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Automatic Optical Inspection System Design for Tell-Tale Clusters in Automobiles UsinG LabVIEW

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Abstracts
Automatic Optical Inspection (AOI) of tell-tale instrument clusters is the extensively researched area in automobile industries due to its simplicity in inspection line and its reliability. The main objective of our project is to develop a visual inspection system for tell-tale cluster using LabVIEW software by Digital Image Processing (DIP).

Keywords: LabView,Clusters,DIP,AOI.

Introduction
In an automobile, an electronic instrument cluster, digital instrument panel or digital dash for short, is a set of instrumentation, including the speedometer, that is displayed with a digital readout rather than with the traditional analog gauges. Many refer to it simply as a digital speedometer. Early analog vehicle instrument panels incorporated little more than a speedometer, tachometer, odometer and fuel gauge. Modern digital instrument clusters, on the other hand, are intelligent devices that communicate with an array of sensors distributed throughout a vehicle, enabling them to display numerous additional features.Prior to fitting an instrument cluster to a vehicle, manufacturers must test each one to ensure that it will perform as expected.

Functional testing
Before they are visually inspected, the system performs a set of functional tests on the displays in the instrument panel. To do so, the panel is robotically placed and pneumatically clamped onto a rotating fixture. During the process, a bar code reader captures data from a bar code printed on the unit to enable each of the units to be tracked through production.Once mounted on the fixture, the instrument panel is connected to a set

of systems through a connector on the rear of the unit. These emulate the systems that are employed in the production vehicle. By interrogating the devices in the panel, the system ensures that it can be remotely powered, whether the CANbus and measurement bus interfaces are operational and if the digital and analog displays are being driven. If the instrument panel passes the functional tests, it is then rotated 180 degrees on a turntable into the vision inspection station.

In the inspection station, monochrome cameras are placed directly above the center point of the tachometer, speedometer, LCD display and fuel gauge. A color camera captures images of the tell tale indicators across the entire instrument panel.

Data from the camera is transferred over a interface to a switch into a rack mounted Intel multicore PC where the images are processed by a vision inspection software . Since the panel itself is backlit, no additional lighting is required to illuminate the panels under test.

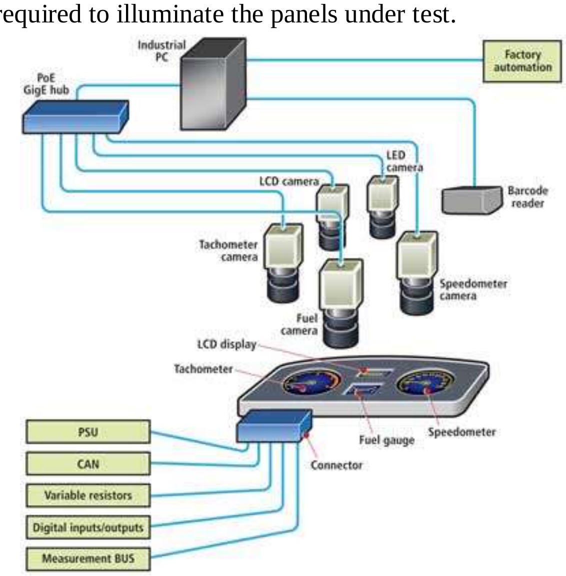

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Figure 1: The vision inspection system uses four cameras to capture images of the tachometer, speedometer, LCD display and fuel gauge and one that captures an image of the tell tale indicators on the entire instrument panel.

The image inspection system calibrates the analog speedometer, tachometer and fuel gauge on the instrument cluster, after which it verifies that they have been calibrated successfully. Secondly, it checks to ensure that all the elements of the seven segment digital LCD display and the color LEDs that illuminate the tell-tale indicators are functioning according to specification.

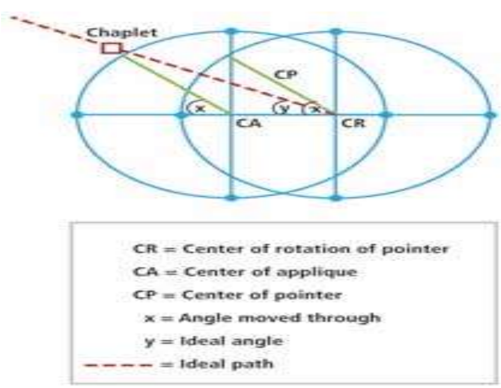

Figure 2: The difference in magnitude between the angle that the pointer was initially driven, and the ideal angle to which it should be driven to point at the center of the chaplet is used to calibrate the tachometer by adjusting the value of the stepper motor offset in the memory of the processor board in the instrument panel.

Display testing

Unlike the analog pointers on the tachometer, there is no requirement to calibrate the LCD display, but simply to test whether all the seven segment display elements are functioning. Prior to doing so, a matching tool is again used to create a reference point from one of the LCDs on the display which the software uses to locate the other seven-segment LCDs on the panel.

A CANbus command is then sent to the instrument panel to illuminate the segments of the display as well as the backlight. The camera in the system then captures an image of the entire LCD display which is transferred over the interface to the PC. There, a set of calliper tools are run in sequence over each segment in the display images to look for dark to light edge transitions in the images of each display element. In doing so, the software can determine whether or not each segment of the display has been illuminated.

Figure 3: A monochrome camera captures an image of the entire LCD display. On the systems host PC, a set of calliper tools are run in sequence over each segment in the display images to look for edge transitions in the image from dark to light. In doing so, the software determines whether or not each segment of the display has been illuminated.

The last image processing tasks verify that all the LEDs that illuminate the graphical symbols or text legends on the applique are operating within specification . Once again, to enable a known template image of the panel to be located in another image of the panel, one of the graphical symbols backlit by an LED on the panel is first lit and located, after which a pattern match operation is performed.

Having done so, the color camera in the system captures an image of all the backlit LED indicators on the instrument panel. Tools within the vision library are used to define rectangular areas around each of the graphical symbols on the images of the instrument panel. The LEDs that light those symbols can then be tested in batches according to their color rather than individually to optimize the cycle time taken to test each panel.

To do so, the system issues a command to the panel to turn on all the LED indicators of one particular color after which the color camera captures an RGB image of all of the illuminated symbols. The RGB values of the images of each specific batch of colored indicators are then transformed into Hue, Saturation and Intensity (HSI) color space. An image histogram tool from the Vision library is then run across each of the rectangular areas bounding the symbols to determine the number of pixels in the images that are of a certain intensity, saturation and hue.

By determining the intensity of light from the indicators, it is possible to ascertain whether they have been turned on. The hue values, on the other hand, enable the system

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to ensure that correctly colored LEDs have been fitted to the panel during the manufacturing process.

NI 1742 smart camera

Smart Cameras for Machine Vision

NI 1742 Smart Cameras simplify machine vision by analyzing images directly on the camera with a powerful, embedded processor capable of running the entire suite of NI vision algorithms. You can use these cameras in a variety of applications including part location, defect detection, code reading, and assembly verification. The combination of the onboard processor with a charge-coupled device (CCD) image sensor provides an easily distributed, all-in-one vision system that transmits inspection results along with or in place of raw images. Housed in a rugged metal case designed for use in industrial applications, all NI Smart Cameras offer built-in I/O, multiple industrial protocols, built-in Web servers, and many other features. You can configure NI Smart Cameras with the included NI Vision Builder for Automated Inspection (AI) software or program the camera with LabVIEW Real-Time.

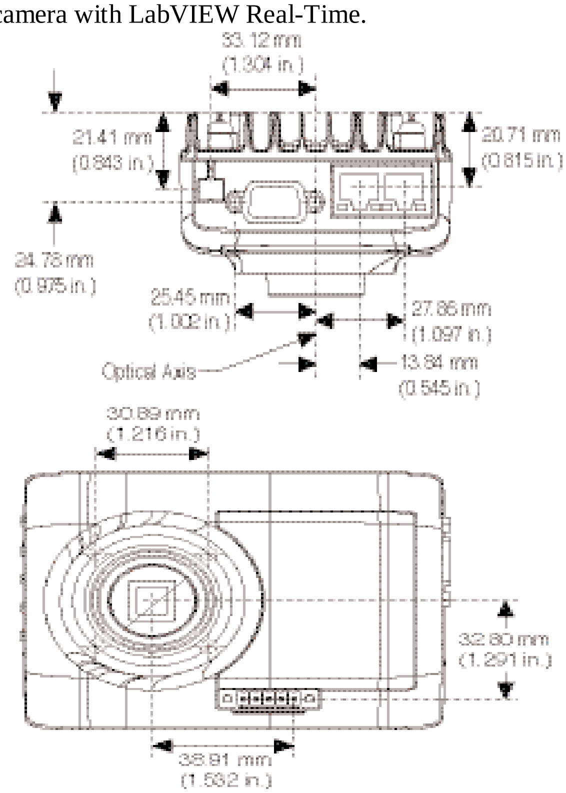

Fig 4: . NI 1742 Smart Camera

Digital image processing using LabView

Digital Image processing is a topic of great relevance for practically any project, either for basic arrays of photo detectors or complex robotic systems using artificial vision. It is an interesting topic that offers to multimodal systems the capacity to see and understand their environment in order to interact in a natural and more efficient way.The development of new equipment for high speed image acquisition and with higher resolutions requires a significant effort to develop techniques that process the images in a more efficient way. Besides, medical applications use new image modalities and need algorithms for the interpretation of these images as well as for the registration and fusion of the different modalities, so that the image processing is a productive area for the development of multidisciplinary applications.The aim of this chapter is to present different digital image processing algorithms using LabView and IMAQ vision toolbox. IMAQ vision toolbox presents a complete set of digital image processing and acquisition functions that improve the efficiency of the projects and reduce the programming effort of the users obtaining better results in shorter time.

A. Digital image acquisition

We generally associate the image to a representation that we make in our brain according to the light incidence into a scene. Therefore, there are different variables related to the formation of images, such as the light distribution in the scene. Since the image formation depends of the interaction of light with the object in the scene and the emitted energy from one or several light sources changes in its trip . Radiance is the light that travels in the space usually generated by different light sources, and the light that arrives at the object corresponds to the Irradiance. According to the law of energy conservation, a part of the radiant energy that arrives to the object is absorbed by this, other is refracted and another is reflected in form of radiosity:

$$\varphi(\lambda) = R(\lambda) + T(\lambda) + A(\lambda) \qquad (1)$$

Where $\varphi(\lambda)$ represents the incident light on the object, $A(\lambda)$ the absorbed energy by the material of the object, $T(\lambda)$ the refracted flux and $R(\lambda)$ the reflected energy, all of them define the material properties at a given wave length (λ) . The radiosity represents the light that leaves a diffuse surface. This way when an image is acquired, the characteristics of this will be affected by the type of light source, the proximity of the same ones, and the diffusion of scene, among others.

In the case of the digital images, the acquisition systems require in the first place alight sensitive element, which is usually constituted by a photosensitive matrix arrangement obtained by the image sensor (CCD, CMOS, etc.). These physical devices give an electrical output proportional to the luminous intensity that receives in their input. The number of elements of the photosensitive system of the matrix determines the spatial resolution of the captured image. Moreover, the

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electric signal generated by the photosensitive elements is sampled and discretized to be stored in a memory slot; this requires the usage of an analogto- digital converter (ADC). The number of bits used to store the information of the image determines the resolution at intensity of the image.

A colour mask is generally used (RGB Filter) for acquisition of colour images. This filter allows decomposing the light in three bands, Red, Green and Blue. The three matrixes are generated and each one of them stores the light intensity of each RGB channel .

Vision Acquisition Express. This block is located in Vision/Vision Express toolbox and it is the easiest way to configure all the characteristics in the camera. Inside this block there are four sections: the first one corresponds to the option of “select acquisition source” which shows all the cameras connected in the computer. The next option is called “select acquisition type” which determines the mode to display the image and there are four modes: single acquisition with processing, continuous acquisition with inline processing, finite acquisition with inline processing, and finite acquisition with post processing. The third section corresponds to the “configure acquisition settings” which represents the size, brightness, contrast, gamma, saturation, etc. of the image and finally in the last option it is possible to select controls and indicators to control different parameters of the last section during the process. In the example presented in Fig. 3 it was selected the continuous acquisition with inline processing, this option will display the acquired image in continuous mode until the user presses the stop button.

B. Mathematical interpretation of a digital image
An image is treated as a matrix of *M*x*N* elements. Each element of the digitized image (pixel) has a value that corresponds to the brightness of the point in the captured scene. An image whose resolution in intensity is of 8 bits, can take values from 0 to 255. In the case of a black and white image images it can take 0 and 1 values. In general, an image is represented in a bidimensional matrix.

Since most of the devices acquire the images with a depth of 8 bits, the typical range of levels of gray for an image is from 0 to 255 .

Another important characteristic in the image definition is the neighbourhood of pixels, that could be classified in 3 groups described in (Fig. 5), if the neighbourhood is limited at the four adjacent pixels is named call 4-neighbourhood, the one conformed by the diagonal pixels is the D- neighbourhood and the 8 surrounding pixels is the 8-neighbourhood, the last one includes the 4- and the D-neighbourhood of pixel.

C.Pattern Recognition
Pattern recognition is a common technique that can be applied for the detection and recognition of objects. The idea is really simple and consists into find an image according a template image. The algorithm not only searches the exact apparition of the image but also finds a certain grade of variation respect to the pattern.

Testing process

The smart camera in the system captures an image of all the backlit LED indicators on the instrument panel. Tools within the vision library are used to define rectangular areas around each of the graphical symbols on the images of the instrument panel. The LEDs that light those symbols can then be tested in batches according to their color rather than individually to optimise the cycle time taken to test each panel. In the front panel of the LabView coding we can see that the image is first acquired and ROI (Region of Interest) is specified . Then the template image for comparison is taken from a separate file path and these two images are sent to the pattern recognition module for searching the template in the acquired image . If the pattern is read , then it is denoted by highlighting the area in both the input and processed images and if pattern is not matched properly, then it won’t indicate any matches. It also specifies the total number of matches detected in the image.

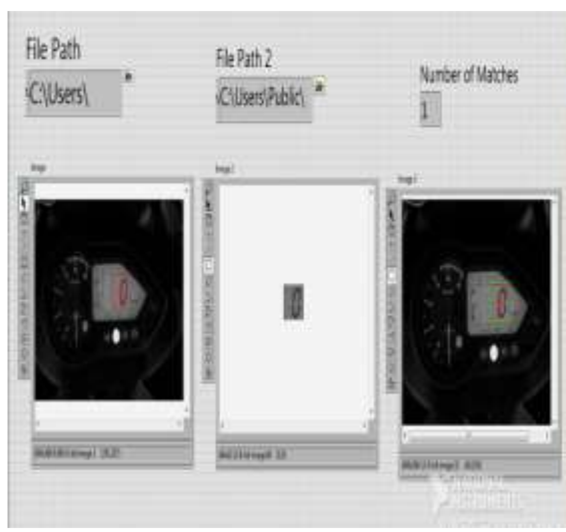

Fig 5 :Front panel of Tell-tale tester coding in Labview

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Conclusion

In this work, an Automatic optical inspection (AOI) system for tell tale instrument clusters using Digital Image Processing (DIP) is designed in LabView software (2012) version.

This module inspects the clusters optically and identifies the clusters with error by capturing the image. It identifies the proper template and performs pattern matching. Then it gives the detected co ordinate as the output if the display is proper.

The automatic tell-tale inspecting is very effective in inspection lines of mass production industries. It helps a lot in minimizing the difficulties in maintaining the quality. It decreases the human error due to its accuracy and its very reliable.

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