Automated Monitoring of Bottle Filling Process Using LabVIEW

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Abstract— **This paper aims at designing an automated system to monitor the bottle filling process in a beverage industry. The objectives of the proposed work are to (i) check whether the reused bottle is free from impurities before it is filled with beverage, (ii) check whether the bottle is filled with proper quantity of beverage. The proposed work is achieved using image processing techniques utilizing the LabVIEW platform without disturbing the high speed production line. The images of bottle are captured using a high frame rate smart camera which is transferred to PC for processing through RS232 port. LabVIEW is programmed to acquire the data and apply image processing algorithms and initiate necessary action like displaying the status of the bottle in the production line, diversion of bottle from the production line if it doesn't satisfy the standards. All these activities need to be performed without disturbing the speed of the production line.**

Keywords—**Beverage industry, Automation, Image processing, LabVIEW**

I. Introduction

The Indian food industry is projected to grow by US$ 100 billion to US$ 300 billion by 2015. The food industry in India widely comprises of food production and food processing industry. Soft drinks industry is one of the most important food production industries. Soft drinks rank as favorite beverage segment, representing 25% of the total beverage market. In the early 1990s per capita consumption of soft drinks in the U.S. alone was 49 gallons. The $27 billion dollar soft drink industry generated about 110 billion containers each year in the early 1990s. About half of soft drink containers were aluminum cans and the other half, were reusable bottles [1]-[3].

Detection of foreign particles in reusable bottles in beverage industries is the main objective/ concern to any beverage industry. In industries, bottles are reused to fill their products at the fast rate, manual check is not possible, the method of cleaning may be accurate but practically it's not possible to assure that the bottle is free from micro-macro impurities. News like a pen cap, insect, match stick, etc… is found in a soft drink bottle is often heard on news paper/TV etc. This is a clear indication of the problem mentioned before. So, this paper aims at proposing an automated monitoring technique which can be carried on before the bottle filling process. The main constrain for the proposed technique would be that the process should not cause any delay in the high speed production line.

The achieve the objectives mentioned in this paper a high frame rate camera is used to capture the image of the bottle before filling it with soft drink, process the data and check for impurities using the techniques of digital image processing and alert the system. If any mismatch is detected, divert that particular bottle from the production line to cleaning process again. A similar technique is also incorporated here to check whether the bottle is filled with proper quantity of beverage after the bottle filling process is completed.

The paper is organised as follows: After introduction in Section I, a brief description on Experimental setup is given in Section II. A brief discussion on sensing elements i.e smart camera is discussed in Section III. Section IV deals with the problem statement followed by proposed solution in Section V. Finally, results and conclusion is discussed in Section VI.

II. Experimental setup

To demonstrate the working of the above proposed objective a laboratory model is setup which would mimic the industrial production line. The Fig. 1 Shows the model of the experimental setup which is used by us to carry out the project. The bottle is placed on the conveyor belt which is rolled at high speeds of the order of 30 bottles per minute with the help of the stepper motor arrangement. The high frame rate smart camera is placed on the housing to capture the image before the bottle is filled. The solenoid is provided after the housing which will be actuated if the bottle does not meet the standard. The same setup is also used to check whether the bottle is properly filled with desired quantity of soft drink after the bottle filling process. Fig. 2 shows the picture of the model which was fabricated to test the proposed technique.
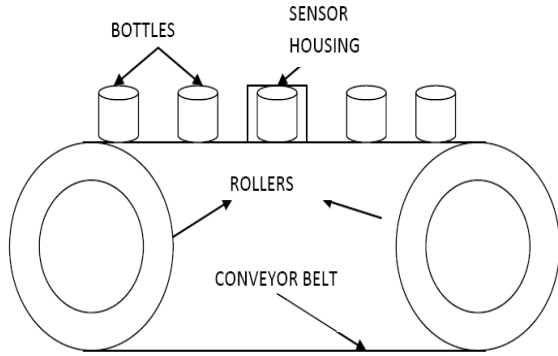
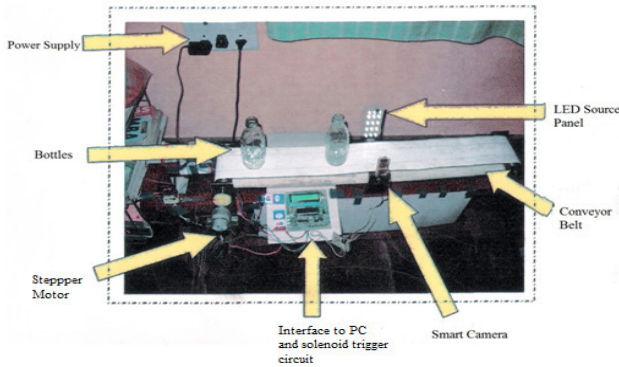Fig 1. Model of experimental setup

Fig 2. Actual experimental setup

III. SENSING ELEMENT

The block diagram representation of the proposed instrument is given in Fig 3

Fig 3. Block diagram of the proposed technique

A. SMART CAMERA

The NI 1744 Smart Camera shown in Fig 4, is powered by a 533 MHz PowerPC processor, is a real-time target for machine vision. The high-quality Sony CCD image sensor acquires SXGA (1280 x 1024) resolution images. This camera has four times the resolution of the NI 1722 and 1742 Smart Cameras. Camera I/O includes two opto-isolated digital inputs, two opto-isolated digital outputs, one RS232 serial port, and two Gigabit Ethernet ports. The NI 1744 also features quadrature encoder support and a direct drive lighting controller that can drive current controlled lights up to 500 mA

continuous or 1 A strobed. It has a maximum frame rate of 13 fps at maximum resolution which can be further increased on compromising the resolution, with a sensor size of 1.25cm, pixel depth of 8 bit, minimum exposure time of 76.7 µs and exposure time increment of 71.6 µs [4],[5].

Fig 4. 1744 Smart sensor

B. LabVIEW

LabVIEW is a fully featured programming language produced by National Instruments. It is a graphical language quite unique in the method by which code is constructed and saved. There is no text based code as such, but a diagrammatic view of how the data flows through the program. Thus LabVIEW is a much loved tool of the scientist and engineer who can often visualize data flow rather than how a text based conventional programming language must be built to achieve a task. LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes, multimeters, etc…. LabVIEW contains a comprehensive set of tools for acquiring analyzing, displaying, and storing data, as well as tools to help you troubleshoot your code.

LabVIEW VI's contains three components-the front panel, the block diagram, and the icon and connector pane. In LabVIEW, you build a user interface, or front panel, with controls and indicators. Controls can be knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. After you build the user interface, you add code using VIs and structures to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.

You can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, and GPIB, PXI, VXI, RS-232, and RS-484 devices. LabVIEW also has built-in features for connecting your application to the Web using the LabVIEW Web Server and software standards such as TCP/IP networking and ActiveX. Using LabVIEW, you can create test and measurement, data acquisitions, instrument control, data logging, measurement analysis, and report generation applications. You also can

create stand-alone executables and shared libraries, like DLLs, because LabVIEW is a true 32-bit compiler. [6],[7]

IV.   Problem statement

Once the images are captured with the help of NI 1744 smart camera the processing of the images is done to achieve the following objectives:

(i)   Display the status of the bottle whether its clean or dirty.

(ii)   Display whether the bottle is filled with proper quantity of soft drink after the bottle filling process.

(iii) Trigger the actuator to divert the bottle from the production line if it doesn't satisfy the desired standards.

V.   Problem solution

The original sample image after being acquired by NI smart camera is been sent to the PC form processing on LabVIEW. After the acquisition of the images by the LabVIEW, the sample image is ready for being processed. In processing, we start off by extracting two color planes from the RGB plane (32-bit) image and converting it to a one color plane image, say red plane (8-bit) image. We convert it to a grayscale (8-bit) image because it reduces the matrix size of the image and computational time is immensely reduced as well as memory requirement is very less.

Now, the whole sample image is not required to be processed. We select our region of interest and mask all the pixels that are out of our region of interest. We extract out our masked region and we are left with only our region of interest. Now, we select the range of pixels in our region of interest which are bright by the operation of cluster thresholding. After thresholding, the whole image is highlighted with red color but in case of a defective image, the defects are easily distinguishable as those portions are not highlighted with red color in our region of interest. The thresholding operation further reduces the image from an 8-bit one to a binary image. Now, we remove those defective portions which were not highlighted in our thresholding operation using a filter.

The filtered image is then analyzed by particle analysis process. This process displays measurement results for selected particle measurements performed on the filtered image. In case of checking the whether the bottle is filled with proper quantity of soft drink or not, we can use the centre of mass technique of particle analysis. Here, we analyze the centre of mass for this filtered image. If there is a defective sample, it's center of mass will be different as compared to the good sample's center of mass. In this way, we can compare the sample's image and find out which sample is a defective one. Now, our program will compute the center of mass of a

sample and compare it with the original good sample's center of mass and if it does not match, it will switch on an alarm signal which will alert the system to knock off the defective sample from the conveyor belt.

In case of distinction between clean and unclean bottle, we can use the particle analysis technique. In case of clean bottle, results in a scalar output of one otherwise the result will be non-zero value. This helps the controller distinguish between clean and unclean bottle. So, as to take up necessary actions [8]-[13]. Fig 5 shows the picture of the front panel designed for the project. Fig 6 shows the block diagram.
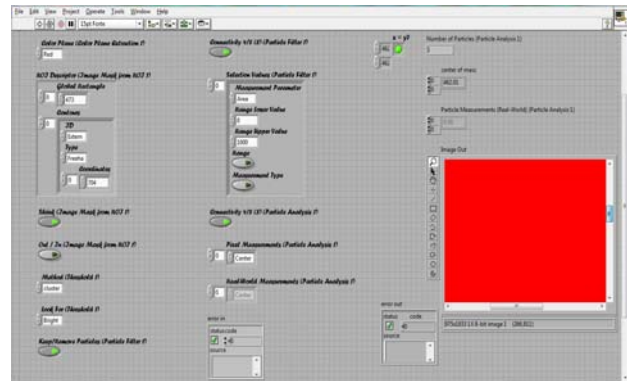

Fig 5. Front panel vi

Font panel consists of many controls and indicators. Colour plane extraction is a control which extracts the image to a red plane one. ROI Descriptor Change Mask is used to define the region of interest. There are on/off button options for masking process which defines which region to be masked, namely the region within or outside of ROI. There are threshold controls to control the method of thresholding as well as what to look for dark or bright objects during thresholding. There are particle filter controls to remove the defective portions which were not highlighted during the thresholding process. At last, we have the particle analysis controls and indicators. The image out is the processed and filtered image upon which particle analysis is conducted. The connectivity, pixel measurements, and real world measurements are the controls required for particle analysis. The results of particle analysis are shown in indicators, viz. number of particles, centre of mass. The two unknowns x and y are our comparison variables. X is denoted by the good sample's centre of mass and Y is denoted by the present sample's centre of mass. If they match accurately, the alarm light glows and the production line is left unhindered and if it does not glow, the bottle is diverted away from the production line.
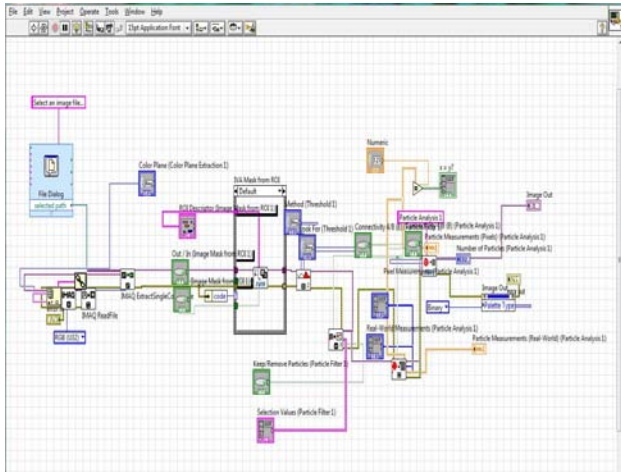
shows the front panel for the clean and dirty bottle respectively. Similarly the check for bottle filled with appropriate quantity of soft drink was also carried over, the system was able to initiate proper action Fig 9 and Fig 10 shows the front panel for completely and incompletely filled bottles respectively.
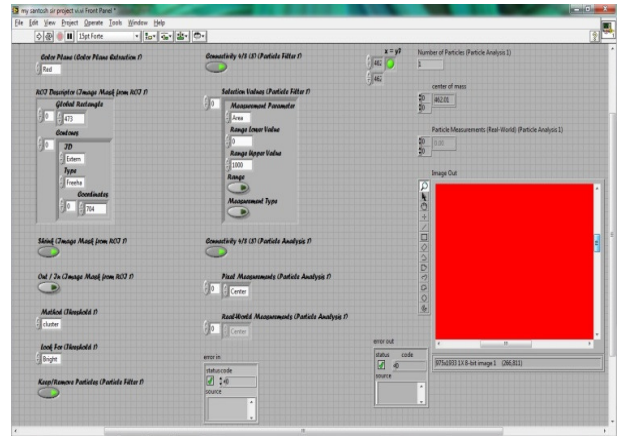

Fig 6. Block diagram vi

Fig 7. Front panel of clean bottle

Block diagram vi consist of program used for the proposed technique. We have an image acquisition control which acquires the image from the smart camera. The acquired image is stored in an IMAQ read file in RGB (32-bit) format. There is a colour plane extraction control which extracts out the red plane (in our case red, maybe blue or green). Now, the ROI controls are used to choose our region of interest and the range of pixels outside our region of interest are masked off. Now, the image mask from ROI is sent for thresholding process where we do cluster thresholding and select the bright objects. Now after thresholding, we send it to the particle filter from where the defective portions of image, if there is any is sent to particle analysis process. In particle analysis, the number of particles in the image and also the centre of mass of our processed image is found out and displayed in indicator. Now, the acquired centre of mass value of the present sample is compared with the original good sample's centre of mass value and if they are found equal, then present sample is good and light glows. On the contrary, if they are unequal, then present sample is defective and light does not glow and signal is sent to divert that bottle from the production line.
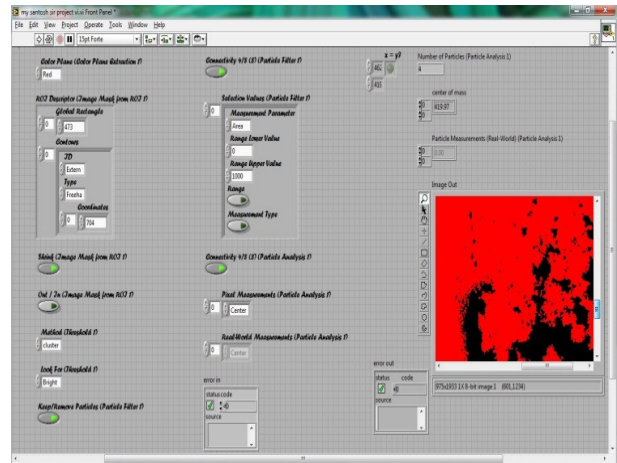
VI.   Results and conclusion

The proposed system was tested with different test cases and keeping the time constraint of production line into consideration. The system produced satisfactory results. The proposed technique was able to detect the impure bottle and initiate action within the specified time interval. For testing the clean bottles, little dirty and very dirty bottles were allowed to pass through conveyer, the system was able to divert the little and very dirty bottles living the clean ones Fig 7 and Fig 8
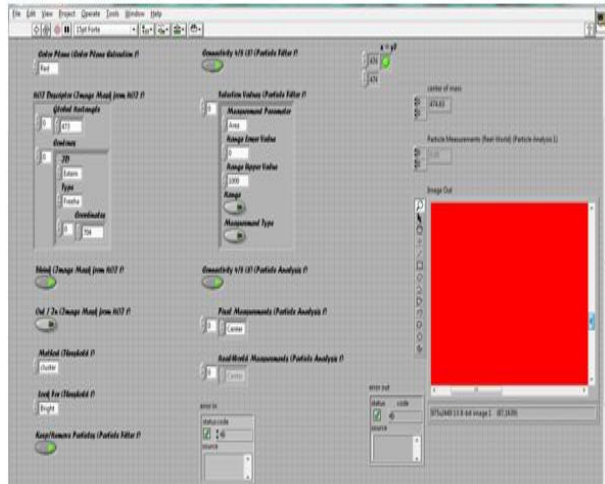

Fig 8. Front panel of dirty bottle

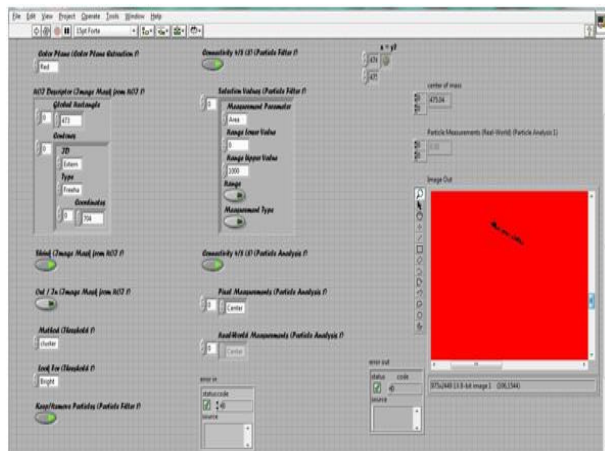Fig 9. Front panel of completely filled bottle

Fig 10. Front panel of incompletely filled bottle

From the above figures it is clear that the proposed system can be able to detect the impure and bottle with inappropriate quantity, all without affecting the production line speed. From Fig 7 and Fig 8 it is evident that the indication is on when the bottle is clean and off when the bottle is dirty and also we can clearly see the change in particle value. Similarly the proposed system could also detect the soft drink quantity in bottle, from Fig 9 and Fig 10 it is evident that the indicator is on when the bottle is filled completely and off when its not. One could also notice the difference in centre of mass between the desired and undesired bottle. Since, the time required for processing is very less the proposed technique can be used in the production line without affecting the production line speed in a beverage industry.

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