A novel approach of reading analog multimeter based on computer vision

Science, Computer Science

INTRODUCTION

Computer vision is an interdisciplinary field of computer science. Gaining high-level understanding from digital images or videos is the primary application of computer vision. Computer vision methods obtain, process, examine and understand digital images, and extract multi-dimensional data from the real world in order to produce numerical or symbolic information.

The prospect of automation is paramount in today's fast moving world. However, there is one such field that has been given little attention with regards to automation, i. e. extracting data from the analog and mechanical devices of yesteryears which continue to exist even in today's technologically forward world. The reason behind this is the huge expenses required to upgrade the existing technology and to a certain extent the urge to protect legacy.

An analog meter is a measuring instrument for measuring a physical quantity such as current, voltage, resistance etc. Analog meters have moving pointer to display readings. An analog meter could be a hand-held device or a bench instrument which can measure readings to a high degree of accuracy. Analog meters, although being older in design is still preferred over their digital counterparts because analog meters are more sensitive to changes in the circuit that is being measured. Analog meters continuously read the test value which is preferable in some applications, like monitoring a promptly varying values. Therefore, this paper intends to aid in automating the monitoring of these data values by reducing the human resource required to constantly monitor the change in the readings of the data.

1. 2 Motivation

A computer vision based method to automatically and constantly monitor an analog meter for changes in value is of great importance since the merits involved in manual human monitoring is both inefficient and straining to the human eye. In certain infrastructures like submarines, laboratories, factories, etc., the equipment in use are still analog and mechanical devices of older days. They are used to monitor data such as speed, pressure, temperature etc. This requires constant monitoring and sufficient man power. The people in charge refrain from upgrading their equipment to newer, faster and more accurate digital systems because of added expenses and heavy renovation involved in the process resulting in down time and increased losses. Some of them also like to retain the antiquity of the infrastructure, which may be lost from the makeover. However, they need a solution to cut down on unnecessary human resource being underutilized. This requires an automated system that can continuously monitor the changes in these equipment which can be used to trigger certain actions correspondingly. The system in contention needs to:

Detect the equipment from the given scenario.

Identify the pointer within the equipment.

Recognize the type and range of values depicted by the respective equipment.

Extract the value pointed to by the equipment.

Return the resultant value in digital form to be further utilized.

Although there have been researches in this area in the past based on computer vision and image processing, the methods proposed however do not take into account the practical scenarios like varying illumination and differing camera orientations which are common in actual use. Hence, there was a need for a new approach which takes into account all these factors and improves on the existing methods to provide a more idealistic and practical approach to read analog meters and extract numerical data to be used as useful information.

BACKGROUND THEORY

2. 1 Background Study

The approach to read an analog meter involves detecting the pointer needle and the angle of the needle. The relationship between pointer needle and the scale value will provide the required reading value. There have been several researches in this regard previously. However they use Hough transform method or its variations to detect the pointer needle. A proposed approach by L. Pei. used improved bigness method to achieve satisfactory segmentation result of pointer meter images. Another approach uses centroid and tip coordinate of pointer of the analog meter to form a straight line to calculate pointer angle between the x-axis and the line that was created joining the tip and centroid of pointer needle. This method by R. Ocampo-Vega and the one by L. Pei. and some others does not deal with the illumination and tilted orientations.

The Hough transform is a feature extraction used in computer vision and image processing. It is a transform used to detect straight lines. The purpose of the technique is to find instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform.

The straight line $y = mx + c$ can be represented as a point (c, m) in the parameter space. However, vertical lines give rise to unbounded values of the slope parameter m. Thus, the Hesse normal form

$r = x\cos\theta + y\sin\theta$,

where θ is the distance from the origin to the closest point on the straight line, and θ (theta) is the angle between the x axis and the line connecting the origin with that closest point.

It is therefore possible to associate with each line of the image a pair (r, θ). The (r, θ) plane is sometimes referred to as Hough space for the set of straight lines in two dimensions.

2. 2 Literature Review

This paper proposes an approach that involves adopting geometric matching and pattern matching to localize the region of interest to deal with the orientation variations that can adjust the tilted image to nearly horizontal position. It also uses pattern matching technique to localize the region of interest from the section of the analog meter image already extracted to locate the coordinates of the corner points to calculate the pointer angle.

The device setup for the experiment is provided in Figure 2.

Image preprocessing is the analysis and manipulation of the digitized image in order to improve its quality. The preprocessing steps involved are converting to grayscale, applying Gaussian and median filters to remove salt and pepper noise etc.

METHODOLOGY

3. 1 Pointer Angle Detection

To find the pointer position on the path of the pointer needle, scanlines are created for searching and calculating the angle of the pointer needle with the required data including coordinates of the centroid, pointer angle on both end scales, length of the scanline, arc points and incremental angle for scanning. Pattern matching is used to localize the region of interest on both scale ends to calculate the required data for the scanlines. (x1, y1), (x2, y2), (x3, y3), (x4, y4), (x5, y5), (x6, y6), (x7, y7), (x8, y8) denote the eight coordinates of eight corner points of localized regions on left and right end scale of meter section are denoted as illustrated in Figure 5. The angle of pointer at left end scale θl and right end scale θr can be computed by (1) and (2), respectively. The scanning angle θs is changing from θr -5o to θl + 5o during scanning, where the scanning angle range θR is equal to θl – θr +10o.

RESULTS AND DISCUSSIONS

The experiments were conducted with random tilted angle value and varying intensity of the illuminations. The proposed approach was able to read the analog meter, detect the angle of the pointer needle and return the approximate value as pointer to by the pointer needle. The pattern matching and geometric matching techniques to localize the region of interest greatly enhanced the readability and performance of the proposed method.

The obtained results were compared to the readings obtained by that of a human eye for realizing the error in the proposed approach. The comparison results are tabulated with the columns MI, SSP, Vhe, Vp, TA, Im where MI is the measurement item, SSP is the selector switch position, Vhe is the value read by the human eye, Vp is the value read by the proposed method, TA is the tilted angle value, Im is the mean intensity of illumination. Table 1 shows the comparison results. The performance the error rate could be affected by varying tilted angle and illumination intensity.

CONCLUSIONS AND FUTURE ENHANCEMENTS

5. 1 Conclusion

Therefore, the experimental results prove that the proposed method for reading analog meter based on computer vision is feasible and delivers expected results. The proposed method successfully identified and read the value pointed by the pointer needle in an analog meter even under varying lighting and illumination conditions and also for tilted orientation of the image. As a conclusion, the effectiveness of the proposed approach has been demonstrated. Since the localization of multiple regions of interest will need a lot of memory and computation power, a powerful CPU and GPU is recommended for enhanced performance.

The success of the proposed approach for reading an analog meter based on computer vision greatly improves the efficiency and performance of the system it is implemented in and the use case it is made for. The method automates the monitoring of changes in value without any human intervention and based on the value returned, appropriate actions could be taken.

5. 2 Future Scope

The proposed approach for reading an analog meter based on computer vision works for only still images and therefore requires a continuous and instantaneous supply of images from an external source to provide real-time data. This may not be feasible as there are delays involved in capturing the image, preprocessing the image, applying the algorithm and extracting the value. One future scope for the proposed method involves implementing it for a video. This could provide a continuous and uninterrupted live feed and real-time information could be obtained. However, this requires very powerful devices and faster preprocessing mechanisms to make it feasible.