Parameter Based Presence and Absence Detection for Automated Visual Inspection Applications

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Abstract: ***Inspection is an important operation for manufacturing industry to ensure the quality and completeness of product getting manufactured. To improve and speed up visual inspection operation automated visual inspection systems are used. Presence absence detection is a visual inspection method to check and ensure that certain feature or component is present in the product getting manufactured. Automated Visual Inspection is widely used in mass production industry and Presence Absence detection method can be used for presence absence detection. The discussed algorithm is a parameter based algorithm and can be successfully used to detect presence or absence of particular component on the product.***

Keywords: Presence-Absence, Visual Inspection, Average, Root mean square, Decision Making

1. Introduction

Inspection of product is an important quality control measure used by most of industries. In Visual inspection checking is based on visual information acquired from image. Visual inspection is useful to check visible features and components of product. To perform the task of visual inspection Automated Visual Inspection(AVI) systems are used [1]. These systems are designed to detect defects and faults in the manufacturing process of the process. The inspection task and technique varies according to the type of the product.

Presence Absence detection is an important inspection task which is done in most of packaged goods industry and also in applications where assembling is done. In Presence Absence detection a product getting packed is checked for presence of particular feature or particular component on it. This task detects whether that component is present or missing from the product, its package. The presence absence detection checks for the completeness of the of the product and therefore it is also called as completeness checking.

The Presence Absence detection does not form a complete visual inspection system but it can be used as the one of the visual inspection function which can be used in the visual inspection system.

2. Background and Related Work

Defect detection has been area of interest of many researchers and many different defect detection methods and algorithms have been discussed in the literature. Presence absence detection is a defect detection method which can be used for various applications. In this section defect detection methods which are similar and related to Presence-Absence detection are discussed.

Leila Yazdi *et al* [1] discussed a method for inspection of bottle cap and liquid fill level in bottle. In this system presence-absence of bottle cap and proper closure of bottle cap, liquid fill level was inspected . A feature extraction method is developed by detecting horizontal lines, by using them region of interest is determined and average lines are calculated . The inspection is done by comparing average line values to prototype.

N. M. Duong *et al* [2] discussed a low cost automated visual inspection system for pharmaceutical products. In this system LabVIEW software and NI camera was used for machine vision and performed different operations. Fill Level, Cap inspection was performed by checking the level of liquid, level and angle of cap.

Giuseppe Di Leo *et al* [3] discussed visual inspection system for defect detection in assembly of electromechanical parts. The system was developed using LabVIEW software, industrial PC and two cameras were used. Processing was done by defining regions of interest(ROI). Also detection of tin plated metal was done for inspection.

Feng Xie *et al* [4] discussed a PCB inspection system based on genetic algorithm. System was designed to detect component placement defect on PCB, that is presence-absence of component on assembled PCB. Image alignment and image subtraction was used to detect defect further supervised learning is used for genetic algorithm.

Iyshwerya K et al [5] discussed a high speed inspection method for Mild steel welding chip. The system was used to detect rust and dent defects. In this system LabVIEW tool was used for image processing and threshold operation, edge detection was used for defect detection.

Chandra Sekhar Nandi et al[6] discussed a mango fruit sorting method. In this system RGB average values over mango region were calculated by using threshold mask of mango. Then Gaussian mixture model was used to estimate parameters of individual classes.

Jun Sun and Qiao Sun[7] discussed a support vector based automated visual inspection for manufacturing industry. In this system C-SVM was used. The system was developed using three basic modules region localization, feature extraction and defect detection. For uncertain sample manual inspection was done and system was trained for that and therefore system becomes adaptable.

3. Methodology Used

3.1. Image Acquisition

It is the first step in the method. Image is acquired through digital camera. The object for which presence-absence detection is to be performed are generally moving on conveyer belt. Therefore to avoid motion blurring aperture of camera should be maximum and exposure time must be minimum. The camera should be properly triggered so that horizontal movement of object in each image is minimum.

3.2. Region of Interest Extraction

Region of the Interest(ROI) is the fixed area in the image over which parameters will be calculated. The ROI must be selected such that it must cover the feature or component on the object of which presence absence is to be detected. Also the ROI must be selected such that it can handle movement of object in the image. The ROI should be such that it captures presence and absence of feature or component on object. ROI must be such that it captures maximum change in intensity when that component is Present and when that component is absent.

3.3. Parameter Extraction/Feature Extraction

After extracting ROI from captured it is transformed from RGB color space to HSV color space and then ROI image in HSV is separated into H-plane, S-plane, V-plane. Each plane captures specific property of image. The H-plane captures color information, S-plane has color purity, color saturation information and V-plane has brightness information. Therefore average and root mean square values are useful to detect presence-absence of feature or component in that ROI. From each of these planes average values and root mean square values are calculated as follows,

$$H_{Avg} = \frac{1}{M\,N}\sum_{r=1}^{M}\sum_{c=1}^{N} H[r][c] \quad [1]$$

$$H_{rms} = \sqrt{\left[\frac{1}{M\,N}\sum_{r=1}^{M}\sum_{c=1}^{N}\left(H[r][c] - H_{Avg}\right)^2\right]} \quad [2]$$

Where H_{Avg} and H_{rms} are average and root mean square values in H plane , $H[r][c]$ is the intensity at r^{th} row and c^{th} column of H plane of size M X N that is the size of ROI is M X N.

Similarly the average and root mean square values in S plane and V plane can be calculated. The RMS value is variance of pixel values and is discussed in [8] reference. It is used for contrast measurement and it shows variation in the pixel values from average value.

3.4. Parameter Selection and Decision Making

Total there are six parameters calculated three average values and three root mean square values. Out of these six parameters few parameters will show large variation and other parameters will not show significant variation in value when component or feature on object whose presence-absence we want to inspect is present and when that component is absent. Out of these parameters, the parameter which shows maximum variation, margin in its value when component is present and when absent on object must be selected for decision making.

The parameter can be used for decision making if the parameter values range in present condition do not overlap with parameter values in absent condition. Therefore training samples are required to select parameter for decision making. For these training samples all the parameters are calculated. Then minimum and maximum value of parameter when component whose presence-absence to be inspected is present and when that component is absent are used. If parameter range for present and absent condition overlap then that parameter is neglected. Let P be one of six parameter calculated then overlap in that parameter's range for present and absent condition can be found as

$$\begin{aligned} P_{Overlap} &= 1 \; if \; \{(P_{Prmin} < P_{Abmin} \; P_{Prmax}) \; or \; (P_{Abmin} < P_{Prmin} < P_{Abmax})\} \\ &= 0 \; if \{(P_{Prmax} < P_{Abmin}) \; or \; (P_{Abmax} < P_{Prmin})\} \quad [3] \end{aligned}$$

Where $P_{Overlap}$ indicates overlap for P^{th} parameter out of six parameters, $P_{Overlap} = 1$ indicates overlap present, then neglect that parameter and $P_{Overlap} = 0$ idicates no overlap, that parameter can be considered for selection. Also P_{Prmin} and P_{Prmax} is minimum and maximum value of parameter when component or feature is present on object. P_{Abmin} and P_{Abmax} is minimum and maximum value of parameter when component or feature is absent on object. These values are calculated for set of training samples. The parameter satisfying overlap condition are candidates parameters for selection. Out of these parameters satisfying overlap condition final parameter for decision making is selected based on margin provided by it. The parameter which provides maximum margin is selected for decision making. The margin of parameter is calculated as follows,

$$\begin{aligned} P_{margin} &= (P_{Abmin} - P_{Prmax}) \; if \; P_{Prmax} < P_{Abmin} \\ &= (P_{Prmin} - P_{Abmax}) \; if \; P_{Abmax} < P_{Prmin} \quad [4] \end{aligned}$$

After selecting appropriate parameter a threshold value is required for decision making. A threshold value for decision making is calculated by using worst case scenario parameter value that is by using maximum or minimum value of parameter in present condition and maximum or minimum value parameter of parameter in absent condition. The threshold for selected parameter is calculated as

$$\begin{aligned} P_{th} &= \frac{P_{Prmax} + P_{Abmin}}{2} \; if \; P_{Prmax} < P_{Abmin} \\ &= \frac{P_{Abmax} + P_{Prmin}}{2} \; if \; P_{Abmax} < P_{Prmin} \quad [5] \end{aligned}$$

Where P_{th} is threshold for selected parameter

After selecting parameter P from six calculated parameters, threshold P_{th} for that parameter, decision making about presence-absence of that feature or component in ROI can be done by using $if \ldots . else$ statement. The figure 1 shows the flow diagram of the above discussed presence absence detection method.

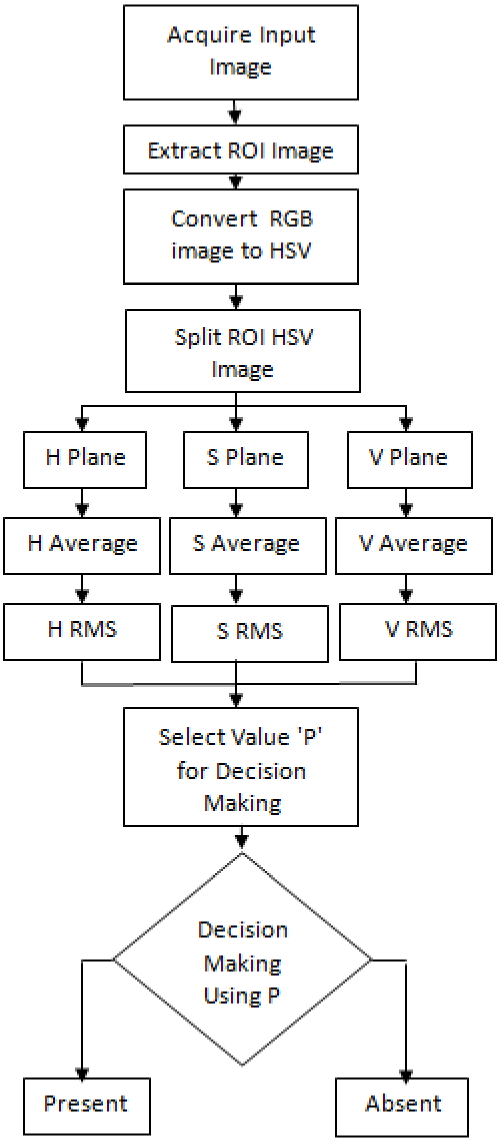


Figure 1: Presence-Absence Detection Flow Diagram

4. Result and Experimentation

The discussed methodology has been tested on various applications, experimentation was done. The results of experimentation are discussed in this section. The discussed method was developed using C++ and tested on Intel Core i7 2.2 GHz Processor running Linux ubuntu operating system using stored images. The figure 2 shows inhaler spray image taken during its packaging process. All the inhaler spray must have cap on their mouthpiece and presence-absence of cap is inspected during its packaging process. To inspect inhaler spray cap presence-absence, the region of interest around area where cap fits on mouthpiece is selected. The figure 3 shows region of interest images. For this region of interest all six parameters are calculated.

Figure 2: Captured image of Inhaler Spray Cap

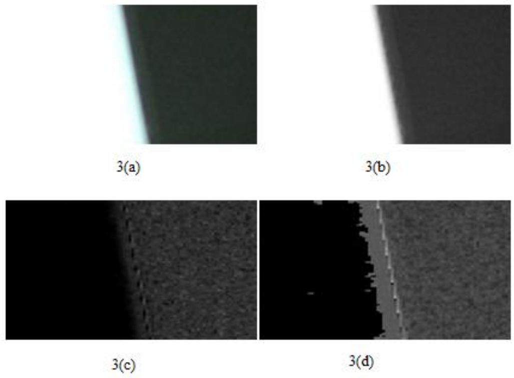


Figure 3: ROI of Inhaler Spray Cap (a) Captured ROI, (b)ROI V image, (c) ROI S image, (d) ROI H image

The figure 4 and figure 5 shows graph of average and RMS parameters. First four samples were taken for inhaler spray cap present condition and next four samples were taken for absent condition. From this graph we can see that V_{Avg} and V_{rms} shows non overlapping, linearly separated values for inhaler spray cap present and inhaler spray cap absent condition. But V_{Avg} shows more margin than V_{rms} and therefore V_{Avg} is selected as parameter for thresholding. V_{Avgth} is calculated by using equation 5 and is used for decision making.

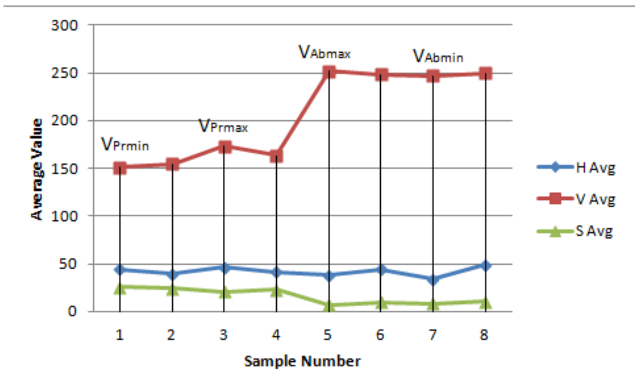


Figure 4: Graph of Average value vs Sample for Inhaler spray

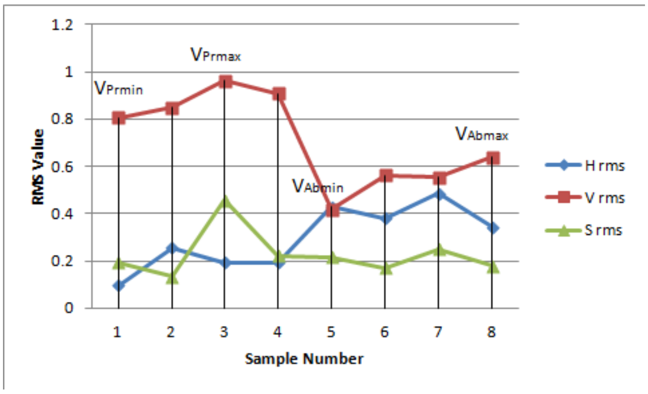


Figure 5: Graph of RMS value vs Sample for Inhaler spray

The figure 6 shows result obtained after decision making, the presence of inhaler cap was correctly detected.

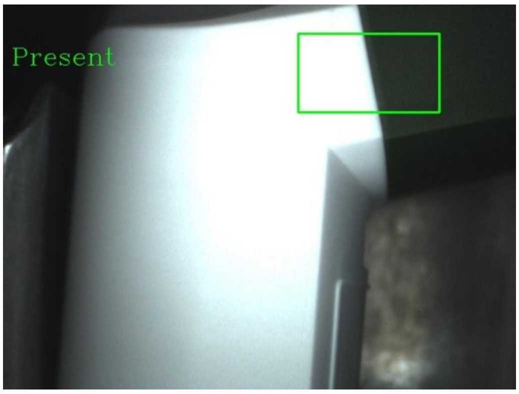
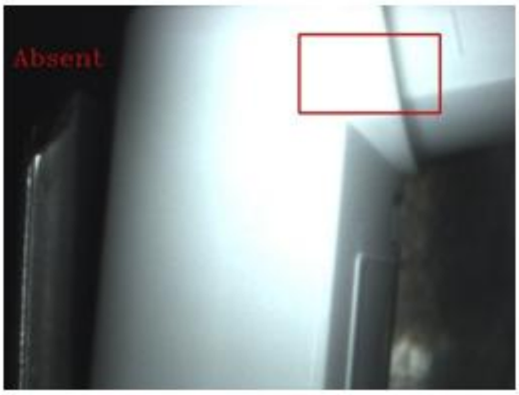


Figure 6: Inhaler Spray cap Presence-Absence Result

7 (a)



7(b)

Figure 7: (a)Captured image of Inhaler Spray with missing cap (b) Inhaler Spray cap Presence-Absence Result

The present condition is denoted by showing ROI in green color and text 'Present' in green color. The absent condition is denoted by showing ROI in red color and text 'Absent' in red color. The figure 7 shows inhaler spray with missing cap and output result.

In bottling industry presence-absence inspection is done for bottle cap and bottle label. For bottling application experimentation on presence-absence detection of bottle cap was done. The bottle cap inspection is challenging using this method as the partially fixed caps must also be rejected. Therefore missing cap, partially fixed cap or improperly fixed cap on bottle represents defective, bad sample that is absent condition and only perfectly fixed sample represents good sample that is present condition. Due to this margin between present condition and absent condition reduces and probability of error increases. The figure7-11 shows result of presence-absence detection of bottle cap for different conditions.

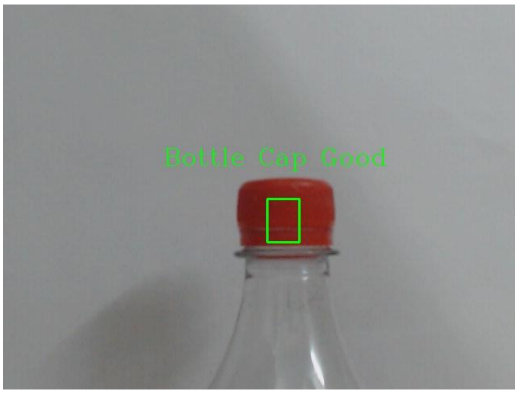


Figure 8: Presence Absence Result of Bottle with Good Cap

Figure 9: Presence Absence Result of Bottle with Bad Cap

Figure 10: Presence Absence Result of Bottle with Bad Cap

Figure 11: Presence Absence Result of Bottle with missing cap

For above discussed applications experimentation was performed and the discussed method detects the presence-absence of the feature-component in region of interest with 100% accuracy.

5. Discussion

The discussed method has been tested to detect the presence-absence of single component on object using single ROI, but it can be extended for presence-absence detection of multiple components on an object using multiple ROI. Additional parameters which captures information other than the average, root mean square can be easily added in the discussed method. The limitation of method is that selected ROI is static and remains same for particular application. Therefore if objects are moving then image capturing, camera triggering and movement of object must be synchronized so that position of object in all captured images remains approximately same. Selection of ROI should done properly to tolerate horizontal shift, vertical shift in position of object inside captured image. If object shifts vertically or horizontally in captures image then ROI may capture other area than intended and it lead to error in the result. During experimentation it was found that the discussed method can tolerate the small shift of object in the captured image.

6. Conclusion

In this paper a method for presence and absence detection of component or feature on object is discussed, also parameter computation and parameter selection for decision making is discussed. The discussed method for presence-absence detection correctly detects presence and absence of feature or component in the region of interest. The method has been tested on three different applications and shows accurate results. The discussed method is simple, fast, efficient and can be used for visual inspection applications. New extra parameters along with these six parameters can be easily added. Even though discussed method uses static ROI it can tolerate little shifts in position of object in captured image.

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