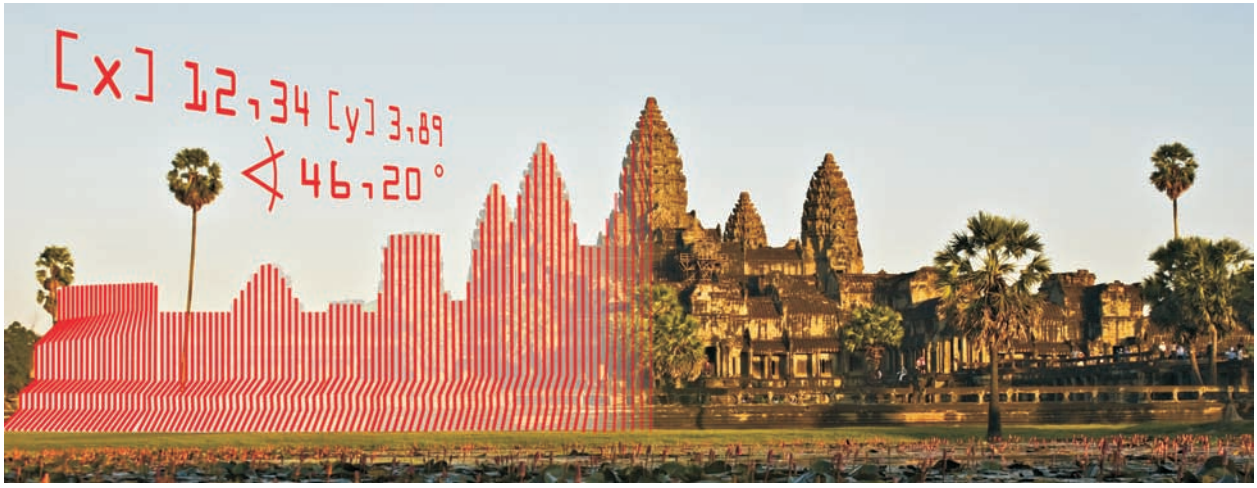

The Angkor Wat temple complex was surveyed using the IMAGER 5006 laser scanner and the uEye camera

Welcome to Real World

USB industrial camera adds color to 3D laser scans

When rooms or objects are to be reconstructed in 3D, laser scanners allow determining the precise distance of every visible point and producing a three-dimensional model. What is missing, however, is the color information. Conventional camera technology, in contrast, can capture brightness and color, but no depth information. The laser specialists Zoller+Fröhlich GmbH have succeeded in merging the two technologies: The Z+F IMAGER® 5006i mobile 3D laser scanner creates a spatial model as a three-dimensional point cloud, while a high-resolution 5-megapixel camera from IDS provides the color images for the texture. The scope of applications for this system is very wide: from the documentation of buildings, such as historical monuments or factory halls, to traffic accident analysis to forensic investigations.

Example 1: Angkor Wat, the huge temple complex in the north of Cambodia, is famous throughout the world. Every year, more than half a million tourists gaze in awe at the over 800 year old sandstone buildings. Today many of the temples are in a poor condition because of natural erosion and deterioration of the stone. Various international organizations are therefore working to protect the fascinating complex. A first step in the conservation efforts is to survey and document the buildings in every possible detail to be able to monitor changes. The combination of laser measurement technology and machine vision allows creating true-to-life models of the temple complex directly on site.

A fusion of two worlds – the Z+F IMAGER® 5006i and a USB uEye camera

The IMAGER 5006 uses a laser measurement process called LIDAR, which is short for Light Detection And Ranging. In this process, a motor-driven mirror system deflects a red laser beam vertically so that it scans all points along a line. In addition, the entire system rotates horizontally, which allows creating a complete representation of the surroundings within the scanner's field of view. The IMAGER 5006 determines the actual distance of each point by calculating the phase difference between the emitted laser beam and the reflected laser beam. The phase difference is integrated continuously, which makes this process much faster than other laser measurement systems, e.g. pulsed systems using time-of-flight measurement.

In the Ultra High Resolution mode, the scanner acquires 40,000 measurement points in the horizontal and another 40,000 points in the vertical direction during each full revolution. Even at a 10 m distance, the individual points are only about 1.5 mm apart. Besides the distance, the system also stores the reflectivity as well as two angle coordinates for each measurement point. From this data, the IMAGER can calculate coordinates which provide a very dense point cloud of the surroundings. Using color mapping, the images supplied by the 5-megapixel CMOS sensor of the USB uEye SE camera from IDS GmbH can be

3D point cloud superimposed with color-mapped image

superimposed over these coordinates to create a true-to-life model.

The built-in IPC with high-capacity hard disk, integrated control panel and interchangeable battery packs allow using the scanner as a standalone unit. Additional components can be connected via two high-speed USB interfaces. Zoller+Fröhlich GmbH also leverage this feature to upgrade previous scanner versions with the compact USB 2.0 cameras from IDS. Mounting the factory-calibrated camera is just as quick and easy as connecting it to the integrated PC. With the uEye's plug and play connectivity, users can start measuring straight out of the box, without additional configuration steps. “The connection via USB 2.0 gave the IDS cameras a clear competitive edge,” explain Franz Härtl and Thomas Abmayr, the engineers responsible for camera integration development at Z+F.

The camera model they have chosen is the UI-1480SE-C, which offers a high sensor resolution of 5 megapixels. This way, even a wide-angle lens with a focal length of 4.8 mm can be used, and the resolution will still be high enough to clearly capture fine details. For imaging the entire surroundings, the camera is automatically moved to different horizontal and vertical positions. An image series typically comprises three different horizontal paths with approx. ten images taken per path. For special applications that require an even higher resolution, the uEye camera is provided with a lens with an 8 mm focal length. The smaller viewing angle allows for a higher spatial resolution of the color images so that the scanner can scan additional positions in this case. As the scanner is also often used indoors, the dynamic range, sensitivity and color quality of the camera were among the engineers' key selection criteria. Before each image capture, the software automatically adjusts the sensor's exposure time to achieve perfectly illuminated images: From a series of frames captured at different exposure times, the software chooses the frame that has the best contrast without overexposure.

Example 2: A serious road traffic accident happens on a busy highway. Several cars are involved in the multiple pile-up. Reconstruction is very difficult, but essential to determine who is responsible for causing the accident. When analyzing the scene of the accident, the police rely on data acquired by the camera and the 3D laser scanner. While the scanner provides the spatial data for measuring the vehicle positions, the camera images deliver valuable details, such as skid marks, that would otherwise be imperceptible. This way, the highway can soon be cleared again and the investigation is conducted virtually on the PC.

In a full 360° scan, laser measurement and color imaging are each completed in about three minutes, depending on the resolution of the measurement points. For imaging covered areas, the calibrated system performs several scans from different positions. It then uses landmarks to create a complete, true-to-life 3D model.

As the laser scanner is Linux based, it was important that the USB camera also supported this operating system. The industrial camera series from IDS provides an elegant solution to the question of software integration: The free “uEye SDK” software development kit runs on Windows and Linux systems, and is identical for all USB and GigE camera series of the German machine vision specialist. The SDK allows users to switch to a different camera model anytime without programming effort. The camera can be integrated directly through the C++/C#/VB programming interface or through one of the standard interfaces, e.g. DirectShow, or interfaces for popular image processing libraries. All cameras from IDS of course also support the new machine vision software standard GenICamTM.

The flexibility and simplicity of camera integration is another benefit for Zoller+Fröhlich: “We are very satisfied with the uEye – it is compact and easy to integrate,” Thomas Abmayr summarizes the experiences in developing the scanner system.

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