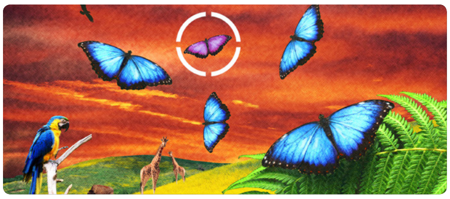


SCORPION VISION SOFTWARE

Tordivel as
Storgata 20, N-0184 Oslo, Norway
www.scorpionvision.com

Scorpion 3D Scanner

Methods and Concepts for creating 3D Images

Introduction

Laser triangulation is a main technology for implementing a 3D Image and thus for making 3D vision systems. Lasers are used to create height profiles captured by an area camera. An ordered collection of height profiles makes up a 3D image.

The Scorpion 3D Stinger Scanner uses one or more laser lines to create a model of the surface of an object. The system can be used in different applications to create real-time 3D Models:

- Measure the minimum and maximum thickness of a pizza
- Measure minimum width or height for a weld
- Measure the 3D position of an object
- Locate surface defects

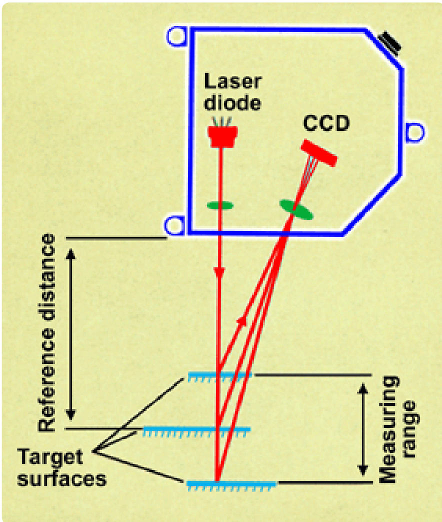
By mounting the system on a robot, it is possible to model the complete surface of any product.

The system has the ability to calibrate N 3D laser systems into one common 3D reference system. With a common 3D reference system and the ability to synchronize image acquisition for multiple systems, the 360 degrees 3D model for a wire or fibre is easily created with Scorpion 3D Laser Triangulation.

The concept of Triangulation

To do triangulation you need a light source with a lens that creates a pattern, typically a dot, a single line or multiple lines. A camera, mounted in an angle, measures the displacement on the surface.

In most industrial applications, lasers are used as the light source, but LED light sources are also becoming more used.



The concept of 3D Laser Triangulation

The light source is often positioned perpendicular to the object and the camera is mounted in an angle relative to the laser pointing direction. In the camera view the line pattern will be displaced in position according to the variations of the surface geometry.

To create a 3D model based on a scanner concept, the triangulation system or the object is moving. The camera continuously takes images of the pattern. These images are analyzed in real-time locating the pattern position. The pattern is often described as a point list where each element is the two coordinates y, z. To create a 3D model the scan movement describes the last dimension x. x is given by the distance between each image or laser line. To create an accurate 3D model it is required that the laser camera is calibrated in mm. This must be done for all three dimensions x, y and z.

From the 3D model, 2D height map images can be created visualising height variations as changes in greyscale values.

3D Laser Calibration

For accurate measurements the system must be calibrated. With Scorpion Vision Software, two calibration steps are performed:

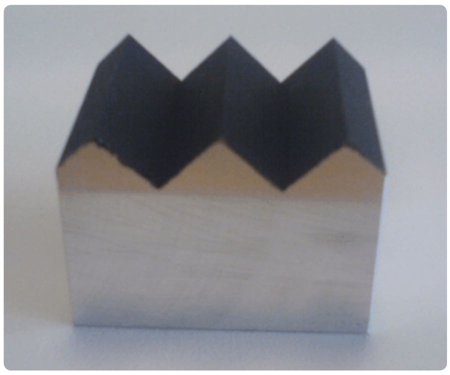
1. 2D Lens calibration to eliminate lens distortion
2. Laser Line Calibration to convert the laser line point positions to physical height.

Lens calibration is executed by taking an image of a standard grid pattern and using the tool Calibrator to calculate the individual corrections for each pixel. Typically this calibration makes the system operate with sub-pixel accuracy and will normally increase the accuracy with a factor between 5 and 100 – typically 20. With this calibration method Scorpion Vision can guarantee optimal performance with regards to accuracy.

Laser Line Calibration

Scorpion Laser Line Calibration requires a physical object with known geometry.

The image below shows a saw tooth shaped object. The lines projected from the laser can then be measured with sub-pixel accuracy and the peak and valley points can easily be calculated.



Saw tooth shaped calibration object

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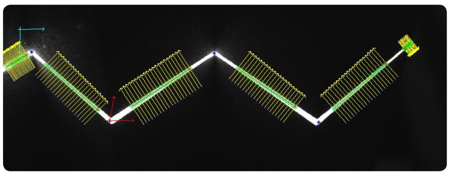
In the External Reference tool the measured point coordinates are matched with the physical geometry of the calibration object. This creates a reference system used for height measurements. The height measurement plane is perpendicular to the object and scaled in mm.
The Laser Line Calibration can be automated and performed using only one image. We call this "One-Push Calibration" making system recalibration fast, secure and very accurate.



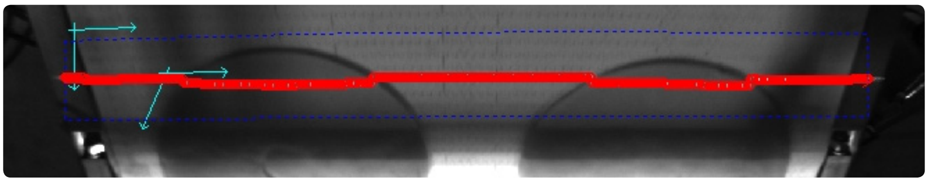
Geometry of the calibration object viewed by the camera

Pattern points measurements

In each image the line is located and measured in a large number of positions. The point positions in the 2D image give the y and z values of the point. A typical 3D reference system will have the x direction in the direction of the movement, the y direction across the laser line and the z value is the height relative to the laser calibration reference system.

Laser line synchronisation

Assuming that we have the standard 3D reference system as described in the previous section, we need to synchronise the image capturing of the laser line pattern to be able to set the correct x value of each line. This can be done by hardware triggering the camera synchronous with the movement. On a conveyor the hw trigger signal is normally derived using a tacho generator.
In a robot system it is easy to link each image to an actual robot position given by x,y,z.



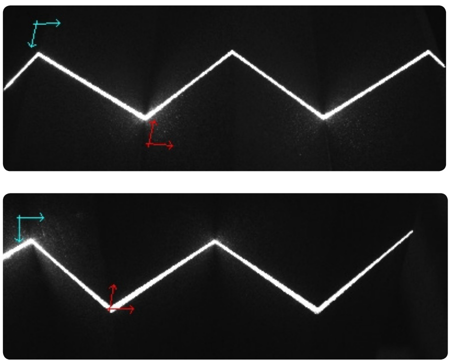
Robust 3D laser pizza profile

Multi-Laser Calibration

Two laser triangulation systems can be calibrated into a common reference system. This can be used to measure the thickness of an object.

The following procedure is followed:

- Use one common calibration object. Below a two-sided saw tooth calibration object is shown.
- Capture the image with both systems at the same time
- Extract the data from both systems and add it into the ExternalReference tool

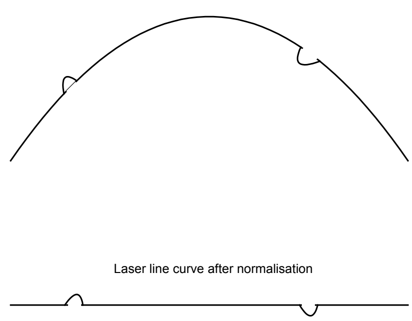


Images from a two-sided calibration

Create models for Surface Inspection

When the inspection task is to detect surface defects rather than measuring the true geometry, the laser line pattern can be normalised to eliminate the influence of the normal geometry.

The resulting pattern will then be a straight line except where smaller out-bound or inbound defects are found.



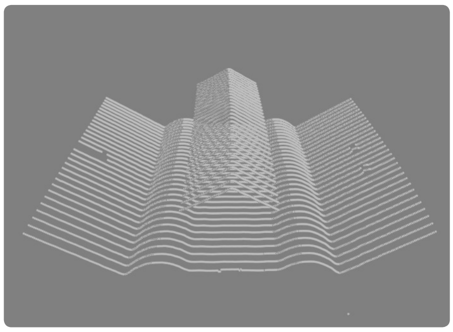
The concept of surface height normalisation

3D Image Displays

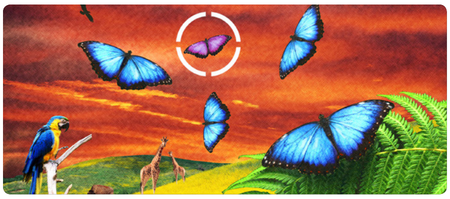
3D Model

Based on measured points from a number of lines/images, a 3D model can be created. This model contains all points measured and can be displayed in 3D.

If several triangulation systems are calibrated together, the points from all systems are displayed in the same 3D model. Alternatively, parts of the points can be displayed in different 3D models. All 3D models will have the same reference system since they are calibrated to the same physical calibration object.



Thickness measurement of a knife



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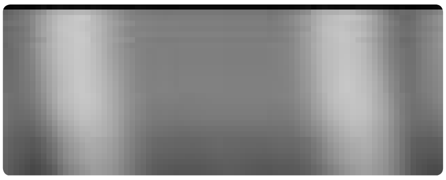
Height Map

Height maps are generated from the points in the 3D model. A height map is a 2D image where each pixel position represents the x and y position of the point in the 3D model and the greyscale value represents the z (height) value. The x, y and z values are referenced to a 3D reference system. The image is created based on a user defined view point and view line. This means that several different height maps can be created displaying various parts of the geometry in different views.



Height map from knife measurement

3D Reference systems

In Scorpion you will have the following types of displays available:

1. the original pattern images
2. the 3D image or model
3. the height map

Since the calibration is done for the original pattern images, all the displays have the same 3D reference. Measurement results can be used and plotted across the different views. Based on the measured points, lines and planes in one of the displays, new 3D reference systems are created and used in another view.

Multiple views and reference systems combined with 2D and 3D processing are essential for 3D Machine Vision.

3D Stereo Laser systems

With the release of Scorpion Version X in 2012 - we have advanced our Scorpion 3D Stiinger Scanning technology by replacing standard 3D Laser Calibration with full 3D Calibration of a Stereo Vision system. This makes it possible to resolve robustly multiple laser lines without any risk of z-folding.

Visualisation

The 3D reference systems and 3D results are plotted in all displays. This feature helps the user to understand the functionality of the 3D inspection system. Displaying results and references in the different images visualise the functionality of each measurement operation. This feature helps to verify the functionality and makes it possible to create and maintain complex 3D measurement systems.

Height Map

Height maps are processed using standard 2D image processing tools. Typical measurements are:

1. Object location
2. Shape and 2D rotation
3. Measure height and areas in a specified measurement region
4. Measure position of max and min height area

Locating pizzas using a 2D blob in a height map

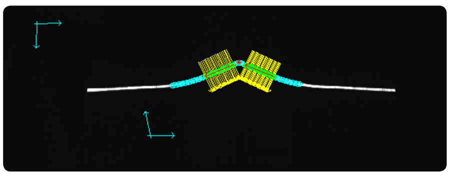
Measurements

Measurements are performed in 2D and 3D images using the common 3D reference system.

Analyzing the 2D Profile image

In these images you can use all 2D image processing tools. Typical measurements are:

1. 3D measurement of individual point heights and position of pattern geometry
2. 3D measurement between points and position of pattern geometries of several patterns - when using 2 or more laser systems
3. Verification of profile geometry

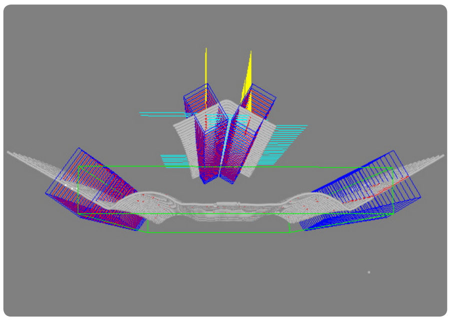


2D laser profile image

3D Point Cloud Processing

In Scorpion there are a number of dedicated processing tools for 3D Point clouds displayed in the 3D model.

1. Plane fit
2. Cylinder, box and sphere fit
3. Geometry tools where planes, 3D lines, 3D points and 3D reference systems can be used to construct new results.



3D point cloud processing

For more information:

Tordivel AS
Phone +47 2315 8700
Fax +47 2315 8701
office@tordivel.com
www.scorpionvision.com