Hazardous Liquid Level Measurement and Control using Single Digital Camera: A Literature Review

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Abstract: *Hazardous liquid level measurement has been actively researched in recent years. This paper provides an advanced literature review on Major recent techniques used for contactless measurement of hazardous liquid level using different types of methods. The first one we present Overview of recent methods used for hazardous liquid level measurement and merits and limitations of each methods, also testing of these measurement algorithms used by different methods are discussed and future modifications or upgradation required are also covered in this paper. We proposed a non-contact type level measurement and control system for hazardous liquid using single Digital camera on top of tank for capturing float images continuously and converting it to number of pixels and 4-20ma standard current signal for measurement of level and control of flow to the tank. Finally our proposed research work with algorithms and conclusion is given so we summarize research results.*

Keywords: ***Contactless measurement, Hazardous liquid Level measurement, Digital Camera, Image Processing, Pixel Counts***

1. INTRODUCTION

The level measurement and control of non hazardous liquid is quiet simple and lots of different methods and sensors are available in market as well but the level measurement and control of hazardous liquid is not possible with direct contact type readily available sensors and if performed using ordinary type of sensors then it is very dangerous for plant as well as safety of system as minor electric spark can produce explosive accident at industries also non-contact type of sensors available in markets are less accurate and costlier too, so in this literature review paper we will discuss each author papers with its advantages and limitations.

We have refer so many different research papers for non-contact liquid level measurement and control methods, the working and limitations of each methods are explained below. Out of which low cost and most safe method of level measurement and control using CCTV camera is proposed for further implementation using Raspberry Pi controller, which will continuously capture the images of float on the top of liquid from top side of tank and will convert that images in to its equivalent pixels which directly proportional to the height of liquid used to measure the level also we have proposed to convert this pixels in to 4-20 mA standard control signal for continuous control of level of hazardous liquid tank.

1. Liquid level measurement by using an image method

As per mentioned in this paper this method of measuring the liquid level in a tank is widely used in many fields such as petroleum industry, chemical industry and agriculture. Depending on whether there is contact with the fluid or not, the measurement method can be divided into two types. One is a contact measurement and the other is a non-contact measurement. Contact measurement includes pressure sensor method and capacitance sensor method, which are not suitable for measuring corrosive or explosive liquid level. Non-contact measurement includes the radar method, the ultrasonic method and the image method in which the system calculates the liquid level by measuring the time between receiving the firing pulse and the reflection wave. The method consist of three major equipments which

are laser light source, CMOS camera and the PC for calculations. The three laser light sources are producing triangle in the liquid, then the image of triangle produced is captured using CMOS camera which will after image processing used to calculate the level using geometrical relations. The sensor must be installed correctly, otherwise it will be difficult to eliminate the measuring deviation. This paper provides a measuring method to solve the above problems by using image processing technology combined with software technology. This method can easily correct the measured deviation from the installation and is suitable for small shaking fluid.[1]

Advantages and limitation

In above method for measuring of liquid level using laser beam is based on time calculation of time delay between beam transmitted and reflected back so it very accurate and very useful where non-contact of liquid with sensor is required so due to which corrosion or erosion of sensors and other equipment is reduced or avoided but this technique is only useful where liquid is non-hazardous and laser beam does not produce any fire or hazards but for hazardous level measurement this method is not safe and can produce explosion of tank too also it will required precise calculation for time delay calculation so frequent calibration is required.

2. Detection of dynamic liquid level based on MIMO Ultrasonic Transducer Array

As per mentioned in this paper conventional ultrasonic liquid-level detection generally provides unreliable statistics due to the dynamically converted fluid level. In addition, it is incorporated that with fluctuations in level change there is also rise or fall of the liquid level. To improve the accuracy of measuring the liquid level using the ultrasonic method in the dynamic modified level measurements more number of sensors required, this paper suggests an attractive ultrasonic method called Liquid-Level Detection based on a MIMO ultrasonic transducer array. This method of measurement differs from the initial ultrasonic fluid level measurement methods result in that a transducer array was used. Based on virtual technology, this method uses a multi transformer array which reduces system complexity and cost which applies synthetic aperture technology for quickly identifying liquid level samples. In addition, an optimized search scheme optimized for the position of focus on the beam forming of the synthetic aperture in each scanning direction was optimized to obtain high-precision samples of the liquid level. The specific method is simulated and tested with the actual system compared to the traditional single-channel approach. This method is based on the boundary-layer and ultrasonic scattering theory, they have propose a simulation method of the ultrasonic echo signal from the liquid level. Clear and realistic measurement results show that the proposed method is better than the traditional method. At the same time, factors affecting a particular method are also explored through simulation. Research reveals that the focal point on beam forming, the SNR of the echo signal and the wavelength of the liquid level affect the proposed method. However, if the focus on beam forming in each scanning direction is set correctly and the sound of the echo signal is effectively controlled, also in this method multiples sensors are used and the average of all sensors outputs are calculated which will reduce the deviation error due to turbulence in liquid, this indicates that it gives the best performance of the specified method.[2]

Advantages and limitation

In above method for measuring of liquid level using MIMO ultrasonic transducers array is very accurate for dynamically converted fluid level compared to single sensor measuring system, also it uses multi sensor array and finally averaging

the values so fluctuations in liquid level will be automatically tolerated but again in this method it is accurate but measurement delay is introduced so every time the measurement will less faster compared to single sensor measurement method so this method is not suitable for fast level changing system, also due to direct contact of sensors with liquid so there will always corrosion and erosion problems so life of sensors will reduced and frequent calibration also required. Due to more number of sensor array and MIMO system for control makes the system more complex and costlier.

3. Height Measuring Systems for Liquid or Particles in Tanks using Image

As per mentioned in this paper there have been many ways to measure the height of the storage volume of liquid or particles inside Storage tanks. Roughly, it can be divided into two types, Contact or non-contact. In contact mode, there are plenty Products that measure the height of the storage volume of fluid or particles inside storage tanks. In non-contact , there are very different studies Solutions such as using a laser image Ultrasonic technology . In many cases where the laser is used laser projectors and receivers required. Although the use of laser technology has the advantages of speed and the efficiency of object-reflectivity plays an important role. If the object-reflectivity is low, then the system will be doesn't work properly. The advantage however is the pantoscopic range the same harm caused by object-reflectivity. Object-reflectivity is the most common failure of contact cases. In this paper, we refer to the height measurement system, Two optical-light lasers are used in conjunction with the CCD Camera. The system is attached to the outside of the storage tank to find the height of a given liquid or particle separated from the material. The system is secure for detecting toxins level in storage and work accidents may decrease. This system calculate the distance between two spots of light on surface of liquid using image captured by CCD Camera. Very simple formula for Scale expanded technique without using graphic identification technique to calculate the two projective distances directly by Spots of image signals.[3]

Advantages and limitation

In this method to measure the height based on the image the system recommends non-contacting Reflective method of measuring the height of a fluid or Cells inside the storage tank. The Image based height measurement system is safe with toxic substances No risk of electrical leakage and electrolysis mounted outside the tank due to breakage or explosion as it do not touch those objects. The measurement system does not use expensive high speed DSP microprocessors used by complex image recognition techniques. it uses simply voltage comparator to determine bright positions Spots. The timer is used to find the number of clocks are counted between two bright spots on material. Circuit is Simple, inexpensive and easy to implement. The only problem for this method is of resolution because minor change in level will not exactly reflected in measuring system so for higher accuracy and higher resolution can not be useful.

3. Water level measurement using NIR-imaging video camera

As per mentioned in this paper for developing all-weather direct and automatic flow measurements Image-based method for single camera system for measuring the water level . First of all, a NIR-Imaging System by Purifying Commercial Video Cheap Camera. Tank and mountain stream studies NIR-imaging works effectively to increase image contrast Suppress reflective sounds on water surface. Compared to the present imaging system that successfully overcomes water

limits Line detection in clear water and at low speeds. Second, Water level conversion based on image ortho-correction is used Photogrammetric principles rather than reading based on identity This applies to images that lack human vision and visibility. The Characteristics of this method: (1) Linear distortion of the image Corrected by laboratory camera calibration and (2) visually-distorted ROI fixes it by remapping the image as an orthographic template image Natural Relative Points (3) Measure The water level (1 mm) resolution is controlled by physical resolution (1mm / pixel) template image. Not only that, it does not require on-site Calibration but also for accurate estimation. The waterway Improved the detection process using a set of algorithms Order-Statistical Filtering for Adaptive thresholding, Syntax Native noise suppression opens the function for multi-points Continuous standards for waterline detection and intermediate filtration Random noise avoidance. Experiments in space show that it is beyond that for uneven light images. Its reliability in different environments and lighting Conditions show that water levels up to 1 cm are effective data ratios up to 95%. This indicates that the specified method with Accuracy is comparable to current float-type automatic water level Gauges in general.[4]

Advantages and limitation

In this method the installation of measuring system with camera is very easy and cheap, also by using this method water level, water velocity and water volumes can be calculated roughly for earlier detection of disaster in terms of flood due to storm, continuous monitoring of rivers level and velocity is also possible. The limitation of this method is accuracy in measurement and due to camera installed in open environment can give wrong readings due to uneven vision.

4. Liquid-level measurement using a single digital camera

As per mentioned in this paper determining filler levels in liquid tanks is still evolving as technologies meet the growing needs of advanced processes in chemistry, food industry or biotechnology. In some applications, mechanical measurement devices may not be installed, e.g. Pressure sensors. For this reason, non-contact and non-invasive methods have been developed in recent years that do not involve electrical connections in tanks. However, these technologies cannot record images to monitor chemical reactions that take place inside the liquid tank during measurement. Although current image-based measurement methods are used in some parts to record images while measuring the liquid level, two laser beams are required in parallel from the projectors. In addition, the wires had to concentrate the liquid on the surface of the float tank, which inevitably imposed critical control over the liquid-measurement. As a result, the installation and calibration of these measurement systems is generally difficult to implement in practice. To improve measurement performance and overcome the difficulties mentioned above, this paper introduces a new liquid level measurement system with a single digital camera (or digital video camera) and a circular float. The fact that a digital camera is mounted on top of the liquid tank to take pictures of the circular float on the liquid surface is simple and straight forward to set up. The appropriate size of the circular float is selected according to the liquid tank size to achieve the best measurement performance, the camera can easily determine the number of pixels of floats in the captured image. Then, the diameter of the float in the image can be determined by counting number of pixels with the good accuracy. From the relationship between the pixel number of the diameter of the float in the image and the photographing distance, the liquid level (volume) can be effectively calculated when recording specific system images for the monitoring process occurring in the tank. The pixel number of the float in the image is first calculated to determine the diameter of the float and pixel resolution can be obtained during the measurement. As a result, the

accuracy and precision measurement by the specific system is significantly improved. It should be noted that the measurement system works satisfactorily in measuring the amount of liquid that is inconsistent with the shape of the measuring tank.[5]

Advantages and limitations

In this method the single digital camera is used to capture the image of float at different intervals then the distance of float is measured using basic formula so accurate measurement are obtained as shown in above table also more accuracy can be obtained by counting height of float in terms of number of pixel counts on the place of measuring height. So it can be improved by counting number of pixel difference between present values and reference values of pixels which will give more accuracy compared to all above methods.

Flowchart for liquid level measurement system[5]

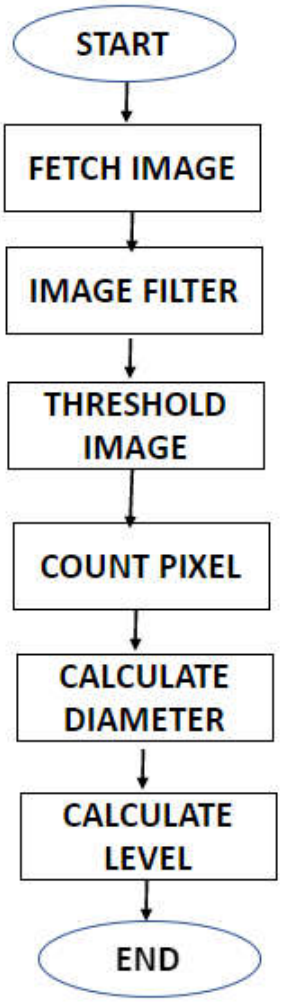


Fig.(1)

6. Camera-based liquid level measurement using the refractive properties of the medium

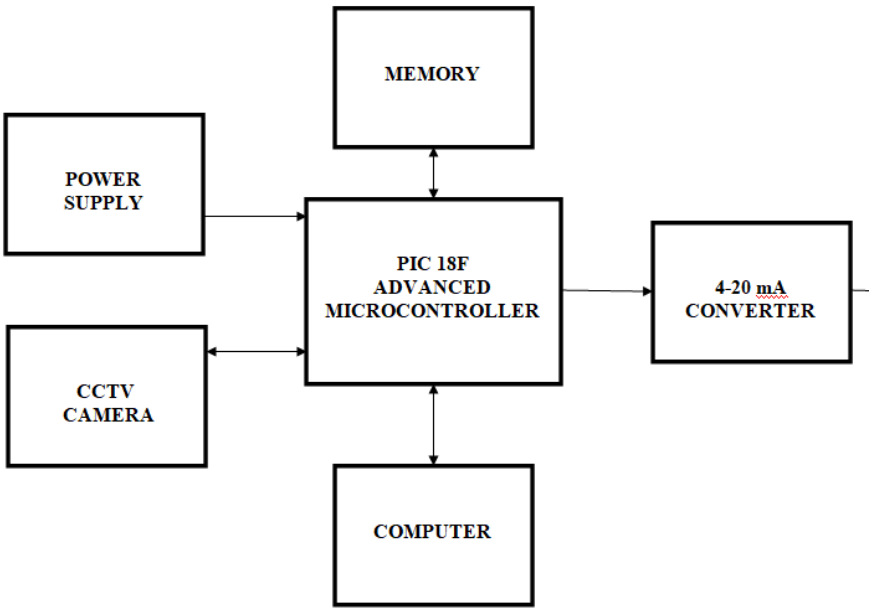
Measurement of the height of a liquid column directly is more simple but indirect measurement is important in many industrial systems, Thus a variety of advanced techniques are available to meet indirect contactless measurement of liquid level measurement of tank is individual needs of process industries with safety of system. Two major categories of Instruments for level measurement are point-level sensors and continuous level sensor, both have their own set for certain applications. Point level measurements commonly used for alarms (eg high-level or low-level alarms) and can be based on capacitance, buoyancy and conductance of liquid but did not give information of intermediate level. Sensory level sensors allow for a much more accurate level control is also important in managing the processes on which they rely or are extremely sensitive to level variation. These types of sensors are usually based on light of electromagnetic waves also other examples are the ultrasonic level sensor, the laser based level sensor and radar level sensor. Although these are technically mature and reliable their cost is high and availability limits their widespread use. To overcome this limitation, more recently, some attention provided with computer-assisted methods to measure or to estimate. Their main advantages are that they rely on cheap or readily available technology, just like them low resolution cameras and low or embedded computers. It works for both proposes computerized visual aids by measuring a level that works by finding the liquid area and comparing its length with a constant reference, usually a ruler. Needless to say, the tasks involved in these methods are complex and very flawed requiring accurate detection algorithms. In this work, a method based on the computer concept for continuous level measurement is proposed that makes use of duplicate liquid formulations to be measured. Object-based methods of 3D object reconstruction , refractive stereo and refractive optical flow has been studied for the past two decades, but no deep attention is given to simple function of measuring fluid level. The method presented here requires only a video camera and a static reference object immersed inside liquid to be measured and depends on the related distance between the camera and the object having a good refractive rate index of the medium. From the values of refractive index, image formation and angle of refraction the level can be calculated using mathematical relations.[6]

Advantages and limitations:

In this technique to measure the level of tank using camera-based image features of the liquid to be proposed which uses refractive properties of liquid image is used. The intuition behind this method and the acquisition of the figures are presented in detail as well its effectiveness is tested with a thorough test against the ultrasonic level sensor. Accuracy, Precision and other applicable performance parameters have been determined and indicated that the proposed computer view is supported and the process gets good results, a reliable method and to allow for easy-to-use measurement and error correction also due to indirect contactless measurement reduces the chances of heating or explosion of fluid but this technique is only suitable for steady liquid level measurement also this method required frequent calibration so consumes more time and less accurate.

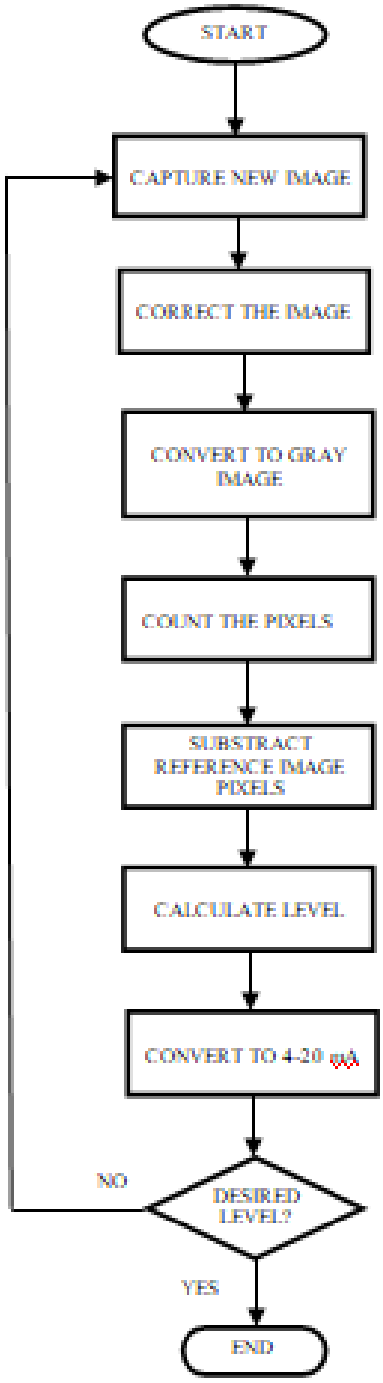
Our Proposed research work:

In this proposed research work we will do real-time contactless measurement and control of hazardous liquid level using single Digital camera by continuous capturing the images of circular float which reside at the top of liquid level from top side of tank then by comparing the total pixels of float with reference value using image processing tool of matlab software the real time liquid level can be found with comparing pre-calibrated values of tank level then by using close loop level control algorithm the 4 to 20ma control signal can be generated using microcontroller and signal conditioning circuit for real time level measurement and control of the hazardous liquid.



Block diagram Fig.(3)

As shown in block diagram in fig.(3), in our proposed research work we are using non contact type digital camera whose function is only to capture images from top side of tank which is electrically completely isolated from hazardous liquid tank with silica glasses. The digital camera operates at very low DC Voltages less than 18 Volt so it is quit safer compared to other sensors. In our project work the digital camera can also be connected to USB port of PC for image capture. The cctv camera connected to PIC18F Advance Microcontroller is continuously capturing images of float at regular intervals and transmits the images to microcontroller for image processing also the pixels of images after processing are stored in memory for further requirements. The 4-20 ma converter is connected to output port of microcontroller which converts total pixels values of image in to 4-20ma control signal, which can be used for operating final controlling element for controlling level. The detail algorithm fig.(4) of this process in given below.



Algorithm Fig.(4)

Here different color circular float is used inside the tank whose color must be differ compared to liquid color for proper measurement. Initially in empty tank the float position is at most bottom side of the tank indicated minimum level of tank and image of this float position is captured and the pixel counts of this position of float is considered as reference value or zero value which will be used every time as reference value to compare with real-time value of pixels. Now consider if level in tank is increased from bottom to top side so float will also move towards top side, if we capture the image of float at different intervals time then we can observe that float size will increase every time linearly in camera picture if we subtract the

reference pixels from real-time pixels then we can obtain the total number of pixels are going to be increase every time as level is increases so same value of pixels with respect to level is almost linear in relationship so it can be used to measure the real time liquid level of hazardous liquid also the measured data is compared with set point value of level then error signal is produced using microcontroller as level controller, so error signal produced will further used to generate 4 to 20 ma signal for real time operating of final control device to control the level of hazardous liquid at desired level. Thus by using digital camera we can measure and control liquid level at any instant of time using single digital camera picture.

Conclusion:

From literature studies of all above research papers our proposed research work will do real-time contactless measurement and control of hazardous liquid level using single Digital camera by continuous capturing the images of circular float which reside at the top of liquid level from top side of tank then by comparing the total pixels of float with reference value using image processing tool of matlab software the real time liquid level can be found with comparing pre-calibrated values of tank level then by using close loop level control algorithm the 4 to 20ma control signal can be generated using microcontroller and signal conditioning circuit for real time level measurement and control of the hazardous liquid, So our proposed system for hazardous liquid level measurement is much safe compared to all above methods and also with measurement we can control the level by converting the signal in to 4-20ma output signal for controlling final controlling element beside that the proposed method is comparatively cheaper than all above mentioned.

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