Automatic Tire DOT Code Identification using CrossCheckHD Sensor Technology

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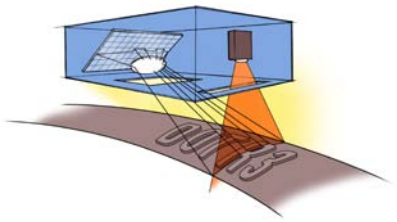


Introduction

The DOT Code Identification System is a sensor and software package used to scan cured tire sidewalls, digitize the surface, and produce a point-cloud file suitable for processing in your preferred 3D vision toolset.

The software provide tools for filtering and flattening the image, and for conversion of the data to a bitmap format compatible with most 3D vision libraries.

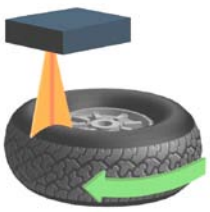
The CrossCheck Sensor must be packaged with a motion control system to set it to the proper standoff distance from the tire sidewall, and to the proper radial position near the bead. Either the tire or the sensor must be rotated one revolution. The system is described below.

CrossCheckHD Sensor Technology

CrossCheckHD™ is a family of high speed laser line sensors. These are referred to by many other names in the industry – laser stripe sensors, sheet-of-light laser sensors, and laser profile sensors. HD designates the high data-density version that utilizes a high speed CMOS detector. These sensors project a line of laser light across a surface, which is reflected back to the sensor through a lens and onto a CMOS detector where each profile is digitized and converted to XY coordinates. The high scanning frequency is possible because the image recorded on the CMOS image sensor is processed directly on-chip, and the 750,000 pixel image is reduced to a 1500 point profile, in sub-pixel co-ordinates, directly on board the chip. The sensor is factory calibrated to convert the sub-pixel co-ordinates which stream from the sensor to real word, NIST traceable measurements expressed in microns. This conversion takes place in the PC-based driver that communicates to the sensor via a Gigabit Ethernet connection. The coordinates are output as streaming data points over Ethernet in a TCP/IP text-based protocol. A software driver command set permits the sensor to be set up and operated from external software applications.

Scanning Resolution

The sensor runs at 4,000 Hz (user selectable), with the tire rotation encoded to 16,384 PPR, then averaged to either 8,192 or 4,096 profiles around the tire.



- For a tire with a circumferential track length of 2000 mm, the circumferential resolution is approximately 0.25mm.
- Data is circumferentially normalized then scaled to an 8-bit gray-scale bitmap (256 increments) over a 3mm depth of field (scaling factor is user selectable). This results in a depth resolution of 0.012mm per gray-scale increment.
- The 50mm wide laser line is digitized into 600 tracks across the radial track for a radial resolution of 0.083mm.
- Under these conditions a character 10mmm high and 6mm wide will be digitized into a grid 120 points high by 24 points wide for a total grid density of approximately 2,900 points.
- Typical DOT characters are about 1mm in depth, so the depth resolution provides for a resolution of 0.012mm, or 85 gray-scale increments over the height range.

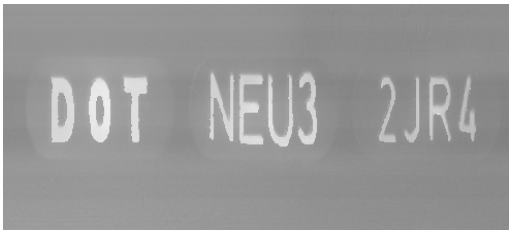
Laser triangulation provides for true geometrical measurement of the tire surface. This has several advantages over traditional 2D camera with external lighting methods:

- By combining sequential profiles, the Profile Sensor generates a data set of three-dimensional (xyz) geometrical coordinates (numbers) whereas machine vision works from a data set of two-dimensional

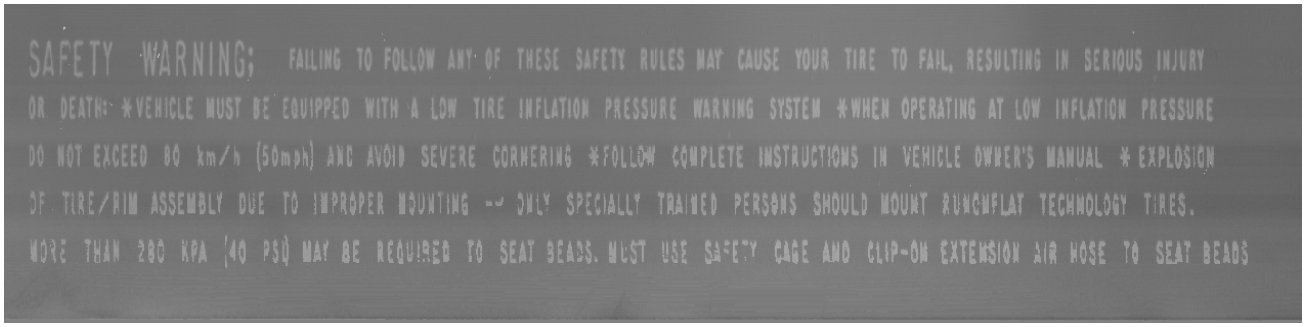
gray-scale images. Traditional vision solutions do not measure the depth of characters, they infer it from shadow contrast.

- The Profile Sensor is calibrated via a method traceable to NIST Standards.
- The laser triangulation method can compensate for varying angles between the face of the sensor and the slope of the tire in the measurement area.
- Laser triangulation is not influenced by variations in surface color, texture, and background lighting.
- The quality metric for the profile sensor is gauge R&R using a certified gauge block. This is quite different from traditional machine vision systems that employ identification schemes such as Data Matrix, where the quality metrics include parameters such as contrast, growth, and axial non-uniformity.

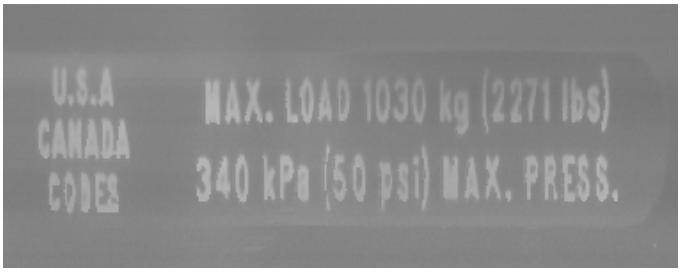
Sample Scans in Bitmap Format



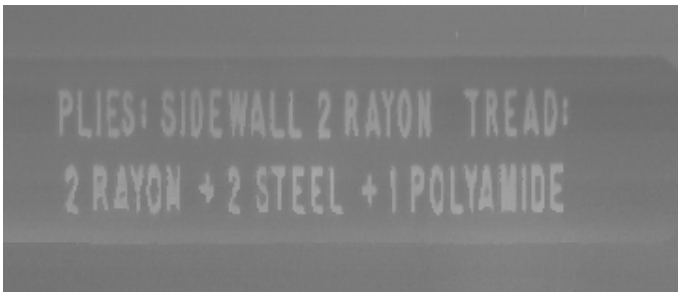
DOT Code bitmap image after normalization
3D coordinates are converted to a 2D gray-scale image



Safety Warning Label Text Bitmap



Load Rating Label Bitmap



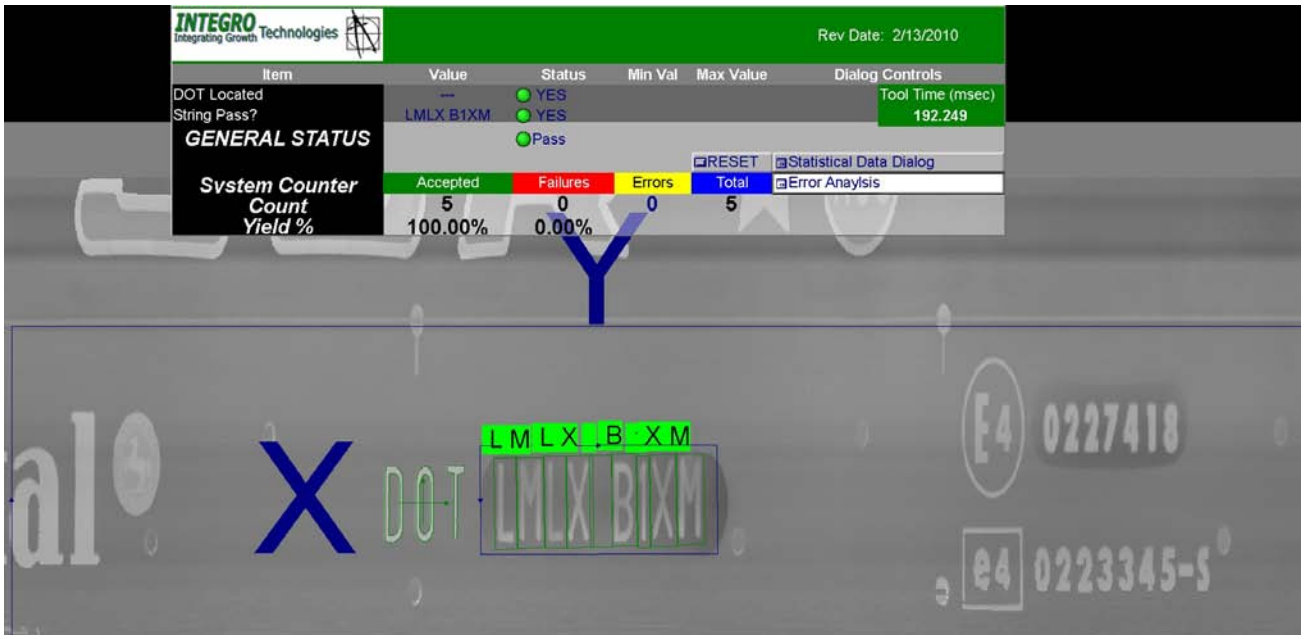
Ply Label Bitmap

Cognex Integration

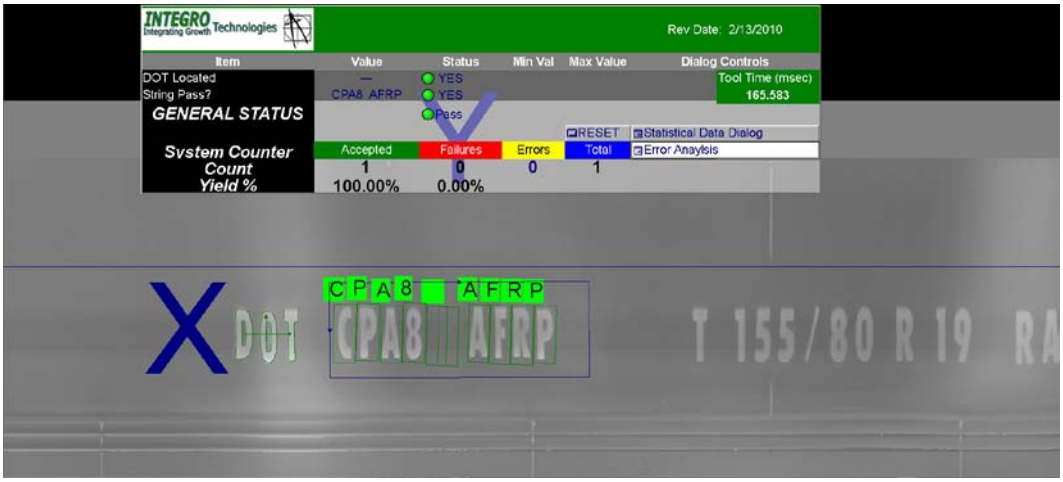
The Cognex VisionPro application has been developed by Integro Technologies of Salisbury, North Carolina, USA. Integro is a certified Cognex Partner Systems Integrator (PSI) specializing in vision system development for industrial inspection and automation.

http://www.integro-tech.com

The image below shows the result of the pattern match routine and the OCR transform of the DOT Code.



Another example:



Electro-Mechanical Integration

In order to automate the tire identification process it is necessary to provide a motion control system to position the tire to the proper location on the tire, and rotate either the tire or the sensor.

- One axis is require to position the sensor to the proper stand-off distance to the tire. Assuming the tire is on a conveyor and laying flat in the horizontal plane the tire would be centered and the sensor would move in the vertical axis. Standoff distance is between 75mm and 100mm (this is for the VHSLE4-080-050-030-660-N sensor).
- A second axis is required to position the sensor to the proper radial location, usually just past the bead diameter.
- The third axis is the rotation axis, which can rotate the sensor in a circle of constant radius, or rotate the tire.
- It is possible in many cases to mount the sensor and motion control system on an existing piece of equipment such as a balancer.
- The sensor package provides for integration with functions for power on/off, cycle start/stop, encoder synchronization, and text output.

Sensor interface Module

Pictured at right, this includes:

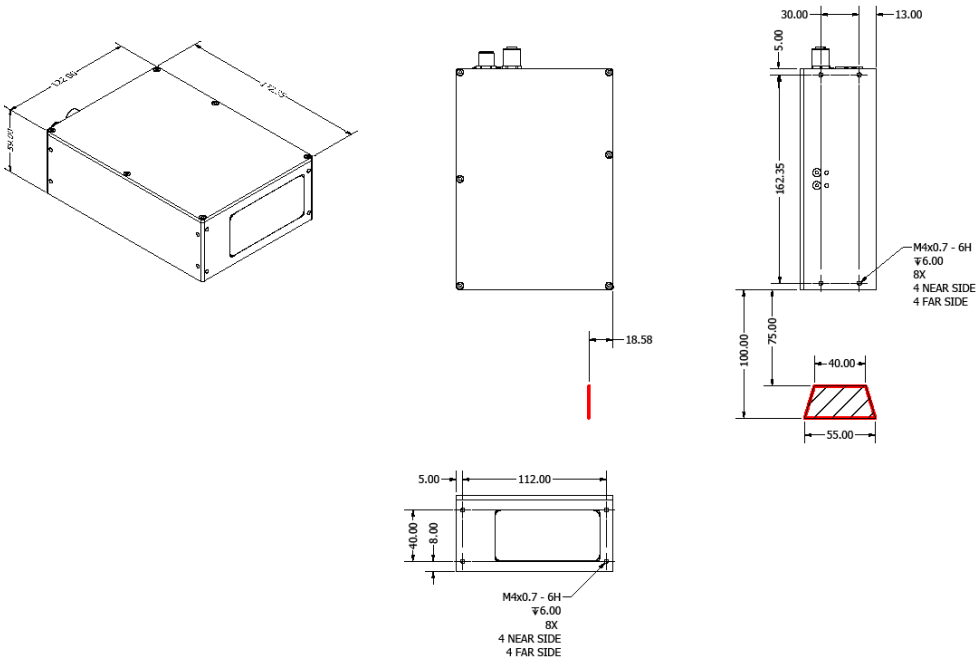
- Power on switch
- Key switch
- Power-on indicator light
- Safety circuit interlock
- Encoder port
- Sensor port
- 110/220V power cord
- Cable length between the module and the sensor is 10 meters maximum

Trigger Input Interface Module

Pictured at right, this includes:

- Power on switch
- Power on indicator light
- Ethernet port
- Trigger port
- Wiring terminals for PLC interface

Dimensional Drawing



CrossCheckHD model VHSLE4-080-050-030-660-N Sensor Details
Contact us for other sensor sizes