

On Line Visual Inspection System for Calibration of Fuel Gauges

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Abstract: In the field of industrial manufacturing, visual inspection is an important task to prevent the inclusion of incorrect parts. There have been demands for such methods able to handle factors caused by positional, rotational alignment and illumination changes. In this proposed innovative approach a binary image of an object having edges is produced by first producing a digital grey scale image of the object with a given resolution and processing the grey scale image to produce a binary image by selecting proper threshold value to get better resolution. It visualizes the gauge parameters, processes it and then after comparing with standard data shows the result whether it is OK or NOT OK.

Keywords: OLVIS, GUI, ROI.

1. INTRODUCTION

This invention relates to an automatic system for illuminating, inspecting and measuring objects, such as gauges, meters etc. There are numerous problems associated with either the manual or automatic approaches to inspection and calibrations. Also manual control inspection is relatively slow and thus a relatively costly aspect of the manufacturing process. The proposed approach provides a faster and more accurate inspection tools to determine the quality of gauges because a computer based electronic imaging system is functionally connected to the camera and uses the measurements obtained from the camera to create a line by line image of the needle orientation [1-2]. In mass-production manufacturing facilities, an attempt is often made to achieve 100% quality assurance of all finished products. With an emerging requirement for improved quality control within the manufacturing industry, the use of visual inspection of the manufactured product becomes a necessity, especially to fulfill the ISO 9000 industrial quality standard. In industry economic considerations play an important role for deciding whether or not a process should be automated [3]. Figure 1, shows an example of fuel gauge to be

inspected. These systems usually perform only simple coarse verifications, such as testing for the presence of an object.

The goal of these applications is to remove defective products from the manufacturing process before additional value is added to the defective product or before the defective product is released to the consumer. Therefore, inspection systems should monitor all manufacturing steps and report defects as soon as possible. Since AVIS operations are non-contact, there is also a lower risk of product damage during inspection [5]. Industry needs automated visual inspection because in the manufacturing process many uncertainties like tolerances, defects, relative position and orientation error, etc. exist, which can be resolved by vision sensing. Vision has undergone a development of over 30 years of research in the computer vision field and application in the machine vision field, resulting in a wide range of different algorithms and systems. The problem is how to match the technology to a specific application in an optimal and cost-effective way [1-4, 7].

2. METHODOLOGY

A binary map of an object having edges is produced by first producing a digital gray scale image of the object with a given resolution and processing the gray scale image to produce a binary map of the object at a resolution greater than said given resolution. Processing of the gray scale image includes the step of convolving the two-dimensional digital gray scale image with a filter function related to the second derivative of a Gaussian function forming a two-dimensional convolved image having signed values. The location of an edge in the object is achieved by finding zero crossings between adjacent oppositely signed values. The

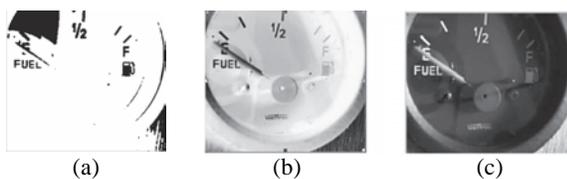


Figure 1: Different Images of Fuel Gauge: (a) Binary, (b) Gray Level, (c) Complemented.

nature of the Gaussian function whose second derivative is used in the convolution with the gray scale image is nothing but its standard deviation, is empirically selected in accordance with system noise and the pattern of the needle [2, 4-6, 9]. To categorize different inspection domains and applications one can choose the type of input data to be used as the classification criteria [5]. A binary image is of class logical binary images contain only 0's and 1's. Pixels with the value 0's are displayed as black and those with 1's are displayed as white. Binary images have the advantage that inexpensive sensors in conjunction with simple lighting arrangements can acquire them, which eliminate shadows and highlights for the purpose of binary representation [2, 10]. Figure 2, shows that there are five standard fuel levels are available. These levels are: full, 3/4th, half, 1/4th and empty. Some tolerances are provided for full, half and empty levels.

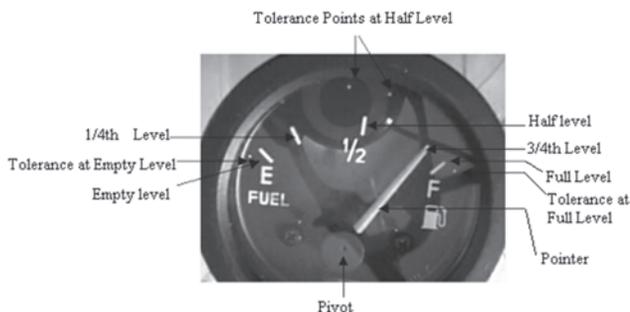
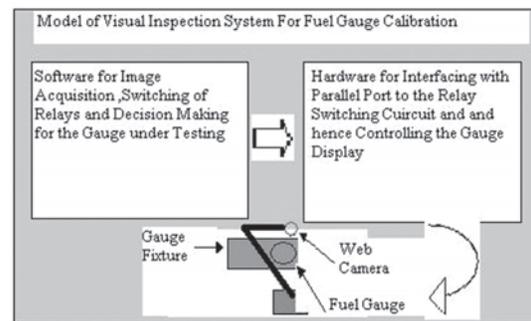


Figure 2: Details of Fuel Gauge Dial

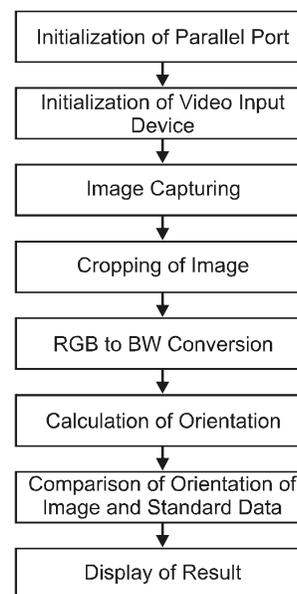
2.1. Visual Inspection Scheme

The various steps involved in this project are fixing of the fuel gauge either manually or automatically through robotic arm doesn't matter, but the alignment of gauge must be matched for all series of testing meters because in this scheme the camera position is assumed to be fixed. So one cannot change the position of camera every time and also it will not be easy to set camera and alignment every time, which may lead to reduce the production quantity. Many people say a vision system consists only of computer, frame grabber, camera and software. However, this neglects important issues like lighting, optics, systems integration and standard industrial inspection practice. A well designed sensing system reduces noise, prevents blur, stops object motion, optimizes the contrast between the part and the background for instance, has a resolution that ensures defect detection in the desired size and emphasizes all features relevant for inspection. In this project, the web camera is used to capture the different images of the pointer [2, 5-9]. The block diagram of proposed AVIS is shown in Figure 3(a). This includes mainly two modules software module and hardware module. The software module contains program for GUI, image acquisition, switching of relays, image analysis and display of result. It is required to

interface the PC's parallel port with the relays. The relays are used here to provide various standard testing steps of fuel gauge [2, 10].



(a)



(b)

Figure 3: (a) Block Diagram of Proposed System.
(b) Block Diagram of Program Sequence.

3. IMPLEMENTATION

The PC supports up to three parallel ports that are assigned the labels LPT1, LPT2 and LPT3. One can use any of these standard ports as long as they use the usual base addresses 378 H, 278 H and 3BC H respectively. The port labels and addresses are typically configured through the PC's BIOS. Additional ports or standard ports not assigned the usual base addresses, are not accessible by the toolbox. Most PCs that support MATLAB will include a single parallel port with label LPT1 and base address 378 [2, 5, 9-11].

3.1. Image Acquisition

The image acquisition is the most important part of this project. As, the quality of image plays an important role in the project, a Logitech make web camera having resolution 1.3 mega pixel is used to get less noisy image [2].

3.2. Image Capturing and Cropping

Image capturing is done using command *getsnapshot*. To extract a rectangular portion of an image, the *imcrop* function is used. The *imcrop* function accepts two primary arguments; the image to be cropped and the coordinates of a rectangle that defines the crop area. The *imcrop* function displays the image in a figure window [2].

3.3. Region of Interest (ROI)

The ROI position property specifies the region-of-interest acquisition window that defines the actual size of the frame logged by the toolbox, measured with respect to the top left corner of an image frame. The ROI position is specified as a 1-by-4-element vector i.e. [XOffset YOffset Width Height] [2, 10-11].

3.4. RGB (Red, Green and Blue) to BW (Black and White) Conversion

Since, it is difficult to select the desired portion from the colored image, the colored image of needle of the fuel gauge is first converted into gray image and this then gray image is converted into complementary gray image, which is finally converted to black and white image by selecting proper threshold [2, 6-7, 10-11].

3.5. Calculation of Orientation of Needle

The angle of orientation of the ellipse is calculated between the x-axis and the major axis of the ellipse. This property is supported only for 2-D input label matrices. The Figure 4(d), illustrates the axes and orientation of the ellipse [2, 10-11]. The left side of the Figure 4(d), shows an image region and its corresponding ellipse. The right side shows the same ellipse, with features indicated graphically; the solid lines are the axes, the dots are the foci and the orientation is the angle between the horizontal dotted line and the major axis [2, 9-11]. The commands used for calculation of orientation angle are *bwlabel* and *regionprops*. These commands give the angle of the orientation of black and white image of the needle in to degree. Then subprograms are used to display the result by comparison as 'OK' or 'NOT OK'. If the calculated orientation angle is within the specified range then it will display 'OK' otherwise 'NOT OK' [2, 11]. The following program is used to calculate orientation of image:

```
array = BytArr(xsize, ysize)
array[indices] = 255B
totalMass = Total(array)
xcm = Total( Total(array, 2) * Indgen(xsize) ) /
totalMass
ycm = Total( Total(array, 1) * Indgen(ysize) ) /
totalMass
center = [xcm, ycm]
x = Findgen(xsize)
y = Findgen(ysize)
xx = (x # (y * 0 + 1)) - xcm
```

```
yy = ((x * 0 + 1) # y) - ycm
npts = N_Elements(indices)
i11 = Total(yy[indices]^2) / npts
i22 = Total(xx[indices]^2) / npts
i12 = -Total(xx[indices] * yy[indices]) / npts
tensor = [ [i11, i12], [i12, i22] ]
evals = Eigenql(tensor, Eigenvectors=evecs)
semimajor = Sqrt(evals[0]) * 2.0
semiminor = Sqrt(evals[1]) * 2.0
major = semimajor * 2.0
minor = semiminor * 2.0
semiAxes = [semimajor, semiminor]
axes = [major, minor]
```

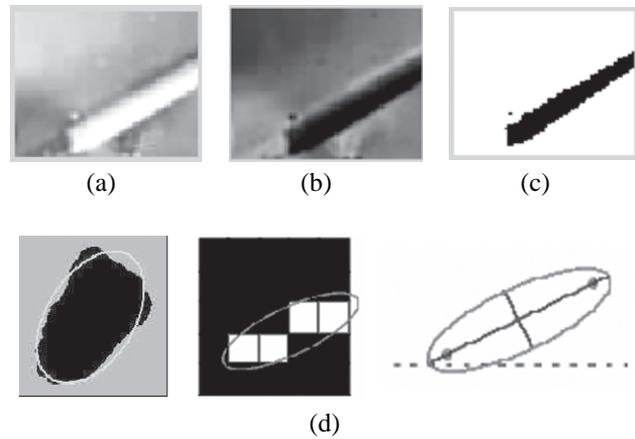


Figure 4: Different Images of Needle a) Gray Image b) Complimented c) Black and White Image and

The orientation of the ellipse is found from the first eigenvector. The orientation is calculated in degrees counter-clockwise from the X-axis. The command used for the calculation of orientation angle is $X = \text{bwlabel}(bw)$; $Property = \text{regionprops}(X, 'Orientation')$; $Y = [property.Orientation]$. These commands give the angle of the orientation of black and white image of needle into degrees and stored in a variable 'Y' and then it is compared with given reference angles. The sub programs used for the comparison of angles and display the concluded result if $[(p > Y) \text{ and } (Y > q)]$; $\text{disp}('OK')$; else $\text{disp}('NOT OK')$.

3.6. Graphical User Interface (GUI)

The GUI has two windows main window and sub window for settings. The window provides complete user-friendly operation. On this window, we can see the database related to number of tested gauges. The main window is shown in Figure 5(a). This window has the following button groups: fuel level, select gauge, start fuel gauge calibration, reset, summary of execution and setting [2, 11].

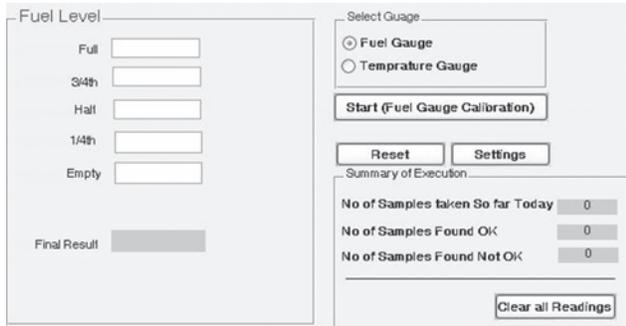


Figure 5: (a) GUI of Main Window

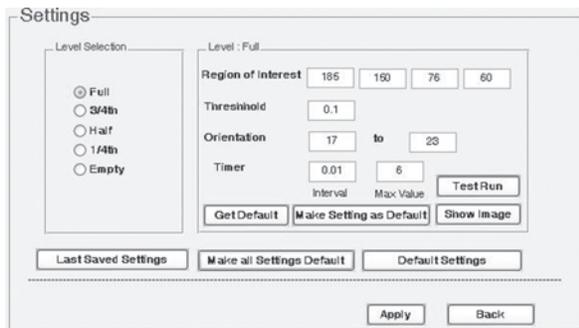


Figure 5: (b) GUI Window for Setting Various Parameters

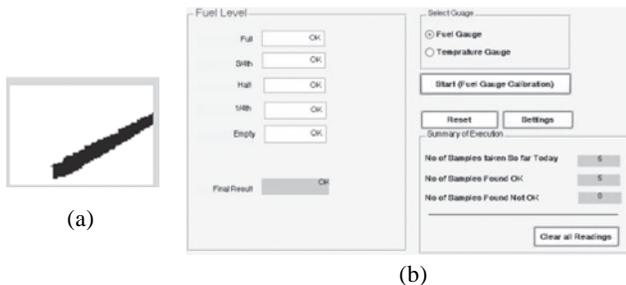


Figure 6: (a) Final Black and White Image
(b) GUI Window Showing Various Results

4. RESULTS

The complete visual inspection system for calibration of fuel gauge is shown in Figure 5 and 6. This system has the following features: easy to use, complete user friendly requires less space as compared to manual system, more reliable than manual system, continuously works, alert signal generated in case of faulty gauge, speed of testing much better than manual system, and setting of parameters is too easy. Using this type of calibration system the efficiency of the testing and calibration system increased. The success rate of this system is approx 98%. The remaining 2% is because of its constraints.

5. CONCLUSION

The results shows that this newly developed system can give better performance provided that two major constraints: light intensity and alignment of fuel gauge with web camera, do

not change. This invention provides a faster and more accurate inspection tool for checking and determining the quality of fuel gauges. In future, this concept can be extended for different analog measuring instruments such as calibration or inspection of temperature gauges, voltmeters, speedometers, automotive and various other industrial applications. This novel calibration system as developed is user-friendly, more accurate than manual calibration and has increased throughput on the line. Further works are in progress to integrate various types of automation needs.

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