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# Automatic Bottle Filling Inspection System Using Image Processing

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**Abstract:** ***The enlargement of Indian food industry is an even matter of fact. Especially the beverage industry is at its peak. So looking at the prevailing conditions it is very crucial to continue an error free fast production line. For this purpose an automated liquid level monitoring system has been proposed in this paper. The work is achieved by using image processing techniques for the detection of the correct liquid level. This project aims at designing an automated system for monitoring the bottle filling process in the beverage industry. The aim is to check whether the bottle is filled with proper quantity of beverage or not. Moreover we have also developed an algorithm in which along with the any color liquid level, bottle cap detection, label detection and dirty bottle detection is done, so that a full proof system can be designed in bottle packaging industry. Since bottling is one of the most common packaging styles in the food industries, in this paper we will depend on the visual inspection of bottles. Checking the quality of the cap closure and over-filling/under-filling checks for the level of the liquid in the bottle have been observed to reach an optimized bottle product. The proposed work is achieved using image processing techniques utilizing the matlab platform without disturbing the high speed production line. We have used a cropping technique for color detection and level sensing. Label detection is done by optical character recognition. All of this activity needs to be done in such a way without disturbing the production line.***

**Keywords:** Automated bottle filling, image processing, cap closure, level inspection, dirty bottle inspection, label inspection.

## 1. Introduction

The Indian food industry is perched for huge growth, increasing its contribution in world food trade every year. In India, food industries broadly comprise of food production and food processing industry and have become a high-profit industry by reason of the scope it offers for value addition. Accounting for about 32 per cent of the country's total food market, the food processing industry is one of the prime industries in India and is ranked fifth in terms of production, consumption, export and expected growth [1]. The total food production in India is likely to double in the next 10 years with the country's domestic food market estimated to reach from US$100 to US$ 258 billion by 2015. Soft drinks industry is one of the most significant food production industries [2].Soft drinks have become world's leading beverage sector. Global consumption of soft drink is increasing by 5% a year, well ahead of all other beverage categories. Soft drinks volume was projected to reach around 467 billion liters making 75 liters per person in India by 2010 [3]. About half of soft drink containers were aluminum cans and the other half, were reusable bottles.

In this case it is very important to take care of the quality of the product delivered. The bottle filling process and reusability of the bottles that are used are the most important key issues. Now to maintain the quality of such large number of bottles is not an easy job. With manual inspection it is impossible maintain the easy manufacturing flow. Detection of foreign particles in reusable bottles and the level of beverage in each bottle are the main objective/ concern to any beverage industry [4]. In industries, bottles are reused to fill their products at the fast rate, manual check is not possible, the method of filling may be accurate but practically it's not possible to assure that the bottle is perfectly filled and is free from micro-macro impurities. In fact, human as inspector are slower and their efficiency is affected by their states of tiredness, illness or other human being shortcomings [5]. In some applications they need guidance to attain proper skills.

Moreover, the inspection of fill levels in liquid tanks is still under development as the measurement techniques have to meet the increasing requirements of modern processes in chemistry, food industry or biotechnology [6]. There are at times special environments which are dangerous and not conducive for human operation. On the other hand, especially in the industrialized environment, it is necessary to improve quality control and productivity in order to maintain an advantage over their competitors. The quality control process to ensure correct filling plays a critical role in the bottlers and distributors of beverages, and for classify the product quality close to release. However, in most domestic industries related to the zone, are not automatic, bringing negative consequences for the operator and for production [7]. In the specific case of Coca-Cola, this procedure is executed manually. A worker observes the bottle's production pass through a conveyor belt and according to their visual criteria, is removed from the process. The checkpoint is an acrylic background illuminated with a high intensity of light, causing the operator after long years of work diseases, such as cataract ts. Given that the human eye is not a digital device, it detects fewer frames per second (FPS) reducing the number of bottles inspected at the end of the day. For these reasons, we performed the automation of this process through the digital image processing which evaluates the quality of filling [8].
The basic mechanism for all bottle visual inspection as for any other visual inspection system is shown in Fig. 1. The first step in a visual inspection system is the image

acquisition, which is concerned about capturing a good quality image through a camera. Camera resolution, its position, color of background and speed of the conveyor belt has important effect on the image quality. Moreover the position and brightness of the light are important factors in the inspection system design (e.g. in reflectance especially when bottle is transparent) [9]. After capturing the image, there is a need for techniques to filter, analyze, restore and reconstruct the images to remove different types of noise in the image and hence enhance its quality. Detailing of the image should be identified properly. In fact relevant information from the image is required to be extracted to reduce the data sets.

In this paper, we have shown basic principles of bottle visual inspection by presenting different methods and techniques for automation of bottling and the most recent algorithms have been stated. In this paper, we have concentrated on developing a combine algorithm for four quality inspection in bottles: Detection of liquid content irrespective of any color, Cap closure, Label checking and Dirty bottle detection. So by developing such algorithm where four most important parameters of automation of bottling are combined we get an efficient bottling system. Besides we have presented a detailed explanation of previous work of level detection and the new algorithm combining the four parameters through list of figures.

## 2. Different Methods

There are many methods through which detection of level can be done. Industries use many different method based on the utilization and environment. Lots of patents have appeared to read liquid level in a tank for simplification of devices in the measurement. Some of them invented a device through which liquid level was measured using laser diode in a tank [10]. However, this seems sometimes frustrated, after realizing that it is impossible to measure liquid level in metal hot furnaces, strong acid and alkali in vessels. Most methods of sensing techniques for measurement of liquid level are depended and needed on physical devices contacted with container or liquid directly. Typically, the working temperature also matters. So work in extreme conditions is restricted. In this case, measurements should be conducted without any physical contact between sensors and containers to avoid damage of it from heat and corrosion. Automatic bottle filling are based on:

- **Flow meter:** It is based on the density of the liquid to be filled.
- **Timing:** It is based on the specific time period.
- **Weight:** It is based on the weight of the liquid to be filled.
- **Level sensing:** It is based on the marked level up to which bottle is to be filled.

So looking at the prevailing conditions it is beneficial to develop a method in which we shall control the level of the liquid without touching the bottle. So we will operate liquid level control system with a webcam keeping an eye on the level. The webcam doesn't need to touch on the tank but provides us with information of liquid's height remotely, which means that the system can measure any kinds of liquid level especially laid on extreme environments. The only condition which must be fulfilled is that the bottle must be transparent.

## 3. Previous Work

Now as we seen in previous section, for detecting the level of the liquid different methods can be used for level sensing. Based on those different algorithms such as Roberts, Prewitt, Sobel, Marr- Hilderth LoG algorithm, canny algorithm etc. can be used. But all these have some advantages and some disadvantages. So initially we used an RGB matrix method for the colored level detection. The proposed method goes as follows:

- First we will capture the image.
- Apply the filter for noise reduction.
- We define a scan line to determine the level of filling with RGB matrix.
- The bottle then starts filling.
- The color of the liquid is then continuously compared with its background color.
- If the color of the liquid reaches up to the defined level, the solenoid valve becomes off and the filling stops.
- Its advantage is that it is simple to compute and less time consuming.
- We will write a program in the matlab regarding the various colours of liquid in terms of RGB and then define the level of the liquid to be filled.
- If the level matches to the defined level then filling system stops.

For ex. we can define that if [1111111111] level which is defined in the matlab matches to the level of the bottle then the process will be automatically stopped.

This method had its own advantages and disadvantages. The main disadvantage being that being an RGB matrix method it could be implemented to detect just three basic colours i.e. red, green, blue. This was a very easy but not a practical solution on basis of industrial application. The results of the RGB matrix method is shown below. Here a red colour bottle is sensed and if the colour exceeds the predefined level the message “full” is displayed.

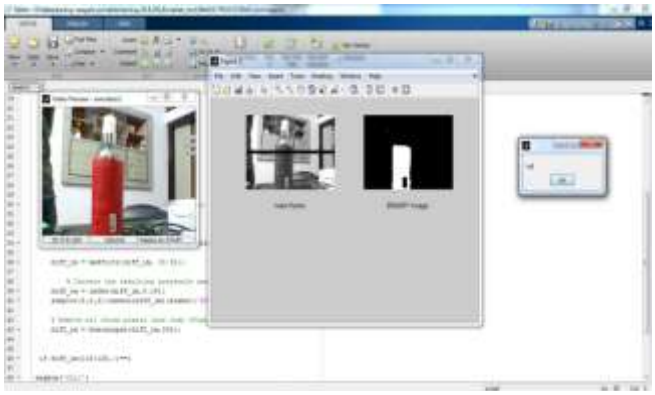

**Figure 1:** Detection of red color and level sensing

## 4. Proposed Work

As we have explained before, in the previous inspection systems, detection of the liquid color was limited. We have removed this hurdle by implementing a new cropping

method. This is capable of detecting liquid of any color, so that the algorithm can be used to detect any beverage except water. Moreover this level detection technique is combined with cap closure detection, label checking and dirty bottle detection into the method to make a single algorithm for the whole system. It is essential to develop a full proof system for bottling so that all four important parameters can be implemented in a single stretch. The label detection is done by optical character recognition method. Here template matching method has been used. For cap closure inspection we have defined a reference level. By comparing that reference with the cap location we can determine the position of the bottle cap, whether it is closed, not properly closed or open. Dirty bottle is recognized by selecting a set of pixels where the color detected would not be same as the liquid color. So as the difference of color would be detected, the bottle would be identified as dirty bottle.

First we present the general modules and image processing methods which are crucial in our system. The figures are captured from plastic bottles.

- Image acquisition: The image is captured by a Logitech webcam. To reduce the reflection of bottles we suggest using a bright LED light source.
- Image environment: The bottle to be inspected should be in a proper light and in an equal background to reduce reflection and detection of other colors.
- Image enhancement: In this segment applying filter for noise reduction.
- Image segmentation: Defining a level for detection of the liquid level. The level should be fix above which the liquid must be full. So any edge detection technique could be entertained here.

### 4.1 Image Cropping Method

After capturing the image and performing the basic noise removal tasks the cropping module is implemented. In this method a small part of the color of the liquid which has to be inspected is selected from the image. Now that color range is compared with the captured image. In result we get the output image in which the color component which is cropped (selected) is only detected leaving the other areas as it is. Now if the detected region goes above the predefined level represented by a line, a message "full" is displayed on the screen. Simulation with different colored bottles is shown below.

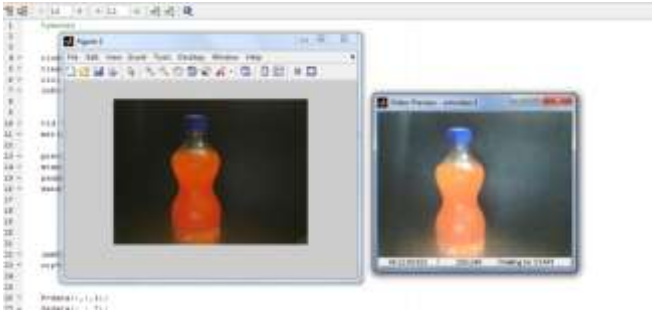

**Figure 2:** Image acquisition of cold drink bottle

Here in figure 2 we can see the image acquisition of cola bottle using a low end web cam. The image should be captured in such a way that the background is equal and lighting is proper.

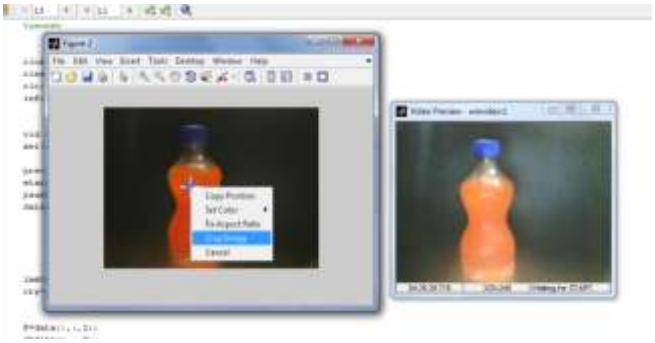

**Figure 3:** Color cropping

Here in figure 3 we can see the color cropping method. As shown above, a range of pixel of color to be detected is selected.

**Figure 4:** Color Detection

Here in figure 4 we can see the detection of color which is cropped. The cropped range of color is compared with the image captured. The part of the cropped color range turns black when. So we can easily detect a liquid irrespective of its color. Obviously, whenever the detected liquid goes above the predefined level a message "full" is displayed.

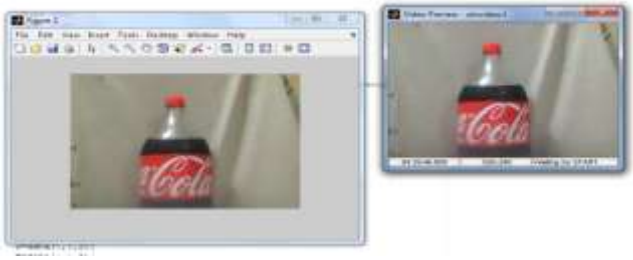

**Figure 5:** Image acquisition of cola bottle

Similarly here in figure 5 we can see the acquisition of cola bottle through a low end web cam.

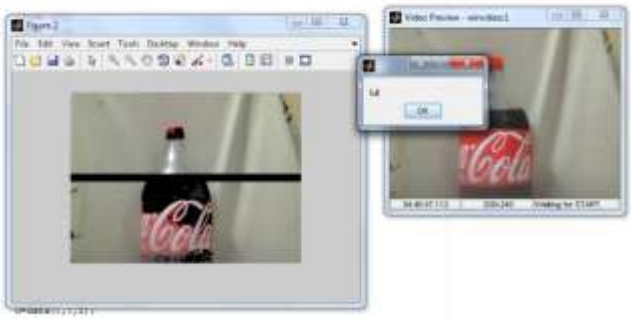

**Figure 6:** Detection of liquid level

Figure 6 shows the detection of liquid level in the cola bottle and display of message full when reaching the defined level.

### 4.2 Cap Detection Method

We have developed the method in such a way that one algorithm includes four parameters of bottling. So it is essential to capture the image in a correct manner which can include all the detectable parameters. For cap detection method we have defined a horizontal reference line. This reference line is different from the level detection line. The reason for keeping both the lines different for their purpose is to achieve an accurate result for cap detection. Along with the horizontal line, we have defined three vertical lines. These vertical lines keep the cap in a fixed position so that every different image can be in the same region of interest. The vertical line is kept exactly at the lowest groove of the bottle neck. First the bottle cap color is detected through RGB matrix method. Once the cap is detected its position is compared with the base reference line. Based on that difference we have defined three detecting levels for bottle cap: cap present, no cap and not proper cap.
Simulation with different cap positions is shown below.

**Figure 7:** Image detected with cap present

As we can see above in figure 7 the bottle with cap present can be detected as the cap detected is touching the horizontal reference line.

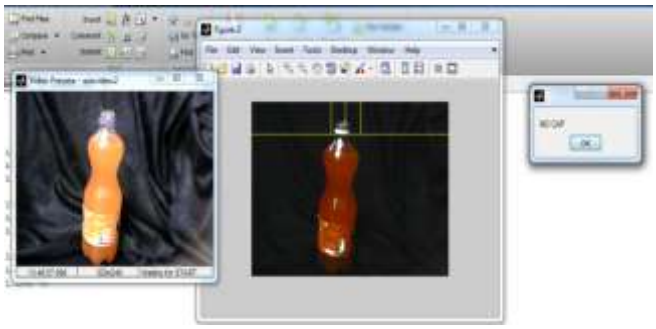

**Figure 8:** Image detected with no cap

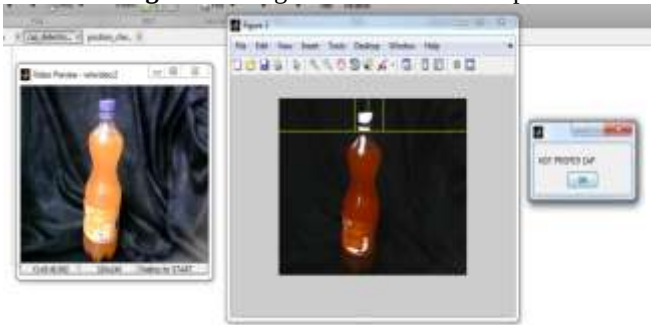

**Figure 9:** Image detected with not proper cap

Here in figure 9 it shows that the position of the cap is above the horizontal reference line and between the defined vertical lines. So if there would be a difference between the base reference line and cap, the result would be “not proper cap”.

### 4.3 Dirty Bottle Detection Method

For dirty bottle detection we have assumed a dark black dot on the exterior of the beverage bottle. In bottling plant there might be a case of reused bottle being dirty. In that situation the whole bottle is diverted from the production to cleaning section. The main challenge in detection of dirty bottle is that if the spots are not so dark, then the detection is tough. To detect a dirty bottle we have primarily fixed an area of pixels on the bottle. If there is a difference of color other than the beverage color in that region then the bottle is detected as dirty.

### 4.4 Label Detection Method

Sometimes in bottling there happens a case when the labeling of the bottle is missed. In this situation it is very important to detect the faulty bottle. We have performed label detection through optical character recognition method. In OCR we have used template matching algorithm. Optical Character Recognition by using Template Matching is a system prototype that is useful to recognize the character or alphabet by comparing two images of the alphabet [11]. The purposes of this system prototype are to develop a model for the Optical Character Recognition (OCR) system and to implement the Template Matching algorithm in developing the system prototype. There are a few processes that were involved in this algorithm. The processes are starting from the acquisition process, filtering process, threshold the image, clustering the image of alphabet and lastly recognize the alphabet. All of these processes are very important to get the result of recognition after comparing the two character images.
As explained above in all previous points, each parameter has its own distinct detection method. Individually their usage becomes limited. So by combining all of these methods we have made an efficient single algorithm system that detects all the four important parameters of bottling in a single full proof system. The proposed algorithm by combining all above parameters is as follows.

1. First capturing image.
2. Applying smoothing filter for noise reduction.
3. Applying edge detection for building reference line.
4. Taking a snapshot of the image and cropping one small part of the required color.
5. Selecting a range of pixels for dirty bottle detection.
6. If the color detected till reference line then “full” else no display.
7. If color difference at selected range of pixel then “dirty bottle” else “clean bottle”
8. Drawing a horizontal reference line at bottle neck base and three vertical lines for cap detection.
9. If no difference between reference line and cap position, “cap present” displayed,
   Else if a small difference detected, then “not proper cap” displayed.
   Else if no cap color detected, then “no cap” displayed.

10. Applying optical character recognition method, if the template is matches with the letters on the label then "label present" displayed, otherwise "no label" displayed.

## 5. Results

Following are the results of the experiment carried out in a well lit atmosphere using plastic beverage bottles.

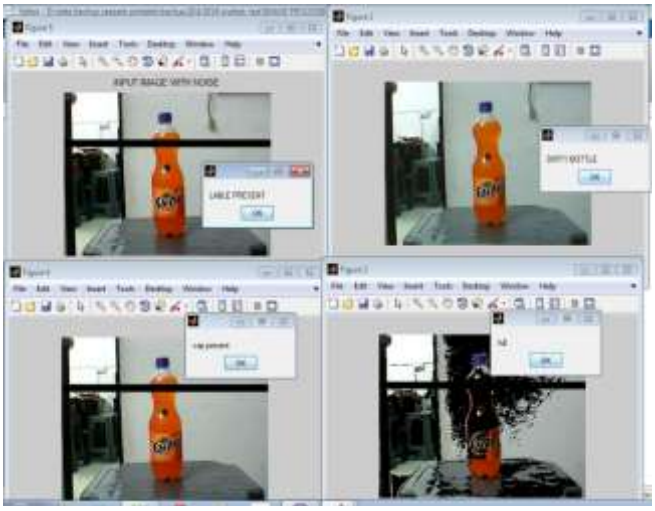

**Figure 10:** Results with label, cap present, dirty and full bottle.

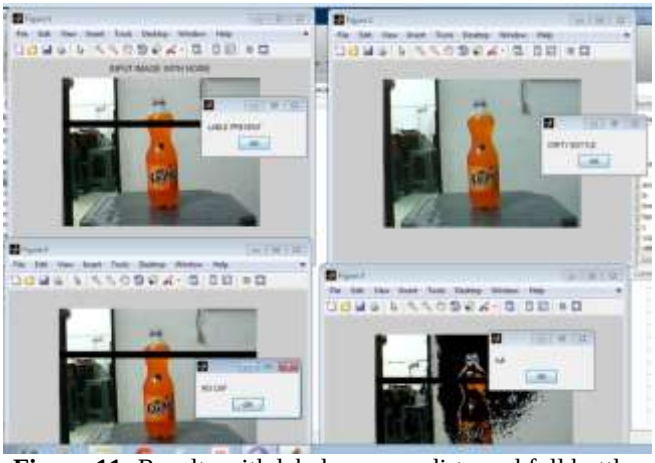

**Figure 11:** Results with label, no cap, dirty and full bottle.

## 6. Conclusion

Bottling industry being a very important industry in food and medical sector, in this paper an algorithm has been shown to consider all four important parameters naming: Level detection, Cap detection, Label detection and Dirty bottle detection in a single algorithm. With this algorithm level of any colored liquid can be sensed along with three cap positions and label checking.

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