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## Digital image processing technology applied in level measurement and control system

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### Abstract

As the diversity of industrial processes, the common level meter devices are more impacted by external factors. This paper presents a new type of digital image processing technology for the level control system, combining with CCD camera technology as one of the measurement method. The fixed beam for measuring needs generated by the laser measurements, shape a special light point on the object surface, We can measure according to the changing scope of these points, or moving distance. From the experiment we can see, the CCD-based level measurement method not only has strong anti-interference ability, good usability, easy adaptability, but also applies to variety of more complex industrial applications.

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*Keywords:* digital image process; level measurement and control; level meter; CCD camera

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### 1. Introduction

At present, the level measurement is widely used in industry. As for the dynamical transportation and transmission of all kinds of raw materials and finished products in each production process, the quantity of material in the container needs to be known in production anytime and anywhere and if the blocked transportation happens, therefore, the concept of level measurement technology is proposed in industrial automation. The level detection equipment called level meter, which is different from the common apparatus adapts to the various industrial conditions, such as impacts and changes of temperature,

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humidity, frequency, ultrasonic wave, electromagnetic wave, and so on and measures normally. There are many principles of level measurement, such as: radar, resistors, capacitors, tuning fork, static pressure, radiation, ultrasound, RF admittance, resistance rotation, hammer, and so on. With the development of technology, there are so many principles and types of level measures, but it still cannot cover all requirements of the industrial materials condition and still need starting from the actual situation to research and develop level meter professionally and deeply according to individual, special site requirements.

As the same as other apparatus manufacturing industries, the research, and development of our level measurement and control technology started late than the west countries; and due to requirements of various industrial production, the necessities of level measurement and control system is urgent, but our technology level still far to meet the requirements, so the phenomenon is many foreign-fund companies dominate the market. Today, the author talks about new technology solutions of level measurement technology in industrial production that is digital image processing technology for level measurement system. It applies to all situations of level measurement and control, and its main principle is to allow the measurement is converted into the data and image; therefore we can directly and accurately calculate its measurement.

## **2. Digital image processing technology**

Digital image processing technology is a relatively new technology, which is new developing field of computer applications when the development of digital computers developed to a certain level in fifties. Transfer the image into a form of data matrix and store them in the computer, or show the application on computer, but also process series of images such as strengthening, deletion, addition etc. Today the application fields of digital image processing technology are fairly broad. The main applying technologies are the image input and output technology, image analysis, transformation pretreatment technology, image recognition and extraction technology for relevant information of image feature. Digital image technology has a further development, progress and improvement till sixties and seventies. The involve fields are increasing and extending, this paper mainly introduces the digital image technology of level measurement and control system

Digital image processing technology mainly focus on image processing technology, and the main measuring parameters of level measurement and measurement is measured by material surface area. Therefore, the precision of level measurement for the image processing of materials surface is very important; specifically include the following two aspects<sup>[1]</sup>.

### *2.1. Image segmentation*

The process of image segmentation means that separate the main target from the sub-body background of the image. The simplest and basic method of image segmentation is to set a threshold value at first, and then convert. The grey grade of pixel greater than threshold value is set to 1, and less than the threshold value is set to 0. So a multi-grey grade image is changed into binary image. And this method is called simple threshold method. This method is simple, and the application is wider, but it is not much used for level measurement. Due to at different altitude and under the influence of various factors such as the atmosphere, image grey values of material are different. Therefore, there will be a big error by using the simple threshold value.

Its main principles are that image is divided into several blocks, among of each there are 50% overlaps and the size is 64 by 64. And then each block do histogram separately. If the histogram shows obvious bimodal features, the simple threshold method will be utilized directly. As the other threshold

values will be obtained by surrounding pixel interpolation values to confirm all threshold values by 64 by 64 blocks; then followed by quadratic interpolation values to confirm threshold values by 32 by 32 blocks, and so on, until each block has its own threshold value. As to specific performance, please refer to Figure 1. Obtain the image of post-segmentation by this way<sup>[2]</sup>.

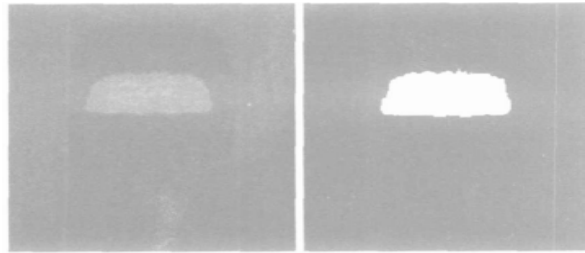


Figure.1 Surface image of raw material and post-segmentation

## 2.2. Area estimation

After describing image segmentation, we'll begin to estimate the surface area of materials in order to prepare following accuracy calculation. The surface image of materials by post-segmentation contains two elements, namely black background on behalf of container surface and white objective on behalf of materials. Now we make the position for "0" and "1". "1" means materials and "0" means background. The quantities of all "1" can estimate the surface area of materials by statistics of binary image, and add section area of container, the formula  $H \approx H_0(S/S_0)$  could be used to calculate height of level.

CCD camera technology and image segmentation technique are two parallel technology concepts. There is no intersection; it can also be applied to the level measurement system. Obtain the image by using CCD cameras to shoot the material surface, through computer digitization, and image processing.

## 3. Level measurement method based on CCD photographic

Level measurement technique takes an irreplaceable position in industrial production. From current situation of our country, the common level measurement instruments will be impacted by external factors during the material measuring of industrial production, such as float type level gauge, which the applied ambient temperature isn't too high, and viscosity of measured objects is small, corrosion is relatively low. As for measured object by capacitance level measurement, not only the physical properties are stable, but also ambient temperature is moderate. Ultrasonic and radar level measurement is a non-contact measuring instrument, which is not significant impacted by measured objects, but the measured result is still different according to the shape and structure of container, changing with the container changes<sup>[3]</sup>. In addition, we also are developing special material level meter, such as the SA-2 blast furnace raw materials warehouse material level meter and the CFL series powder level meter, but its application scope is limited, which cannot affordable.

Therefore, combine the advantages and disadvantages of above measuring instruments, this paper proposes a new level measurement method based on CCD (Charge Coupled Device Charge), CCD level measurement is a new computer visual measure method which takes CCD as the image sensor, and takes computer as image processing to obtain material level. The CCD Level measurement methods are generally divided into active and passive methods, but the active methods - structured light methods are more applicable. The main application of the principle is that emits controlled light source that point to the measured target, and obtain target image by the measuring the model for level measurement. This

method is not only practical, simple, easy, affordable, but also applies for a variety of industrial measurement applications<sup>[4]</sup>.

Right below Pic2 is the CCD 2 Schematic diagram of level measurement. The fixed beam for measuring needs generated by the laser measurements, shape a special light point on the object surface, when the object is changing or moving, the formative image of special light point on the CCD image plane also changes in movement, then you can measure according to the changing scope of these points, or moving distance<sup>[5]</sup>.

In this principle, it is no needs to assume a intersection between laser light and CCD level measurement plane 1 that can self-control and get maximum angle  $\theta$  in allowable installation conditions,  $L$  means horizontal distance between centre of CCD camera and the laser light. From  $d_1$  to  $d_2$  means from spot image of surface 1 and surface 2 of the distance to the centre of CCD image plane. In the actual application choice, we have to take into account the restrictions of installation conditions, the impact of the laser; the device costs and device simplify such factors. In short, the CCD-based level measurement method not only has strong anti-interference ability, good usability, but also applies to variety of more complex industrial applications; the devices should be affordable with easy adaptability

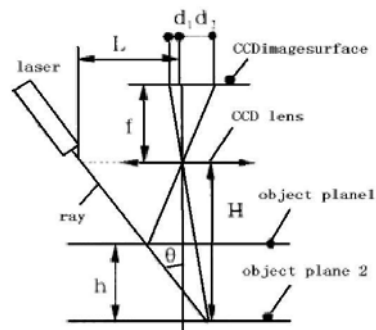


Figure.2 Schematic diagram of CCD level measurement

#### 4. Basic principles of level measurement and control system

##### 4.1. System composition

The specific model of level detection system structure drawing is shown in Figure 3, mainly consisted by the CCD camera, computer, servo motor and controller. The basic working process is first take the photos in real time and real site by CCD camera to obtain the surface image of material in the container and then transfer to the computer. Analyze and process the obtained image signal by using computer function of analysis, processing and storage etc. Estimate the material level according to the result of analysis and process. Finally the implement control procedures, reasonable and effective control the flow with effective regulate the feed valve by servo system, which form a material level measurement system<sup>[6]</sup>.

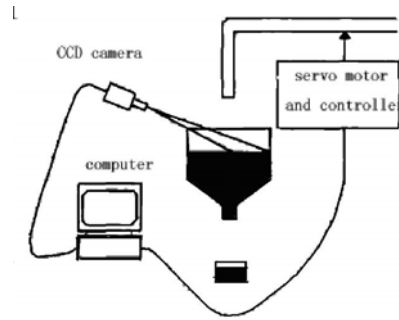


Figure.3 Schematic diagram of level measurement system

#### 4.2. The basic principles of level measurement and control

First, arrange position between CCD camera and the container with the material accurately. The relation sketch is above Figure 4. As a general rule, CCD camera and materials container are in diagonal relationship, and in the same plane as well. The included angle between CCD camera plane and material surface are designated as  $\theta$ ,  $\theta_0$  means included angle between CCD camera plane and bottom of the container. It can be observed that the general size of the container is far less than distance between CCD camera and container, therefore it is:  $\theta = \theta_0$ . Then get the following approximate relation (1):  $h = h_0 \times S \div S_0$ . In the relation :  $h$  means the material level of the container,  $h_0$  means the height of the container,  $S$  means surface images area of material captured by CCD cameras,  $S_0$ , means cross-sectional area of the container<sup>[8]</sup>.

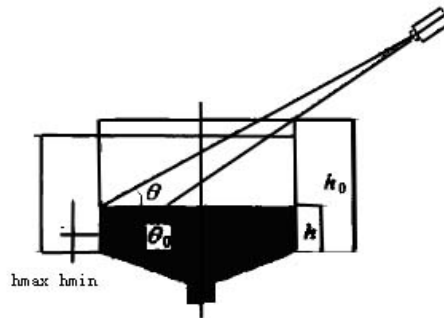


Figure.4 position relation sketch between CCD camera and the container

According to Eq. (1), it is convenient to transform the image area above to a boring height. When the cross-section shape of the container is other shapes, such as oval, round and diamond shapes etc., but no matter how its shape changes, there will always be a Similar monotonically increasing function between the data image area and the material level. However, it should be notice that, as shown in figure  $h_{\max}$  is highest material warning height,  $h_{\min}$  is the lowest material warning height.

#### 4.3. Design of system control algorithm

For some measurements of materials in industrial production, the control of materials flow is a very critical step, the so-called level measurement is mainly to control the flow of materials as one of the main purpose. This involves design and control of algorithm for the system. In different production processes stages, the demand for materials is very different. In many cases, the change will be quite significant,

which is related to the opening and closing of valve. Therefore, we could control the flow of the material change by opening and closing the valve. When reaching the highest warning level, design closing valve; and when reaches the lowest warning level, the valve will open to the maximum flow. Generally the best is implementation of automation. So that we should be absolutely abandon single controller approach because the controller will be unable to meet the above requirements, besides making the corresponding control algorithm according to the different stages of level measurement and control

Regarding design of control algorithm in each stage usually has a function that we will eventually show in image. The specific control algorithm is as follows: When the material level reaches the lowest warning level, the valve automatically opens to the maximum degree in order that the materials enter the container quickly and reach the required value to ensure adequate materials supply of container; When the material level reach to the highest warning level, the valve will automatically shut down, which not only have limited material access to the container beyond the needs causing wastage, but also avoid the material overflowing from container.

## 5. Conclusions

This paper proposes a level measurements system of digital image processing technology is widely applied and easily realized comparing with common measuring device. The relevant data, experimental, calculation, and practice have revealed that the control system has a very good measurement accuracy and control effect. In addition, with the assistance of CCD camera technology, the system becomes more perfect.

With the introduction and analysis of level measurement systems, there will be a good prospect, and level measurement technology development need further develop in the future, It will progress in the direction of simplify, cost-effective, automation, imagination, defamation and wider application field.

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