New Algorithm of Liquid Level of Infusion Bottle Based on Image Processing

Huasheng Zhu
Department of Computer Science and Technology
Nanchang Institute of Technology
Nanchang, China
E-mail:zhuhuasheng@sohu.com

***Abstract*—The key of intelligent infusion system is to detect liquid level of infusion bottle fast and accurately. We proposed an automatic detection algorithm of liquid level of infusion bottle based on image processing, by designing edge detection, binarization, filtering, image projection and motion detection to realize automatic liquid level detection. The algorithm has the advantages of stable noise-resistence, rapidity and simplicity, etc. Experimental results of the algorithm show that the algorithm is effective and feasible.**

Keywords—liquid level; edge detection; projection analysis; motion detection

I. INTRODUCTION

At present, there are lots of articles in which adopt optical-electronic sensing techniques to implement the intelligent transfusion system [1-2]. Its fundamental principle is to compute the population of output liquid by counting its number per minute. But it also has many shortcomings. Firstly, it is required to install sensor to transfusion equipment, which will has an impact on nurses and patients; Secondly, it is lack of intuition and confidence, because the system obtains the volume of remaining liquid in the transfusion bottle by calculating. Thirdly, the operation is complicated, and the working mode of computer is stand-alone. So the system which based on above theories has not been widely applied.

Intelligent transfusion system based on computer vision has overcome above disadvantage. It can manage a plenty of infusion process in a centralized and intelligent way without effect the normal course of infusion.

The key of intelligent infusion system is to detect liquid level of infusion bottle fast and accurately. We proposed a fast and efficient detection algorithm of liquid level of infusion bottle.

II. SYSTEM STRUCTURE

As shown in Fig.1, the hardware of intelligent transfusion system consists of the IPCamera, Intranet, Computer and Alarm.

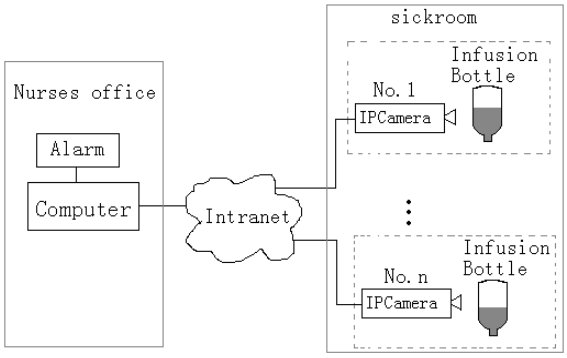

Figure 1. Hardware structure

Flow chart of application has been shown in Fig.2. First, capture image through the computer and automatically determines the location of warning line according the infusion bottle location. Then capture the image again and detect the location of liquid level in the infusion bottle. Finally compare the location of warning line and liquid level. If the liquid level is not below the warning line, repeat the detection of liquid level until it is below the warning line. Then alarm system, and stop the detection.

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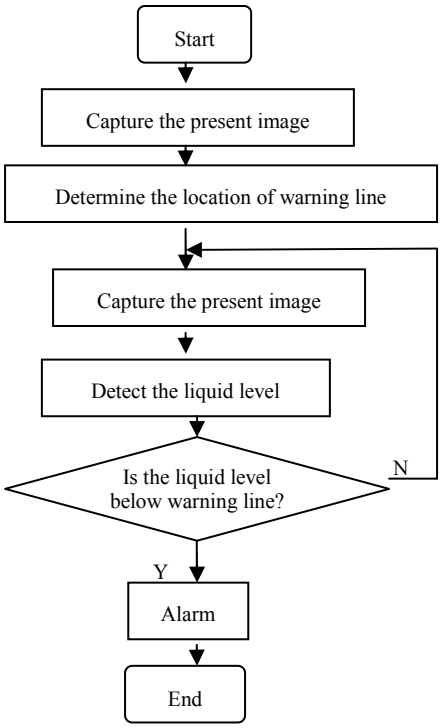

Figure 2. The flow chart of application

III. LIQUID LEVEL DETECTION

For the image of liquid with the same dielectric has almost the same gray value, there are two kinds of dielectrics at the vicinity of liquid level; the image of the region near the liquid level has strong horizontal edge information. As shown in Fig.3. However, except the liquid level there are some other edge lines in the horizontal direction, such as: the edge line of the label, the edge line of the bottleneck, and so on. In a conclusion, it is difficult to identify the liquid level from an image.

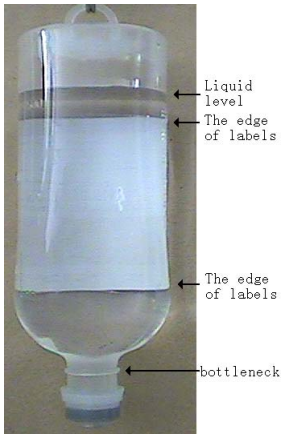

Figure 3. Infusion bottle

Algorithm principle: it has several obvious edges in the horizontal direction, only the liquid level will move down gradually, and others are in a relatively fixed position. According to this characteristic, the liquid level is the moving one.

The algorithm flow chart of liquid level detection is shown in Fig.4.

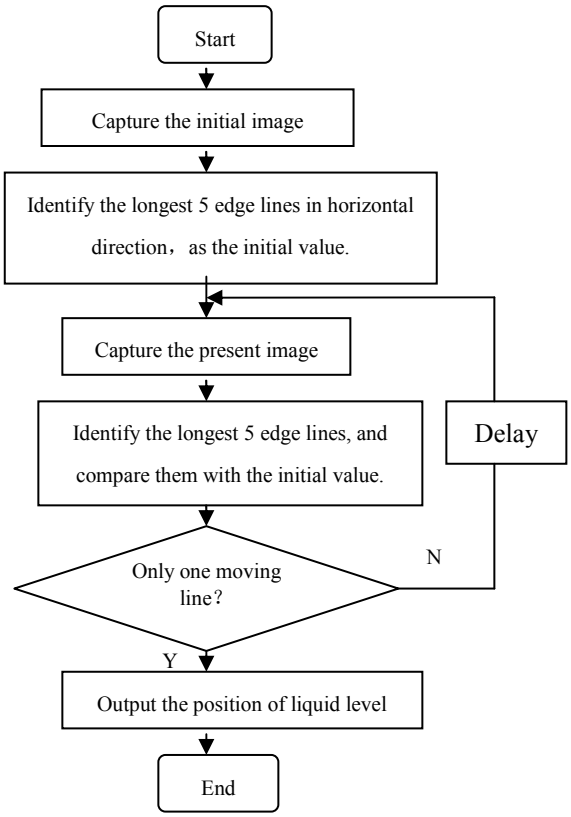

Figure 4. The algorithm flow chart of liquid level detection

The concrete process of the algorithm is as follows:

Step 1: Capture the initial image, I(x,y) , as shown in Fig.5(a).

Step 2: Detect the edge of the image.

In the purpose of improving the calculating speed of edge detection, Sobel[3] is chosen to detect the edge and properly optimize it on the basis of itself. Sobel is completed by using two direction templates and the image carries on the neighborhood convolution. One of the two templates is used to detect vertical edge; another is used for horizontal edge.

Choose horizontal direction template H for horizontal edge is needed only in liquid level detection.

$$H=\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

The edges in the Fig.5(a) are detected using (1) to generate an edge image as shown in Fig.5(d).

$$E(x,y)=I(x,y)\otimes H \tag{1}$$

E(x，y)is the edge image, I(x，y)is the image of infusion bottle, and H is the template.

Step 3: Image binaryzation[4] and filter[5] .

Image binarization is performed which key factor is to select the threshold. Experimental results show that in the gray image about 10% of total pixels are the edges information, so set the pixels which brightness above 10% as the foreground and others as the background.

Then filtering is applied to the image for eliminating the interference. We can filter in a 5x5 region. The principle of filtering: If white pixels are more than 12 in a region, the pixel in this region sets white otherwise sets black. Filtering image is F(x,y), which is shown in Fig.5(g).

Step 4: Horizontal projection [6]

Project the image in horizontal using (2). Fig.5(j) is the projection image.

$$prj[y]=\sum_{x=0}^{M-1}F(x,y),y=0,1,...,N-1 \tag{2}$$

Step 5: Find the longest 5 edge lines in the projection image, L1~L5, as initial value.

Step 6: Using the capture image as the current image after a period of time, and then redundant the 1~4 steps to find the longest 5 edge lines. As shown in Fig.5(k) and Fig.5(l): the lines, L1~L5.

Step 7: Compare the edge line of current image with the initial value, the moving one is the liquid level line. L2 is the liquid level line in Fig.5. If there has no moving line or more than two moving lines, return to the previous step.

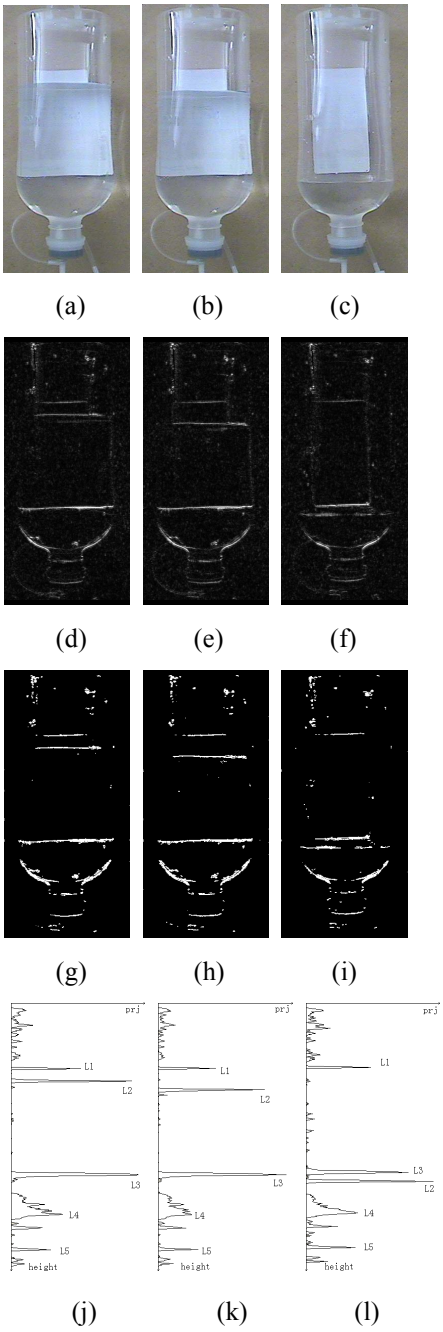

Figure 5. Liquid level detection

IV. ANALYSIS OF THE RESULTS

The system has been repeatedly tested to test the validity and practicability of the algorithm. The system adopts HIKVision DS-2CD812PF as IPCamera. To simulate actual environment, the system has been tested with interferences generated by changing the light, tilting of infusion bottle and etc as shown in Table I . The system would make the

examination mistaken when the light changes too much in a moment.

TABLE I. THE EXPERIMENTAL RESULTS

Interference source	Number of experiment	Accuracy
The change of light	100	99%
Tilting of infusion bottle	100	100%

The result images in different environment are shown in Fig.6(a) and (b) represent the initial image and the current image. (e) and (f) are the binarization images. (i) is the initial value of the edge, (j) is the current value of the edge. And it is easy to find the liquid level, L2, after comparing (i) with (j). It is easy to find the liquid level, L2, after comparing (k) with (l).

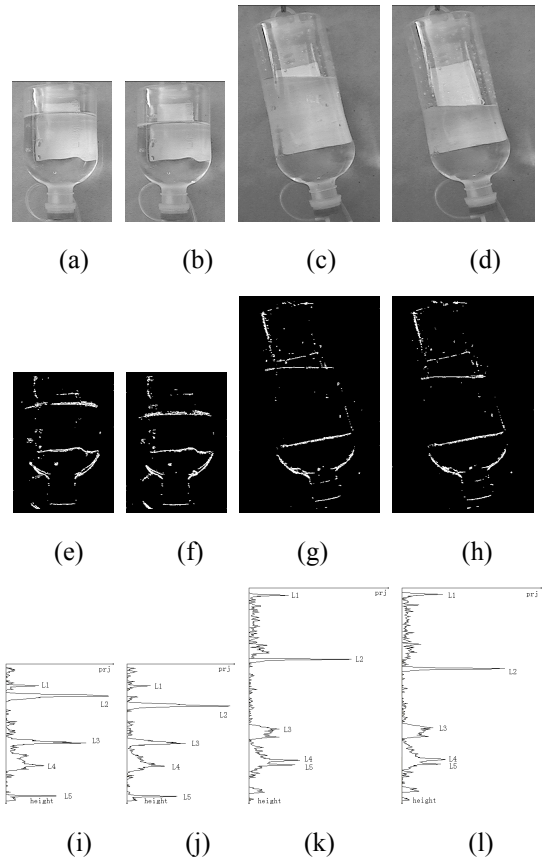

Figure 6. The experiment results in different environment

V. CONCLUSION

There are a lot of methods to detect the liquid level. But many of them are vulnerable to outside interference, which reduces the reliability of the system. For example, Time Difference[7-9] for the detection of liquid level is easily interfered by light's change; Edge Detection of liquid level is easily interfered by label's edge when the liquid level is detected from an image.

This paper presents a fast, simple and stable algorithm with strong anti-jamming. And the algorithm will not interfered by label edge. The experimental result has confirmed the validity, feasibility and superiority of the algorithm.

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