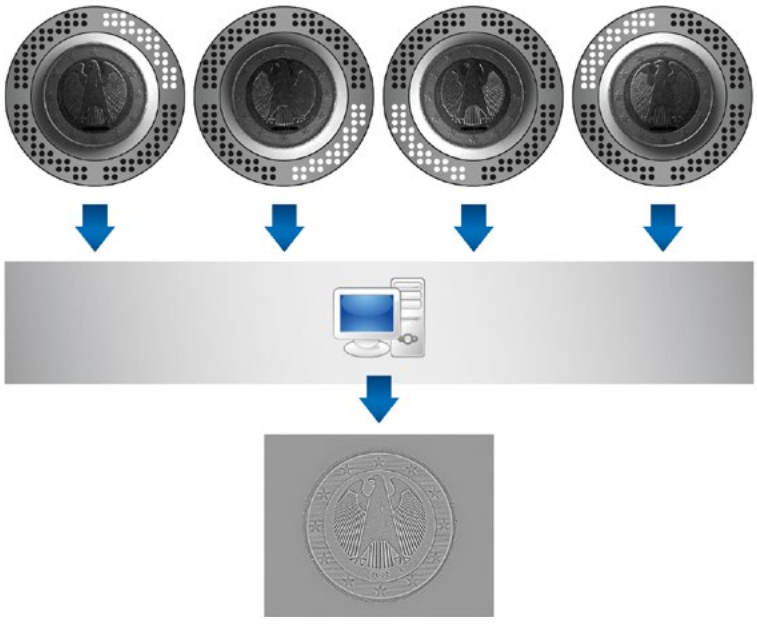
Capturing even the finest detail

The 3D technique shape from shading can be used for automated quality control in virtually every industry. Evaluating the spreading of light intensity identifies even the slightest irregularities on the object surface, such as cracks or scratches. High-performance industrial cameras with integrated lighting controller are a valuable asset for simplified system design and quick implementation.

3D methods have conquered the world of automation and are used in many fields of quality assurance, logistics and metrology. Approaches are as different as the applications. Stereo methods, for example, require two cameras and can only be used with stationary objects, which makes them slow. Triangulation techniques or projection methods are based on motion – either that of the projected measuring points moving on the object surface or that of the object moving underneath the measuring points. The time-of-flight method utilizes one camera only and can be applied both on stationary and moving objects. The 3D shape from shading technique measuring inclination and curvature from different lighting directions is appropriate for both stationary and moving objects. The lateral resolution (x, y) is defined by the camera used and therefore may be very high. This combination enables universal and flexible use.

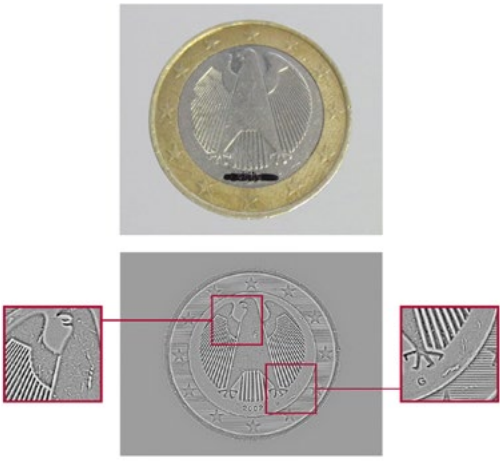
The reverse principle of a sundial

The shape from shading principle is quite simple conceptually. It can be described as a sundial in reverse where the length of the shadow cast by the rod of a defined height will determine the sun's height and direction and thus the time – a high-tech sundial will even deliver the day. As a 3D technique, height is measured using the length of a shadow cast by a defined lighting direction. Complete information about the surface gradients requires a minimum of three, typically four different lighting directions. The gradients serve to identify



In shape from shading applications, the inspected object is being successively illuminated from four different directions while taking one gray-scale image each. The evaluation of the resulting surface shadings provides information about the surface quality.

the heights z (x, y). In most applications, lighting is sequentially triggered while the camera is capturing the image sequence for later evaluation by the software. Very short exposure times minimize blur when measuring moving objects. Alternatively, the lighting direction can also be coded by color and a 3-chip camera will capture the set of images in just one shot. Color cameras are not recommended for shape from shading due to the high color crosstalk of the Bayer filters.



Reliable detection of the finest irregularities in structure and shape even on reflective, glossy or colored surfaces.

The CX.I and LXT cameras feature 4 power outputs with pulse width modulation and up to 120 W (max. 48 V / 2.5 A) output power which allows for direct control of external lighting units.

Irregularities in geometry quickly identified

In recent years, shape from shading has been particularly popular in inline surface inspection and sorting applications. One reason is that evaluation of the grayscale images taken from each lighting direction can remove differences in surface reflectivity (albedo). This way, irregular geometry quickly and easily distinguishes from irregularities caused by color, reflections or texture which is much more complex with other methods. The method is commonly used in the packaging industry, e.g. when Braille information, as raised dots, must be inspected for correctness and accuracy on a printed box.

Shape from shading made easy

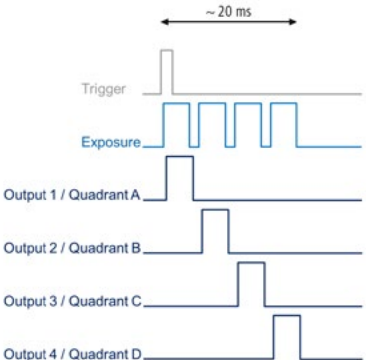
Ideally, four lighting units are sequentially triggered in order to take one grayscale image each for transmission to the evaluation unit. Cameras like the CX.I and LXT models of Baumer are now available with four separately triggerable power outputs. The integrated GenICam™ compatible sequencer and outputs with up to 48 V / 2.5 A allows for lighting units and image acquisition triggered directly by the camera. This eliminates the need for an external lighting controller and the additional costs and cabling required. High dynamic inspection rates however not only call for high frame rates but also extremely short exposure times. The VCXG.I cameras acquire images in burst mode at maximum frame rates for transmission to the evaluation unit at lower frame rates according to the available bandwidth. The integrated Sony® sensors deliver images with a high dynamic range to ensure evaluation stability even on glossy

metallic surfaces. The minimum exposure time of 1 µs significantly reduces motion blur and therefore allows for high throughput.

Saving cost and time

Enhanced cameras with integrated lighting controller and four individually triggerable outputs reduce the number of components in a shape from shading application and therefore save material and integration cost. For a simplified system structure, enhanced reliability and quicker setup.

More Information:
www.baumer.com/cameras



Example sequencer timing for triggering four lighting units (output 1 to 4) straight by the camera (e.g. VCXG-13M.I) without the need for an external lighting controller.

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