Reading Analog Gauges Using Open CV for Hazardous Area Applications

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Abstract— **Analog meters are widely used in the Process industry due to their ruggedness, simple construction, high reliability, and easy operation. Most of the applications use analog meters as they provide accurate results for the purposes. They are easy to use and still the first choice for the industries to do measurement. A Human Operator has to manually take the measurements which causes errors. In hazardous areas like Oil and Gas industries, mining industry the operator's safety is at stake while taking measurements.**

This paper suggests a simple application that makes use of image processing. The application takes an image of the gauge and reads the value. Before giving any result, the application first calibrates the image in small angular values and then makes use of the calibrated values in the measurement stage to convert the angles into meaningful values to display. This measurement technique will help the human operator to work in hazardous areas without any health risk.

Index Terms— **Analog gauges, OpenCV, Hough Transform, OCR, Tesseract.**

I. INTRODUCTION

Measuring Process parameters in hazardous industries is known to be a risky and life-threatening task. Although smart meters are replacing the older ones, there are still many old mechanical meters in operation around the world whose replacement is a time consuming and costly affair.

In many developing countries, manual on-site recording is still prevalent. Manual recording at hazardous areas may lead to serious health issues for the worker at the site.

With the rapid development of image processing technology, the current in the image accurately uptake, pattern recognition and image information extraction, and algorithm design have made great progress, which provides a possibility to interpret the data indicated by the analog gauges.

According to the requirement of an automatic interpretation of analog gauge dial's indicating data, some automatic reading devices have been developed so far, but in practice, there are still problems as follows: The first issue is how to pick up the useful information of the original image.

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In the filming of a meter dial, the right light, accurate focus, and enough resolution photographic equipment are all needed, at the same time the read dial should be disposed of assuring clean and tidy, so as not to affect the quality of the original images; The second one is how to design the automatic interpretation algorithm which is one of the keys to achieve the task. A proper protocol should be offered to extract the center of the dail, pointer, et cetera to get the required output from the image acquired for indicating data. The third one is how to recognize the dial pattern accurately[1].

Here in this paper a suitable method to interpret the image for proper image analysis is discussed.

II. APPROACH

A. Tesseract

Tesseract is an open-source OCR engine. The Optical Character Recognition tool recognises texts in images such as photos and scanned documents. Such kinds of images containing written text are converted into machine readable text data. As Tesseract is an open source text recognition system, it can be used free of cost. It supports a wide variety of languages.[2]

In this project first we started with the Optical Character Recognition (OCR) to identify minimum value, maximum value, and unit on the gauge, so that after extraction of minimum and maximum value we can easily manipulate and divide the scale of the gauge into an equal number of parts, and where the pointer will point we can easily extract that value. But the tesseract engine couldn't perform well as it was detecting random points shown in Fig. 2.1. It could not detect the numbers 0,4,8 and only detected 6,10,mbar, KI 1.6. As it could not locate satisfactorily the minimum and maximum value, so we moved onto another approach

Fig. 2.1. Tesseract OCR could not detect all numbers.

B. Open Source Computer Vision(OpenCV)

OpenCV as the name suggests is an open-source platform having a huge collection of libraries using which we can develop real-time computer vision applications like machine

learning, and image processing and now it plays a major role in real-time systems in today's fast-growing systems. The library has more than 2500 optimized algorithms in OpenCV.

The algorithm OpenCV can be used to detect and read faces, objects, and classify actions of human activities in videos. OpenCV is such a strong platform that can track camera movement, moving objects, three-dimensional models of objects, et cetera.

Using OpenCV library, you can −

● Read and write images

● Capture and save videos

● Process images (filter, transform)

● Perform feature detection

● Object detection such as faces, eyes, buses in the videos or images.

● Video analysis such as motion estimation in it, background subtraction, and object tracking.

OpenCV was originally developed in C++. Python and Java bindings were also provided. The platform is versatile and runs on various operating systems like Windows, Linux, OSx, FreeBSD, Net BSD, Open BSD, et cetera.

C. Computer Vision

Computer Vision can be defined as it explains how to understand a 3D scene from its 2D image, in terms of the properties of the structure present in the scene.

Computer Vision greatly overlaps with the below fields−

● Image Processing
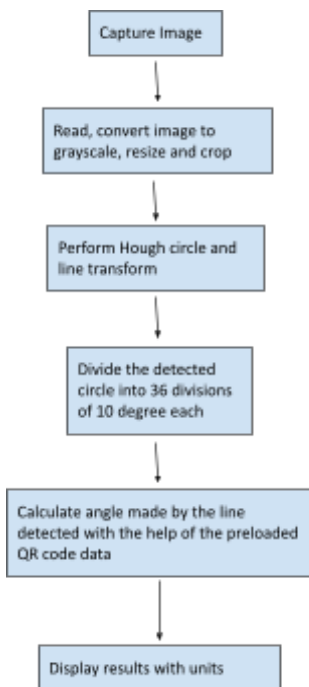
● Pattern Recognition

● Photogrammetry

Fig. 2.2 Block diagram of the system

III. METHODOLOGY AND EXPERIMENTATION

A. Image Preprocessing(capturing image and camera specs) The preprocessing of the input images is crucial to the recognition system's accuracy.

The devices which are used to capture an image are cameras, scanners. They also store pixels(numerical value) of the image. OpenCV is a library that processes digital images, therefore we need to store these images for processing.

In OpenCV, the Mat class library is used to store the values of an image. It represents an n-dimensional array. It is used to store image data of grayscale or color images, voxel volumes, vector fields, point clouds, tensors, histograms, et cetera. This class comprises two data parts: the header and a pointer

● Header − It consists of information such as the address of the matrix, size, and the method used for storing.

● Pointer −It stores the numerical values(pixels) of an image.

The image is captured with a camera mounted in front of the gauge. Firstly we converted each test image to jpeg format. Then the captured image is read and converted to grayscale. Then further it is preprocessed in which we cropped, removed noise, and resized the gauge images to increase the accuracy of the output.

B. Hough Transform

Hough transform is a feature extraction method for detecting simple shapes such as circles, lines, et cetera in an image. The "simple" characteristic is derived by the shape representation in terms of parameters. A "simple" shape will be only represented by a few parameters, for example, a line can be represented by its slope and intercept, or a circle which can be represented by x, y and radius. (hough space)

1. Hough Circle Transform

We use the HoughCircles function[2] in OpenCV which gives the circle center coordinates and the radius of the circle. Then we performed the Hough circle transform to detect the outline of the gauge. Firstly the radius,x and y are found. But, we had to limit the radius of the circle to be detected since it was detecting unnecessary circles as shown in Fig. 3.1. This was done by defining the minimum and maximum radius.

Samples give good results if we restrict the search from 35-49% of the possible radii.

According to that, it draws the circles and its center's. You can see the drawn circle(s) with green and the center(s) with a small red dot. Then it plots lines from the center going out at every 10 degrees and adds markers from 0 to 36. Hence, the detected circle is divided into 36 equal divisions with 10 degrees separation.
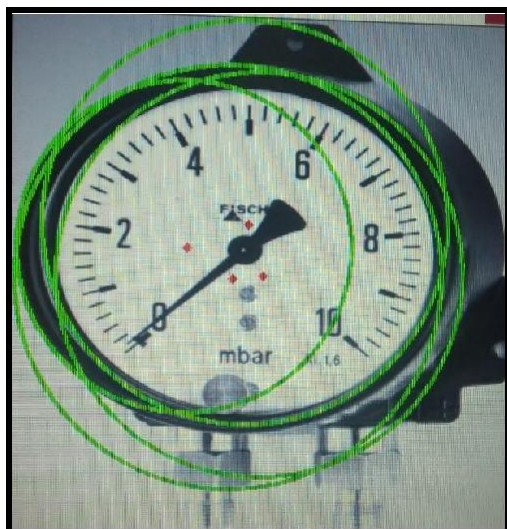
Fig. 3.1 Hough Circle Transform detecting multiple circles.

2. Hough Line transform

HoughLines function[3] is used for detecting lines from the image and is implemented in the function HoughLines and HoughLinesP [Probabilistic Hough Transform]. We are using HoughLinesP in our application - this is the more structured implementation of the Hough Line Transform. The idea of the Hough transform is that every edge point in the edge map is transformed to all possible lines that could pass through that point. Each edge point is transformed to a line in the Hough space, and the areas where most Hough space lines intersect are interpreted as true lines in the edge map. A vector will store the parameters (x-start,y-start,x-end,y-end) of the detected lines in the function. The line equivalent to the radius of the circle is selected. And all the other lines are discarded that are outside the radius. Then we detect the pointer on the gauge. Further, we calculated the angle made by the pointer line with the reference line. When you change the threshold, the number of lines detected vary.

C. Determining the Angle

We use the function of arctan to determine the angle made by the largest line that is. Pointer(found by HoughLinesP) on the gauge. Arctan takes the inverse of the tangent function of the line's slope[4]. And therefore this results in Angle of the Pointer

A. *Reading the gauge with the help of QR Code*

From the above steps, we easily calculated the current reading of the dial pointed by the pointer. We use the QR code (that is stuck on the gauges) to store the data related to the gauge. It stores the data of that particular gauge like the minimum value, maximum value, minimum angle, maximum angle, unit as shown in Fig. 3.2 and Table I. This data is further used to calculate the current reading. You can also store additional information like gauge shape, needle, color, et cetera. For industrial applications, the QR code needs to be generated at the time of installation to store the above data.

Fig. 3.2 QR code mounted on the gauge

TABLE.I. DATA STORED IN THE QR CODE

Parameter	Value
Minimum angle	37
Maximum angle	318
Minimum value	0
Maximum value	15
Unit	lb/in²

V. **TEST RESULTS**

Fig. 4.1 Original Image of the gauge.

Fig. 4.2 Detection using Hough Circle Transform and 10-degree separations marking.

IV. RESULTS AND DISCUSSION

Dial Gauge Images with different pointer locations and values and tested.

A. Using the Hough Circle transform, the outline of the gauge and the center point is detected which is shown in Fig. 4.2

B. And using the Hough Line Transform, a pointer is detected which is shown in Fig. 4.3

Fig. 4.3 Hough Line for the detection of the Pointer

V. OUTPUT

Fig. 6.1 is the image of the output window which shows the result of the experimentation. The value observed is 14.40 lb/in².
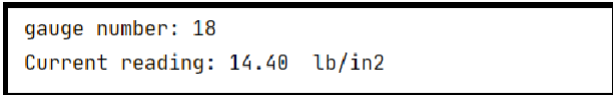

Fig. 6.1 Result

VI. APPLICATION AREA

In hazardous areas like chemical, metallurgical, oil and gas, mining industries where the automated system is used to replace the human operator and carry out a measurement that the human operator could perform. Also, manual reading is prone to human error, hence this method is more efficient.

VII. PROJECT CONCLUSION

A method has been developed to automatically read the circular analog gauge with just an image of the same gauge using computer vision and the OpenCV library. This method uses the Hough line and Hough circle transforms to detect the circular rim of the gauge and the pointer. We are determining the value displayed on the gauge by calculating the angle made by the pointer. A QR code is developed for every gauge which stores relevant information like minimum angle, maximum angle, minimum value, maximum value, et cetera which will help in the calculation of the angle of the pointer.

Our initial approach involved the usage of OCR, which is optical character recognition for directly reading the values on the gauge. But the system was unable to read the numeric values on the gauge hence we decided to shift the approach of calculating the angle using OpenCV. This approach has given us satisfactory results for different values of gauges. This method is only applicable to gauges having linear and circular scales.

This method is developed primarily for industries carrying out hazardous and life-risking tasks like mining, petroleum, oil, and gas, et cetera. This system eliminates human errors while reading the values displayed by the gauges.

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