Real-time Liquid Level and color Detection system using Image Processing

Fars Samann
University of Duhok

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Fars Esmat Samann
[1]College of Engineering, University of Duhok, Duhok, Kurdistan Region - Iraq

ABSTRACT

Detecting the level of the liquid is very essential for any chemical study in research labs. The objective of this paper is to design real-time liquid level detection system using image processing. Besides, this system is able to indicate the color of the liquid during chemical reaction. The proposed system was developed using vision assistant tools in LabVIEW and webcam. Regarding to webcam resolution, the average accuracy of the system is approximately 99%.

KEYWORDS : Liquid level/color detection, Image Processing, LabVIEW.

1. INTRODUCTION

Most of the chemical studies in research labs require reliable and precise liquid level measurement system. Liquid level measurement can be used to evaluate the quantity of liquid in the cylinders during chemical reaction. Measuring the changes of liquid level and color for specific intervals is very important in chemical reactions (MOSES, RAJA, RAJ, & JIJI, 2016). Several types of sensors have been used to measure liquid level like ultrasonic and pressure sensors. These sensors may cost a lot and may require direct contact with liquid like pressure sensor, which is not suitable for chemical reaction (Manashti & Azimi, 2013) (KHARADE, GENDLE, LODHA, & JADHAV, 2017). Water level detection based on image processing was proposed by couple of papers to measure the level of water in reservoir using surveillance cameras for flood monitoring (Hasan, et al., 2016) (Lin & Sun, 2016) (Manashti & Azimi, 2013).These detection methods were design to measure the water level in reservoir. Therefore, it is not very sensitive to the small changes in the water level. The aim of this paper is to design effective real-time liquid level/color monitoring in cylinders during chemical reaction. This system can be used to monitor and control chemical reaction. In addition, it is possible to record the changes of liquid level with respect to time during chemical reaction and saved it in xlsx file. This system is very useful in case of long chemical reaction duration because it is difficult to monitor the changes in the cylinder for long period of time manually.

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Corresponding author's e-mail : fars.samann@uod.ac

2. METHODS AND SYSTEM DESCRIPTION

Real-time liquid monitoring system is very useful in research labs to detect the changes in the level and the color of the liquid during chemical reaction. The proposed system is implemented using 0.3 megapixels webcam (resolution 640×480) and LabVIEW 2017 (vision and motion VIs Tools) (NI Vision 2017 for LabVIEW Help, 2017). The process of the system is demonstrated in fig. 1.

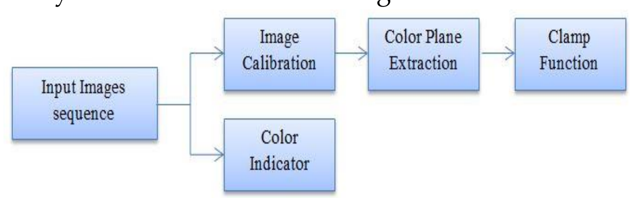

Fig (1) : Process of the system

The algorithm of liquid level measurement is based on thresholding edge-detection method. This method measure the profile of picture through calculating gradient magnitude of Region of Interest (ROI). Then, a threshold is applied to detect the sharp changes in the brightness.

2.1 Camera Calibration

A webcam with 640×480 resolution was used to acquire the images sequence of the tested object. The webcam is located in front of the chemical cylinder as shown in fig. 2. The camera is mounted on holder stand to control the elevation of the camera with respect to the cylinder.

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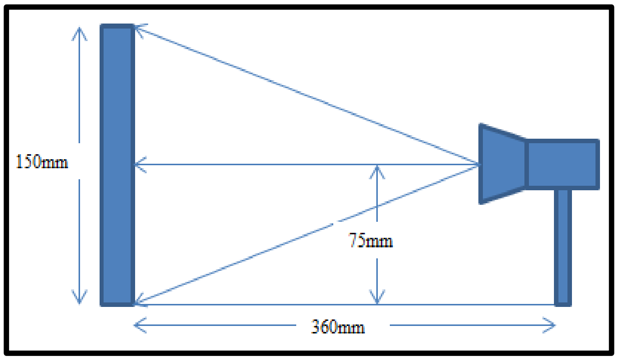

Fig (2) : Location of the camera regarding to the cylinder

The center of the camera is calibrated and positioned to the center of the cylinder (see fig. 3). This is to ensure that the optical axis of the camera is aligned perpendicularly to the tested object.

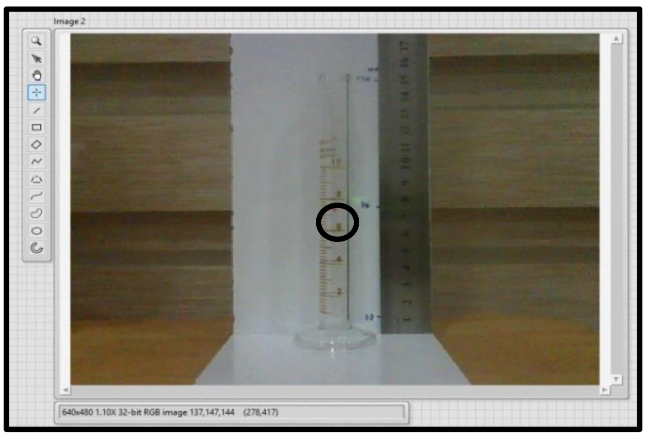

Fig (3) : Camera alignment with respect to the cylinder

In liquid-level detection algorithm, image calibration is required to provide a pixels-to-metric unit conversion factor. The calibration factor in term of pixels/mm is calculated by selecting two points from a reference image these two points as shown in fig. 4. The ruler is used to present the metric with respect to the tested object. Image calibration was calculated using NI Calibration Training Interface. This information is used to convert mm to ml throughout liquid-level measurement to provide corresponding values in real-word unit (ml).

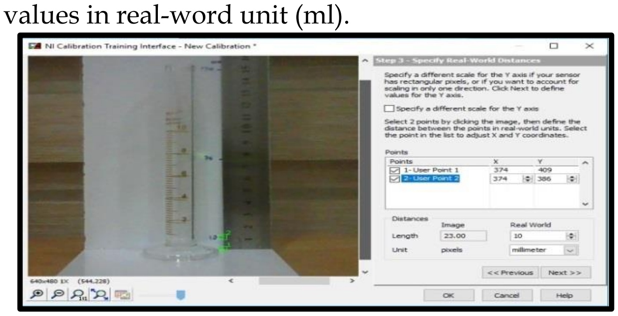

Fig (4) : Image Calibration Training interface

2.2 Liquid-Level detection algorithm

The algorithm of liquid-level detection is based on Clamp function to calculate the distance in teams of pixels between the upper and lower edge of an object inside the ROI. These two edges are identified using rake-based edge detection algorithm. Edge detection is mathematical method that is used to detect the points in one-dimensional image (grayscale) at which the brightness of the image changes sharply or it has discontinuity. The detection of edges is based on thresholding method. First, the gradient magnitude of the grayscale image is calculated the profile of the image as follows.

$$|grad\ g(x,y)| = \sqrt{\left(\frac{\partial g}{\partial x}\right)^2 + \left(\frac{\partial g}{\partial y}\right)^2} \qquad (1)$$

Where $\left(\frac{\partial g}{\partial x}\right)$ is the change of intensity in X direction, and $\left(\frac{\partial g}{\partial x}\right)$ is the change of intensity in Y direction.

The signal-to-noise is computed for each detected edge point to differentiate between reliable and noisy edges. Where high signal-to-noise ratio indicates reliable edge, low signal-to-noise ratio implies noisy edge as shown in fig. 5. (NI Vision 2011 Concepts Help, 2011)

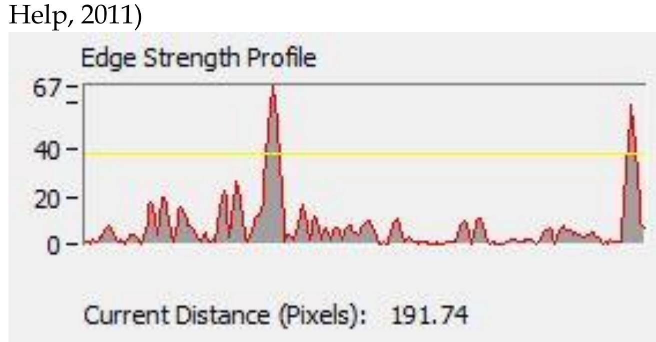

Fig (5) : Edge strength profile of the image

Then, a threshold is applied to classify whether there is an edge or not (see fig. 5). The following flow chart demonstrates the stages of the proposed algorithm.

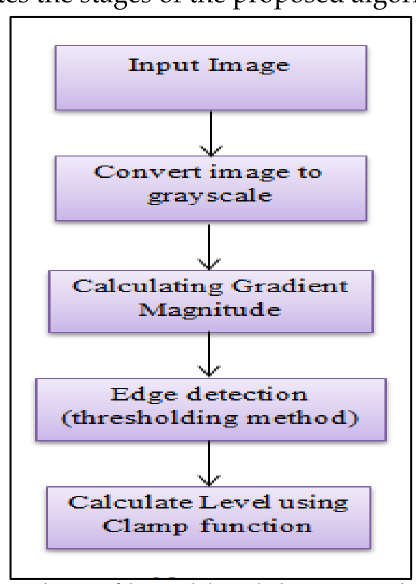

Fig (6) : flow chart of liquid-level detection algorithm

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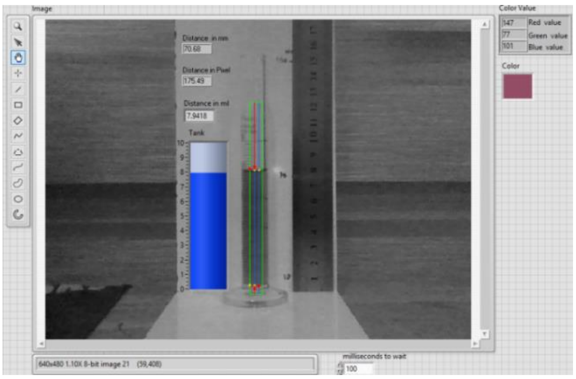
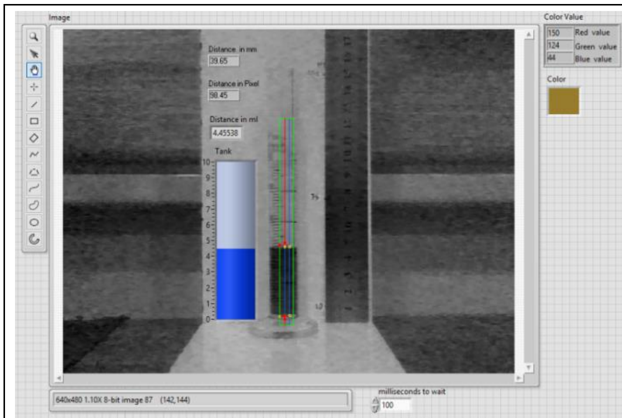
2.3 Color Indicator

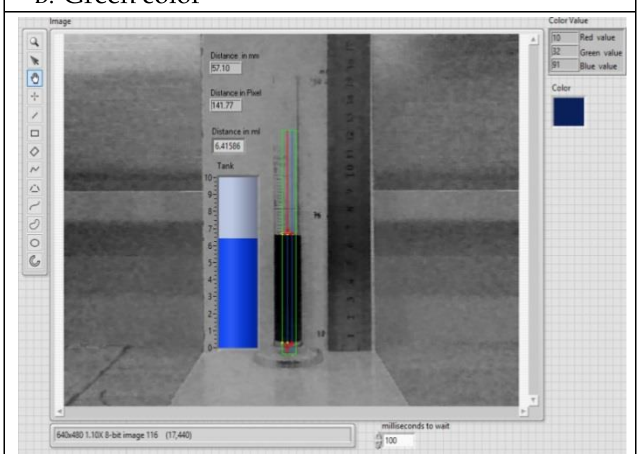
It is possible to indicate the color of liquid inside the cylinder by simply reading a pixel value from the image inside ROI. Then, this pixel value is converted from unsigned 32-bit integer into a cluster composed of the three colors in mode (R, G, B). These three values are companied together to the corresponding RGB color as shown in fig. 7.



A. **Red color**



B. Green color



C. Blue color

Fig (7) : Indicating the color of Liquid

3. EXPERIMENT AND RESULTS

Graduated glass measuring cylinder is considered to test the performance of liquid level detection algorithm. The capacity of the cylinder is 10ml with graduations marked every 0.2 ml. The webcam is installed in front the chemical cylinder to measure the level and to indicate the color of liquid. The graduated cylinder is filled with amount of liquid(Y) and the liquid level is increased from 1 ml to 10 ml in step of 0.2 ml to check the reliability of the system. Then, the webcam is used to measure the level of liquid (X) inside the cylinder. The water is mixed with red, green and blue ink respectively to check the validity of the system as shown in figure 6. Where Y is the actual level of liquid, and X is the measured level of liquid. The accuracy of the algorithm is measured as following.

$$IF\ (Y > X) \qquad (2)$$

$$accuracy\% = \frac{Y}{X} \times 100$$

$$ELSE\ accuracy\% = \frac{X}{Y} \times 100$$

The difference between the actual level and measured level of liquid is calculated as following.

$$Max\_difference = max(abs(Y - X)) \qquad (3)$$

The performance of the algorithm is located in table 1. The results show that the suggested algorithm of liquid level detection is effective and accurate. The maximum difference between the actual level and measured level is approximately ±0.139ml. The average performance of the proposed system is approximately 99%.

TABLE (1) : Performance of the system

ACTUAL LEVEL (ML)	MEASURED LEVEL (ML)	ACCURACY %	DIFFERENCE
1	0.989	98.863%	0.011
1.2	1.199	99.888%	0.001
1.4	1.393	99.479%	0.007
1.6	1.577	98.551%	0.023
1.8	1.913	94.118%	-0.113
2	2.014	99.330%	-0.014
2.2	2.181	99.136%	0.019
2.4	2.369	98.692%	0.031
2.6	2.536	97.519%	0.065
2.8	2.696	96.282%	0.104
3	3.062	97.966%	-0.062
3.2	3.223	99.283%	-0.023
3.4	3.487	97.494%	-0.087
3.6	3.693	97.490%	-0.093
3.8	3.821	99.458%	-0.021

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4	4.050	98.770%	-0.050
4.2	4.259	98.610%	-0.059
4.4	4.409	99.796%	-0.009
4.6	4.627	99.410%	-0.027
4.8	4.815	99.688%	-0.015
5	5.011	99.783%	-0.011
5.2	5.183	99.672%	0.017
5.4	5.440	99.256%	-0.040
5.6	5.584	99.709%	0.016
5.8	5.826	99.556%	-0.026
6	6.059	99.028%	-0.059
6.2	6.201	99.983%	-0.001
6.4	6.397	99.951%	0.003
6.6	6.526	98.883%	0.074
6.8	6.727	98.929%	0.073
7	6.935	99.076%	0.065
7.2	7.203	99.955%	-0.003
7.4	7.314	98.836%	0.086
7.6	7.672	99.058%	-0.072
7.8	7.848	99.389%	-0.048
8	8.028	99.654%	-0.028
8.2	8.205	99.934%	-0.005
8.4	8.403	99.959%	-0.003
8.6	8.606	99.932%	-0.006
8.8	8.806	99.933%	-0.006
9	9.010	99.885%	-0.010
9.2	9.190	99.896%	0.010
9.4	9.409	99.905%	-0.009
9.6	9.585	99.840%	0.015
9.8	9.790	99.894%	0.010
10	9.901	99.008%	0.099
Average Accuracy		99.103%	
Maximum difference		0.1130 ml	

The rate of change of liquid level inside the cylinder is recorded and plotted with respect to time as shown in fig. 8. This system can monitor the rate of change of liquid color with respect to time as well.

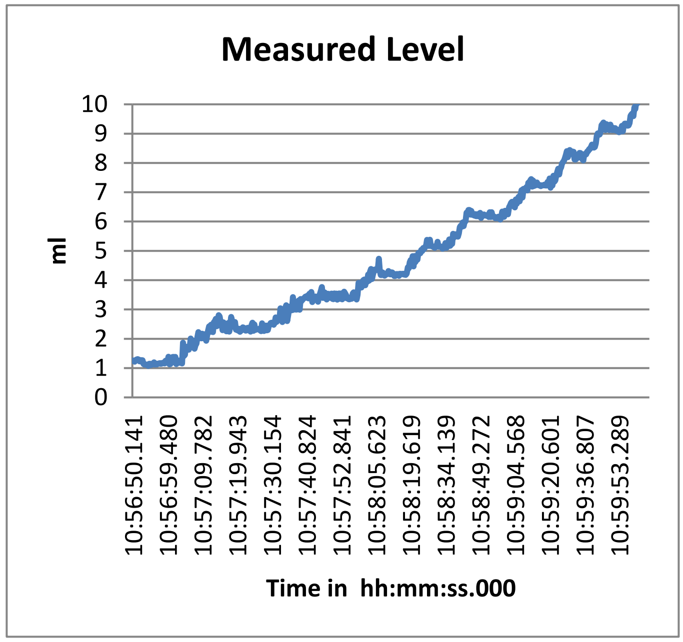

Fig (8) : Liquid level inside the cylinder with respect to time

4. CONCLUSION

In this paper, Real-time liquid level/color detection system has been designed and implemented using image processing techniques. The proposed system is developed using a webcam and LabVIEW vision tools. In general, the accuracy of the system is significantly accepted and it gives very reliable and precise results with minimum webcam resolution. In addition to the measured liquid level value, the rate of change of liquid level/color with respect to time can be recorded in excel file. Therefore, this system provides essential benefit of remote monitoring for chemical reaction that requires long period of time. The application of the presented system within monitoring chemical reactions can provide an overview about the level and color of the liquid during the chemical reaction. Future work, it is possible to add fog removal filter to this system to enhance the performance in case of fog generated during the chemical reaction on the wall of the cylinder.

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