SCORPION VISION SOFTWARE

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3D Robot Inspection

INLINE 3D AUTOMOTIVE MEASUREMENT SYSTEM

by Helge Jordfald and Thor Vollset, September 2008

Tordivel AS is a supplier of robot inspection machines. These machines are used in automotive and pharmaceutical manufacturing for zero defects assembly verification. The systems are used in an inline or offline configuration.
The platform is Scorpion Vision Software offering complete 3D machine vision support. Scorpion 3D Robot Inspection is an extension of an existing product. This article describes the machine and how it was used to solve a challenging 3D measurement task in the Automotive Industry.

Scope

The scope of the application is automated 100% inspection in an assembly line of control arms used in automobiles. Proper functionality require a correct 3D positioning of 2 bushings mounted on the control arm.

A 3D model is a collection of 3D points - a point cloud.

The inspections

- 3D Distance between bushings, nominal distance: 256 mm, resolution better than 0.2 mm
- 3D Rotation, nominal angle: 2.0, resolution better than 0.15 degrees
- Presence and position of lid

The system replaces a mechanical measurement device. The reason for replacing the system is to be able to handle multiple products.
To utilize the capacity of a fully automated assembly line, automatic inline inspection of the control arm is required. The part is inspected when positioned on a pallet and include automatic change over between left and right models as well as different types.

The application requirements

- Part Size: 300 x 300 mm x 100 mm
- Cycle time is 6 seconds.
- Pallet position +/ 10 mm in x, y and z
- Required 3D resolution is 0.1 mm
- Handle four different control arms

Scorpion 3D Robot Inspection System

The key element in the measurement station is a 3D camera system (image 1) with the following elements:

- Three AVT Guppy Firewire cameras
- 9 x9 Lasiris Laser Grid

Image 1, 3D camera system

The 3D camera is mounted in a 45 degree angle relative to the control arm. This allows the system both to measure the control arm and the bushing that are positioned perpendicular to the control arm.
The Toshiba Cartesian Robot (350 mm and 400 mm long axis) moves the 3D camera system in seven different positions in a measurement cycle capturing 19 images. The Scorpion system control the robot removing the need of a teach pendant. The integrated Python framework is used to implement the robot interface. Python is the largest and fastest growing open source scripting language and makes interfacing and adoptions expeditious in Scorpion, removing the need for a traditional development tool.
The LED illumination and laser is controlled by an Advantech IO module connected over USB-2 to the Industrial Computer. The light sources and laser are switched on and off at the different measurement positions (image 2).

The interface to the production system is ProfiBus using a standard OPC interface.

Scorpion Vision Solution

The Scorpion version 6 application is running on a 2.4 GHz Quad Core Industrial PC with Windows XP. All 19 images plus the 3D model generated are displayed in the Scorpion GUI. The complete measurement sequence is controlled from the application using the standard

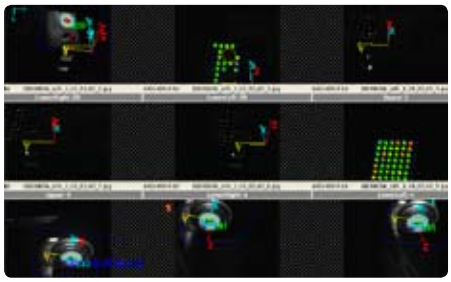

Image 2, Measurement positions

Scorpion event based command structure.
The dot matrix laser pattern is used to create points in the images for generating 3D Point Clouds and the LED lights are used to create appropriate light conditions for other 2D and 3D measurements.

All cameras are individually 3D calibrated in a two step process: First elimination of lens distortion using a 2D grid pattern then 3D camera calibration using 10 xyz-points from a known object. The result is high precision 3D camera model. Image processing in Scorpion is configured using standard 2D and 3D tools without any programming.

The ability to combine 2D and 3D measurement in Scorpion proved vital to increase the accuracy and the robustness of the system.

Application strategy

- Create a 3D image from point clouds generated by laser grid pattern in two image positions
  - On the flat areas of the link arm
  - On bushing 1 mounted on the link arm
- Locate 3D planes from the point clouds
  - Locate a 3D plane of the link arm
  - Locate a 3D plane on the bushing 1.
  - Calculate the angle between the planes
- Create 3D reference systems at the bushing planes for performing accurate 2 D measurements
  - 2D location of bushing points
  - Locate 3D point using 3 camera Stereo Vision
  - Measure the 3D distance between the points

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Scorpion 3D Image Processing

A key feature in Scorpion Vision Software is the ability to create and use 3D Images. Based on the 3D image, Scorpion has tools to locate objects and perform geometrical operations in a framework with true 3D reference systems and 3D visualisation.

Image 3, dots located by a blob tool

In this application the dot matrix laser generates dots that are located using a Blob tool. The output of the Blob is a sequence of x and y coordinates. The order of the coordinates in the sequence is not significant. The Blob output is used as input to the "CreatePointCloud" tool. The tool use correlation or blob search to locate the corresponding dots and use the dot disparity to generate a 3D Model/point cloud from the dots (Image 3 and 4). There is an extensive set of constrain parameters for excluding points and ambiguities in the fit process.

Any single 3D point or sequence of 3D points can easily be plotted in the 3D Model using a simple Python scripting.

Image 4, Matrix laser light source generating bright dots on an automotive part

Scorpion 3D reference System

Working in the 3D model and stereo camera systems in different positions requires methodes to construct, move and transform 3D reference systems.

From the 3D calibration, the 3D Camera/ Stereo Vision system has a common 3D Reference system. The 3D reference system when the camera system is in robot position 1 is defined as the Global 3D reference system. When the camera system is moved to another position, the local 3D reference system in the camera system is transformed to the Global 3D reference system according to the robot coordinates.
All 3D points are thus created in the same Global 3D reference system. The points are used to create one 3D image and measurements are in this 3D image.
The bushing 1 plane and the control arm plane are located from 2 sets of point clouds merged into the 3D image. The vector angle are measured in this image.

Based on the Global 3D Reference system new 3D reference systems can be constructed and moved according to a priori geometry or based on 3D location from 2D images. Reference systems can also be transformed between planes. A constructed, moved or transformed 3D reference system can then be transferred to an image/camera at any position by using Euler, PRY or Quaternion calculations (Image 5). This same applies to 3D robot guiding applications.

Combining 2D and 3D measurements

The ability to combine 3D reference systems with any 2D image in Scorpion is powerful. For high precision measurements in 2D, cameras must be perpendicular to the object plane and scaled accordingly.

For the bushing 1 the exact plane is measured from the point cloud. The 3D reference on the bushing 1 plane is then transferred to the 3 cameras and used to create virtual cameras

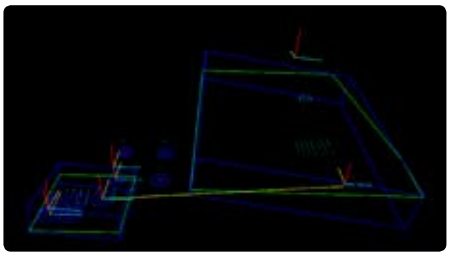

Image 5, 3D reference system transferred to the image

positioned perpendicular to the object with image plane at the object plane.
For the bushing 2 the 3D reference systems is moved according to a priori geometry knowledge and then transferred to the cameras when they are in the correct position.

Consequently we can now use standard 2D measurements like Template matching, Polygon matching, Circle and Line finders to measure the geometry with improved accuracy (Image 6).
Accurate 2D location in all 3 cameras is used by the Locate3D stereo vision tool to calculate precise 3D coordinates of the hole in bushing 1 and the centre point of bushing 2. These points are used for calculating the 3D distance between them with a 0.1 mm resolution.

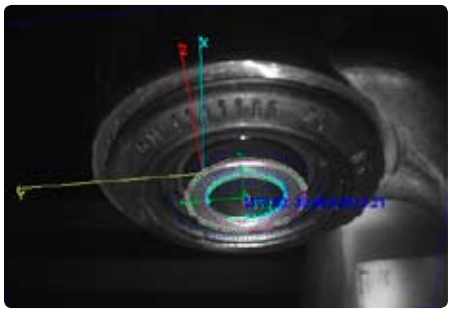

Image 6, 2D measurement in a 3D plane

Scorpion Vision Software in brief

Scorpion Vision Software is a powerful, flexible and extremely expeditious system software tool for industrial vision.

The most advanced 2D and 3D solutions are made without any kind of programming.

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