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QUALITY ASSESSMENT OF BISCUITS USING COMPUTER VISION

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Abstract

As the developments and customer expectations in the high quality foods are increasing day by day, it becomes very essential for the food industries to maintain the quality of the product. Therefore it is necessary to have the quality inspection system for the product before packaging. Automation in the industry gives better inspection speed as compared to the human vision. The automation based on the computer vision is cost effective, flexible and provides one of the best alternatives for more accurate, fast inspection system. Image processing and image analysis are the vital part of the computer vision system. In this paper, we discuss real time quality inspection of the biscuits of premium class using computer vision. It contains the designing of the system, implementing, verifying it and installation of the complete system at the biscuit industry. Overall system contains Image acquisition, Preprocessing, Important feature extraction using segmentation, Color variations and Interpretation and the system hardware.

Keywords:

Image Analysis, Image Acquisition, Preprocessing, Feature Extraction Using Segmentation

1. INTRODUCTION

As the biscuits which belong to the premium class, maintaining the quality of it becomes very important. Consumers always expect the good quality biscuits. Therefore the quality inspection of cookies occupies the vital role as far as biscuits industries are concerned [1]-[2]. In most of the biscuits industries quality inspection is still carried out by human. The food products like biscuits, which are manufactured millions per day, real time fast inspection becomes essential. Human decision in quality inspection is highly variable, costly and time consuming. Bringing the automation in the inspection provides the perfect solution for the fast, more accurate system. The computer vision is a technique which eliminates these issues, provides high speed and constant results which becomes an interesting solution. The computer vision uses the theoretical image processing algorithms for making the independent and non-instructive system [2]. The basic components of the computer vision systems are lighting system for providing the constant light, the camera for capturing the images, the computer software and hardware [3].

It is a computer vision based system for real time quality assessment of high class cookies. Tools, software and platform to be used are scientific python, Open CV, Linux, and IBM PC (Industrial Business Machine). Work stages are requirement study, planning, design, iterative implementation with design refinement, testing. These are the various parameters which are taken in to understanding while deciding the quality.

- The circularity of the biscuit for deciding the broken biscuits.
- The number of almonds present on the biscuits.
- The color variations from center to edge.
- Inspection speed.

Therefore the overall objective of the system is to design, implement, and verify the computer vision system for quality assessment. Finally there is installation of the system at biscuit industry.

2. SYSTEM BLOCK DIAGRAM

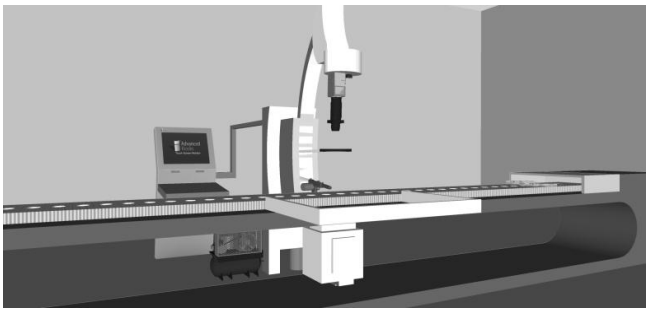


Fig.1. Quality assessment of Biscuits using computer vision

The Fig.1 shows the system block diagram which contains cookies on the conveyer belt, light illumination system, sensor for determining the presence of the biscuit, high resolution industry application camera, camera holding structure, computer hardware structure and pressure compressor for rejecting the defected biscuits.

At biscuit industry, the system will be placed before packaging process for checking the quality. After the process of manufacturing the biscuits, they will come on the conveyer belt [4]. The sensor senses the presence or absence of the biscuit exactly below the camera and triggers camera to capture the image of the biscuit. The captured image by the camera is processed in the system. The system software works and decides quality of the biscuit. If the biscuit is defected, it will be thrown out of the conveyer belt by applying pressure using the pressure compressor. The whole control of the system is handled by IBM PC which is nothing but the industrial computer machine used in vision system.

3. METHODOLOGY

3.1 SYSTEM SOFTWARE

The software tools contain scientific python and OpenCV with Linux operating system. Python is a higher level language and is used for many real time industrial applications [5] [6]. Python is an open source language and it allows syntax highlighting and

ease of use. There are various steps in the system software. They are as following.

3.1.1 Image Acquisition:

It is nothing but capturing the image and converting that image in to digital image using the scanners or cameras. DMK23U445 camera is one of the best solutions for many industrial applications. The captured image is processed in the preprocessing steps.

Supply voltage: 4.5 to 5.5VDC

Current consumption: approx. 500mA at 5VDC

Max. Temperature: -20ºc to 60ºc

Fig.2. DMK23U445 camera

3.1.2 Conversion of Image in various color spaces:

The OpenCV reads the image in BGR format, so it is necessary to convert image in RGB format [5]-[6]. Also for performing the segmentation, the RGB image is further converted into the HSV format as HSV color space is same as the way human perceives. From HSV image, the (V) Value part is eliminated because it is varying more due to light variations as the results are shown in Fig.3 and Fig.4.

RGB to HSV conversion formula:

$$\begin{aligned} R' &= R/255 \\ G' &= G/255 \\ B' &= B/255 \\ C_{\max} &= \max\left(R', G', B'\right) \\ C_{\min} &= \min\left(R', G', B'\right) \\ \Delta &= C_{\max} - C_{\min} \end{aligned} \tag{1}$$

Hue, Saturation and Value calculations:

$$H = \begin{cases} 60^{o} \times \left(\dfrac{G' - B'}{\Delta} Mod 6 \right) \\ 60^{o} \times \left(\dfrac{B' - R'}{\Delta} + 2 \right) \\ 60^{o} \times \left(\dfrac{R' - G'}{\Delta} + 6 \right) \end{cases}$$

$$S = \frac{\Delta}{C_{Max}}, V = C_{Max} \tag{2}$$

3.1.3 Segmentation:

Segmentation is nothing but getting the minor details from the image and differentiating the image from the background. Segmentation is basically done for acquiring the meaningful features from the image and at the same time eliminating the unnecessary parts of the image so that the segmented image will give better representation of the image as compared to the previous image [7]. Image processing has various methods for image segmentation. In this paper, the thresholding based segmentation is done. The threshold values are set checking the images planes values at different conditions. Using these threshold values, the image is converted into the binary image. The binary image contains some noise inside it. The biscuit contour is found and it is filled with high value and the area outside it is filled with the lower value. This is called as 'Biscuit Mask'. Biscuit mask is multiplied with the RGB image to get the Segmented Biscuit as shown in Fig.4. After segmentation is done as a preprocessing step, the biscuit image is ready to study the details on it. The parameters discussed earlier are studied and detected using the image processing methods. The following Fig.5 is showing the segmented biscuits results.

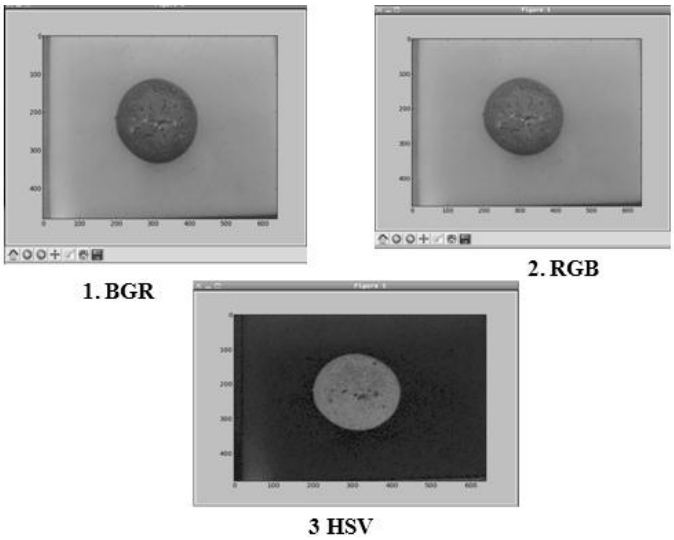


Fig.3. Image Conversion in HSV

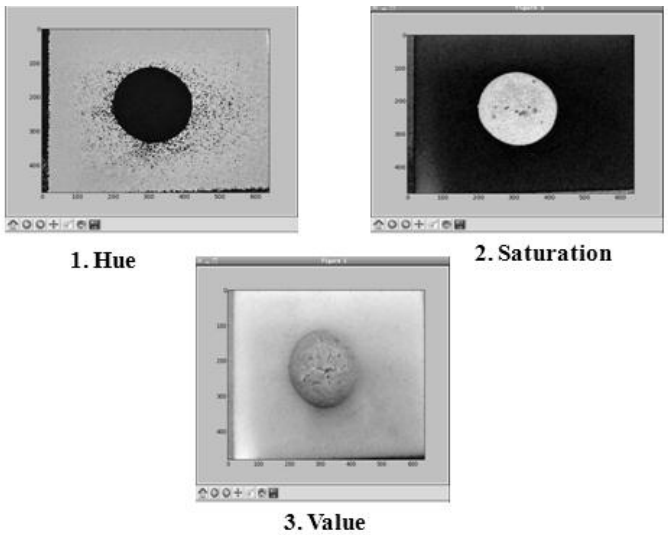


Fig.4. Hue, Saturation and Values planes

3.1.4 Ellipse fitting around biscuit:

Fitting an ellipse around the region of interest can help in finding out absolute circularity of the Biscuit. The region of interest here is biscuit area, so after fitting an ellipse, its measure

and minor axis are measured. The difference between both the axis is calculated and accordingly the broken biscuits are checked.

Threshold value = 15 pixels.

As shown in Fig.6 major axis is 246 pixels and minor axis is 195 pixels. As the difference between both the axis is more than the threshold value, the biscuit is detected as broken.

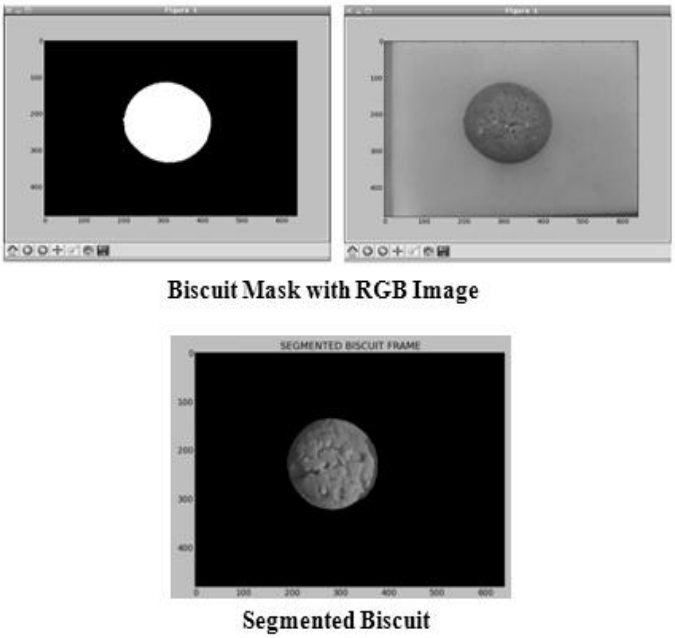
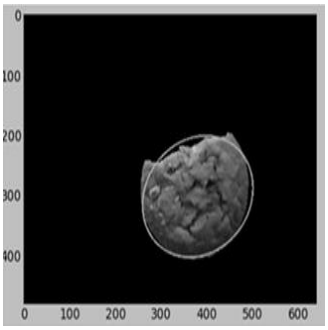


Fig.5. Segmentation



Time	0.145
Area	36848
Major Axis	195
Minor Axis	246

Fig.6. Broken Biscuit with observed values

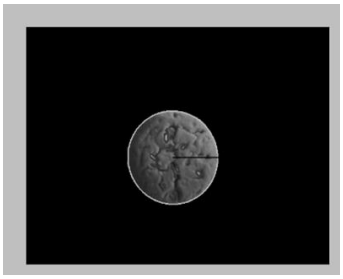
3.1.5 Almond Detection:

In almond detection the number of almonds present on the biscuit is needed to be detected. In this, the threshold values for the almonds are decided. Binarization is done using the threshold values. The contour of the almond is found and the almond area is filled with 1s and area outside is filled with 0s. This is called as almond mask. This mask is convolved with the original RGB image. The final result will show the number of almonds present on the cookie as shown below.

The contour around the almond is formed only when the individual almond area is more than 50 pixels. Then only it is considered as almond. After forming contours around all the almonds, the numbers of almonds are measured. The almond area of all the almonds is measured.

Threshold for almond area = 250 pixels

If the biscuit is having almond area less than the threshold value, it is classified as 'less almonds'. If the biscuit is having almond area more than the threshold value, it is classified as the 'good biscuit'. And if the biscuit is having not a single almond on it, it is classified as 'no almonds'. No almond biscuit is detected as a defected biscuit.



Time	0.240
Area	27981
Major Axis	187
Minor Axis	190
No of almonds	9
Almond Area	536.5

Fig.7. Almond Detection with observed values

3.1.6 Color Variations from Center to Edge:

The color characteristics of image occupies the more importance in image processing [8]-[9]. Color variations of the biscuits are necessary for detection of the overcooked and undercooked biscuits. In the manufacturing process, sometimes the biscuits got extra or less heated so that it affects the taste of the biscuits. Hence color variations are needed to be studied from center of the biscuit to the edge of the biscuit. RGB color variations are more responsible for under heat or over heat biscuits and from RGB, Red color affects more on the process. The allowed change for these colors is as follows. As one can see from values that the Red color variations are more.

$$R = 145\text{-}220$$

$$G = 45\text{-}92$$

$$B = 225\text{-}230$$

The variations of Red color are measured from center to edge of biscuit. The above values of Red color are considered as the threshold values. If the pixel values are more or within this range, they are filled with 1s. If the pixel values are less than this range, they are filled with 0s. The area for 1s and 0s is measured. If the more area is filled with 0s, that means the biscuit is overcooked. Accordingly, the threshold values are set to decide overcooked and undercooked biscuits. The graphical representation is as shown in Fig.8.

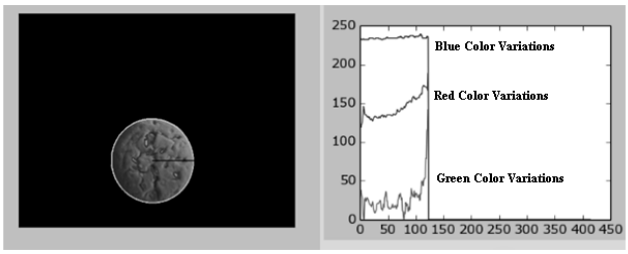


Fig.8. Color Variation Graph

3.1.7 Graphical User Interface (GUI):

After the detection of all the important parameters of the biscuits which affects the quality of the biscuit, it is necessary to develop the interface of the system with the operator. Therefore

the GUI design is done. It shows the captured frame with the respective measurements.

3.2 SYSTEM HARDWARE

Hardware of the system contains the IBM PC which handles the whole control of the system and it is the heart of the system. It contains the power supplies, Relays for power switching, SMPS, CPU, LCD display same as that of computer, Cooling system etc. The system software is tested using IBM PC, as shown below:

Fig.9. System Hardware

3.2.1 Feature Addition from the Industry:

After the successful tests under different lighting conditions, the system tested at the biscuits industry where some measure observations noted.

- Software worked with the speed of the conveyer (300 BPM(Biscuits Per Minute))
- Non uniform light was falling on the biscuit from the lights on the factory.

Also the industry expected to add some features in the system they are as follows:

- User friendly interface for the operator.
- To make system more robust.
- To provide constant lighting effect.
- To make single integrated enclosure.

3.2.2 Modified Mechanical Design:

As far the company expectations, the mechanical design of the system is done, which the single integrated design is providing the closed camera structure for uniform light, also the high visible LED light ring is inside the closed camera structure and the overall robust structure is made.

At front side the LCD screen is kept so that the operator can see the results at front side. The remaining structure of the IBM PC is kept at the backside, which is also a closed structure. The space for the industrial conveyer belt is kept. After finishing with software part, the system is tested by interfacing with the mechanical hardware and the conveyor belt. The designed system is as shown in the Fig.10 and Fig.11 shows the closed Camera structure and lighting system.

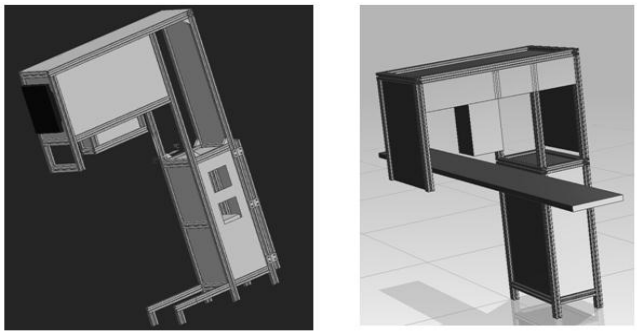
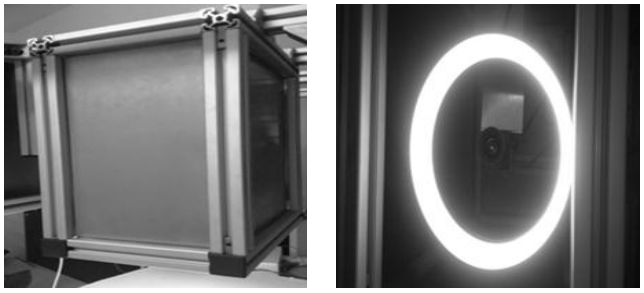


Fig.10. Modified Mechanical Design



Closed Camera Structure LED Ring

Fig.11. Camera Structure

4. RESULT ANALYSIS

The final results of the system contain the real time checking of the biscuits. The GUI is further modified for making the system more users friendly, so that the operator can easily analyze the process of quality inspection. The results are verified and checked at different time by taking various samples. Successful testing of the system is done at the industry. The system is ready for the installation at the biscuit industry with the single integrated enclosure.

If all the parameters of the biscuits are in the range then the biscuit is classified as Good biscuit, if the parameters are exceeding the threshold values then it is classified as Defected biscuit. Fig.12(a) shows Good biscuit result. And the following Fig.12(b) shows Defected biscuit.

The performance measures:

Inspection speed: 5 biscuits per second and 300 BPM

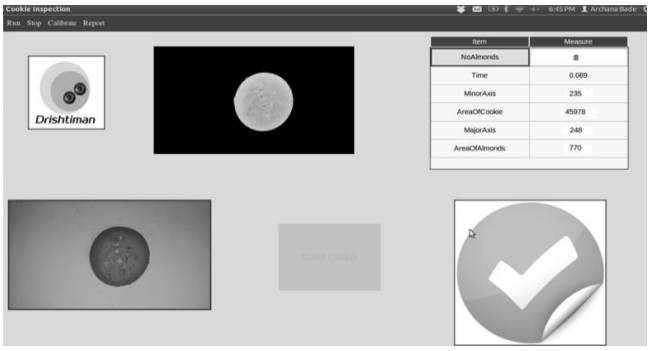


Fig.12(a). Good Cookie

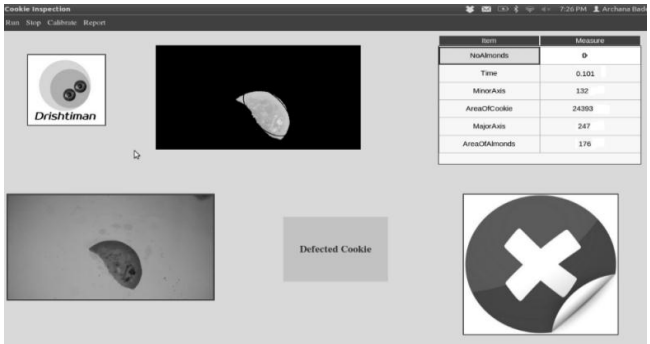


Fig.12(b). Defected Cookie

5. CONCLUSION

In this paper, we explained the real time system for the quality assessment of the biscuits of the premium class using the computer vision. The application is implemented in Python using OpenCV library in Linux environment. The system software as well as the mechanical hardware of the system is explained. The software is successfully running with the speed 5 biscuits per second and 300 biscuits minutes on the industrial conveyer belt. The whole system structure is made as a single integrated structure. Also the user friendly graphical user interface is designed. The results are checked and verified using different situations and using different samples.

The computer vision technology provides alternatives for the system to become independent and providing the more processing speed. Increased inspection speed of the system is the most appropriate advantage as compared to the human. Also the computer vision systems provide consistency in the inspection by avoiding the variability of the results.

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