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Foreign Material Detection for Beverage Industry

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Abstract: Product quality inspection is required in industries for standardized products, which leads to the establishment of a quality inspection system. Nowadays, despite doing our best efforts on every beverage processor, sometimes foreign material might accidentally end up in the finished products. The problem is related to a manual inspection that can cause human error and product quality. Therefore, the main objective of this study is to design a detection system that can detect foreign materials on the beverages bottle. The proposed method used in this study consists of i) pre-processing, ii) image segmentation, iii) feature extraction, and iv) classification. Image processing algorithms in MATLAB may be used to identify foreign objects and contaminants in beverage bottles. The photograph must first go through the pre-processing stage. As a result, the segmentation procedure focuses on separating foreign materials from the contaminated region of the bottle. The Otsu method and the k means clustering method was used in this procedure. GLCM, histogram analysis, and quadratic distance were used to classify the product for feature extraction and classification. Both experimental and simulation findings are found to be identical for both parameters.

Keywords: GLCM, Otsu, K-means, Foreign Material Detection

1. Introduction

Despite doing their best efforts on every beverage processor, sometimes foreign material might accidentally end up in the finished products. Nowadays, it is challenging to create a high-quality product that is both low-cost and quick to manufacture. Most factories, on the other hand, continue to use human labour, which is problematic due to human error. It can lead to a loss of accuracy in the reading of the results, which could be caused by fatigue or sickness. This method is inefficient, takes a long time, and is difficult to get the desired outcome. If the product is not thoroughly inspected, the individuals may be exposed to poisonous food. Hence, the use of technologies such as image processing to identify foreign elements in beverage products may be designed to create good systems.

In image processing and machine vision, image acquisition is the process of obtaining an image from a source, usually hardware devices such as cameras, sensors, and so on [1]. Because the system

cannot conduct any processing without a picture, it is the earliest and most important stage in the workflow sequence. The researcher in [2] used the camera to capture the image of the bottle through a computer network to inspect the colour concentration and water level of the bottle.

In the industrial area, foreign elements are extremely difficult to detect. To tackle this problem, foreign materials and identification are necessary, but the procedure requires a significant amount of effort, plant disease expertise, and additional processing time. The researcher in [3] stated that collecting leaf and fruit image databases, pre-processing photos, segmenting image 7 using the k-means clustering methodology, feature extraction using the GLCM method, and finally, system training using the SVM algorithm is all part of the proposed detection system. The image processing technology is increasingly being used in a variety of sectors. This is because this technology can recognize and recognize objects based on images. The image processing technique begins by operating on the picture, which is then analysed to get the desired result. The researcher in [4] proposed a project that is used to create a system that uses the image processing approach to examine plant images. Pre-processing, picture segmentation, feature extraction, and classification are the five stages of the proposed technique [4].

Image pre-processing is a technique for improving image data with noise while also enhancing some aspects of the image for future processing. Image resizing and shape, noise filtering, image conversion, image enhancement, and morphological procedures are some of the techniques used at this step [3]. Pre-processing is the first and most crucial step in normalizing the image's pixels. For additional analysis, it is necessary to correct and increase the image intensity, eliminate undesired distortion, and enhance image characteristics [2]. Colour concentration and water level are two quality checks that the system inspects via a computer network which is pre-processing, colour concentration with the histogram and quadratic distance, and level inspection with coordinate vertical and horizontal reference levels are all part of the study After the image has been pre-processed, Otsu's approach is used. For the computing process, this approach converts the picture to a binary format. Pixels and bi-modal histograms are the two kinds of threshold images examined using the Otsu technique [5].

Image segmentation is a technique for breaking down a digital image into segments and converting it into something that can be analysed more easily. The object and borderline of an image are located via image segmentation. The researcher in [3] introduced a modern technique that is using of digital image processing to diagnose plant disease quickly and accurately. In MATLAB software, they created the k-means clustering method with a multi SVM algorithm for illness diagnosis and classification. For digital image processing, the MATLAB program is excellent. K-means clustering with the SVM algorithm delivers great accuracy while consuming relatively little processing time [3].

Feature extraction is a step that involves collecting a huge amount of data to correctly characterize it. This is a crucial step in determining the contaminated area. The level Cooccurrence Matrix (GLCM) method is a way of obtaining statistical texture characteristics of second order. Third and higher-order textures analyse the connections among three or more pixels and have been employed in a variety of applications. These are theoretically conceivable, but due to computation time and interpretation difficulties, they are rarely used [7].

The HSV colour space is used to generate histograms, with each pixel contributing either its Hue or Intensity. The colour histogram is extracted as a two-part feature vector which is a quantized set of grey and a representation of the Hue between 0 and 2 quantized following a transformation [6]. The histogram maintains a consistent colour transition, allowing us to smooth the data using a window-based method during retrieval. The outcomes were compared to those obtained with the RGB colour space [6].

2. Materials and Methods

Image capture, pre-processing, segmentation, feature extraction, and classification are the five key methods used in this study to identify foreign material within the bottle. All these operations are performed on a bottle picture using the MATLAB Processing package. The suggested system is depicted in Figure 1 as a block diagram.
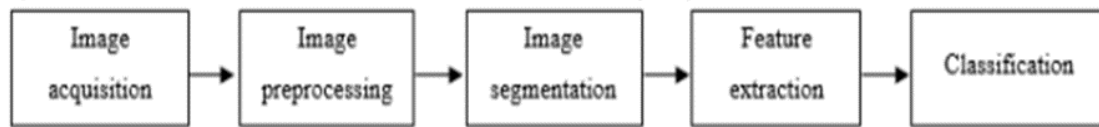
Figure 1: Block diagram for the proposed system

2.1 Software Development

To achieve the project's goals, a variety of methods and algorithms were employed to construct the system. Each approach and algorithm used in this project is interconnected and plays a critical part in achieving the desired outcomes. Because this project is entirely computer-based, image processing techniques in the MATLAB software are performed to analyze the bottle picture. The tools in MATLAB software, such as image processing tools, help to speed up the process of analyzing the bottle image.

2.2 Flowchart of Systems Development

The complete process of detecting foreign materials in the beverage industry is shown in Figure 2. To process images, each operation in the system employs a different algorithm, and the system is fully based on MATLAB software.

2.3 Image Acquisition

The process of obtaining a picture from a source is known as image acquisition. The picture of the bottle that has been captured in this project must be in RGB colour space, and the image must be gathered in one dataset file. The dataset of the bottle is taken in these systems using the smartphone camera, which is launched when the system is started, and it immediately detects the colour of the bottle in the good condition subject and captures the image of the subject, generating a reference image that is a good condition of a subject.

2.4 Image Pre-processing

The image is changed with improved image resizing at this step for better analysis in the subsequent procedure. Pre-processing entails converting picture pixels to match the needed information. The original image in this project has a pixel size of 4000x6000. So, the height and width of a picture are multiplied by a scaling factor when it is resized. If the scaling factor in the vertical and horizontal axes is not the same, rescaling changes the spatial extents of the pixels as well as the aspect ratio. Keeps the spatial extent of each pixel while isolating a sub region of the image from cropping. Cropping photos can be done from the centre or a variety of locations around the image.

2.5 Image Segmentation

This project's image segmentation is divided into 2 parts. The separation of bottle images from their backgrounds is the emphasis of the first step. This segmentation part can be created using the MATLAB Colour Threshold. This process is required to make the identification of foreign elements of the bottle image easier. The image will be converted from RGB to HSV colour image, which is known as a threshold image, throughout this process. The colour is filtered from the threshold image, and only the colour inside of the bottle is picked, with the other colours being deleted. The test image is then selected, and the subject's backdrop which is the white colour background is deleted.
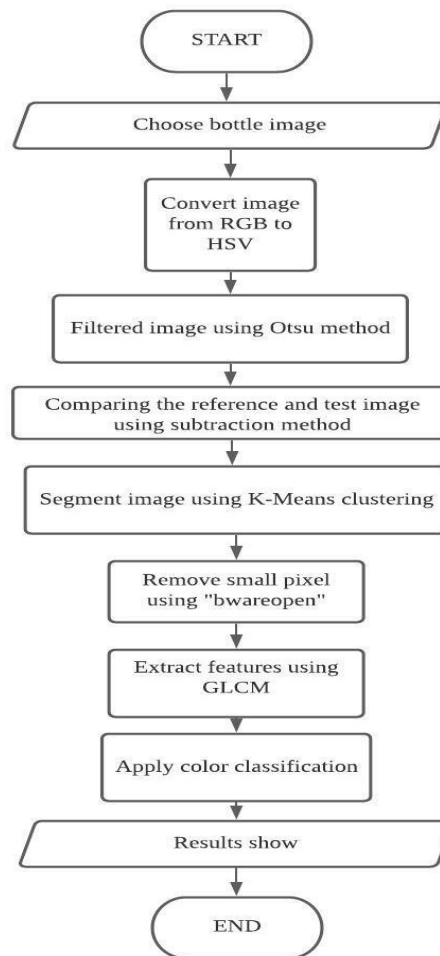
Figure 2: Flowchart of the project

The segmentation is made in the second process to separate the contaminating section from the bottle. The k-means clustering technique is used in this step to identify foreign material of bottle components using a set of clustered features. The image is transformed into five colour segments in this procedure to improve the image and allow the system to read the contaminated location which is the image will then be turned back to black and white. The black and white image is easier for the system to interpret in the following phase, the system picked it as an output result.

2.6 Feature Extraction

Using image processing techniques, the technique will determine whether the bottle is contaminated. To perform feature extraction, the image produced from the segmentation needs to apply the Gray level co-occurrence matrix and ResNet50. By applying GLCM to an image and evaluating the spatial connectivity of picture pixels, the texture of the image may be assessed. The bottle in a subset of the bottle dataset is divided into 2 groups, one of which is a reference image, and the others are testing images.

The ResNet50 design modifies the settings of the final layer as well as the whole linked layer. The ResNet design requires a 27 256x256 picture input size. The resnet50 function in Neural Network Toolbox may be used to load models like "ResNet-50." Individual layers can evolve independently of one another because of batch normalization, a network layer. It's used to make the previous layers' output look more natural.

2.7 Classification

The classification process is used in this project to determine whether the positioning of the bottle can be detected by the camera or not and the texture of the bottle image. Then, in this system, Convolution Neural Network (CNN) Image Classification and Gray level co-occurrence matrix (GLCM) is used to solve the classification process. In this CNN Image Classification, a group of datasets for train data is required to identify the desired data information to be classified while the image acquired from the segmentation technique must be exposed GLCM.

To get the image's distribution data, the image is turned into a red, green, and blue histogram for colour classification. To get a value between 0 and 1, the picture must be normalized. To display the image's dispersed data, the red, green, and blue histograms are separated into 10 bins and mixed to create one RGB histogram with 30 bins.

For Convolution Neural Network (CNN) classification, when the kernel is symmetrical, the convolution process becomes a correlation process because the convolution layers are made up of a series of coevolutionary kernels in which each neuron acts as a kernel. Because their algorithms evaluate nearby pixels, pooling is becoming increasingly significant to reduce function map and network parameter measurements. Pooling layers are invariant in encoding.

The Euclidian Distance method in Eq.1 is used to classify the bottle's colour concentration. To get distribution statistics for the three colour channels of red, green, and blue, the RGB picture is displayed in histogram form. Each hue is separated into ten bins: red, green, and blue. The RGB histogram, which has 30 bins for overall bins, will then be created by combining each colour.

$$Vthresh = \sqrt{[P1(i)-P2(i)]^2} \quad , i = 1,2,3,..,30 \quad Eq.1$$

3. Results and Discussion

The result and performance of each process were evaluated using their parameters, which included the feature extraction and classification procedure. By comparing the findings between the bottles, the efficacy and algorithms utilized may be examined because of this assessment. The training process for this process has been conducted by using 200 images for reference and a test image of the bottle. Figure 3 shows the RGB histograms for the reference and test images, respectively. The colours red, green, and blue are combined and separated into three parts. The first eight bins are represented as red component values in the reference and test picture, the green components are placed between bins 9 and 19, and the blue components are placed between bins 20 and 27. The rest of the bins are disregarded, resulting in a background colour image.
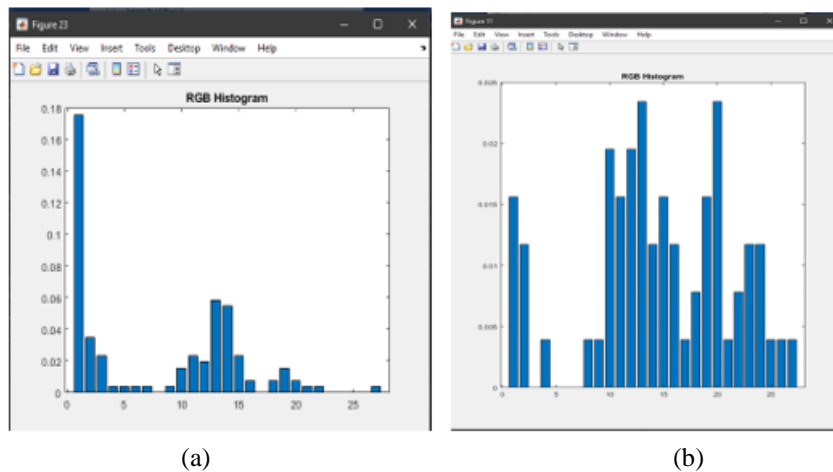

(a)   (b)

Figure 3: (a) RGB for the reference images. (b) RGB for the test image.

Bin 1-27 has the red component value, green component value, and blue component value. It is because the bin is from the backdrop colour picture, so the other three bins are ignored. The distance and difference of two-colour pictures, image colour pass which is reference image and image colour fail, are calculated using the value of bin 1-27. which is a test image.

Figure 4 shows the CNN classification process to acquire the percentage of accuracy and loss of positioning bottles. The total image for the train was 200 images (2 classes) for the test. During this process, they were 50 epochs and 800 iterations. The epoch determines how many times this algorithm iterates over the full training dataset while the iterations looped or cycled the same process, generally intending to achieve the target, by repeating the train data a pre-set number of times. By using this process, the loss changed from 4.70 to 0.68 while the accuracy changed from 21% to 78%. The loss became decreasing, and the accuracy became increasing due to the neural network detecting the iteration that has around 800 data. The research's data and analysis are presented in the findings and discussion section. This part can be arranged in any logical sequence, such as according to the stated objectives, the historical chronology, different case groupings, different experimental settings, or any other logical order considered acceptable.
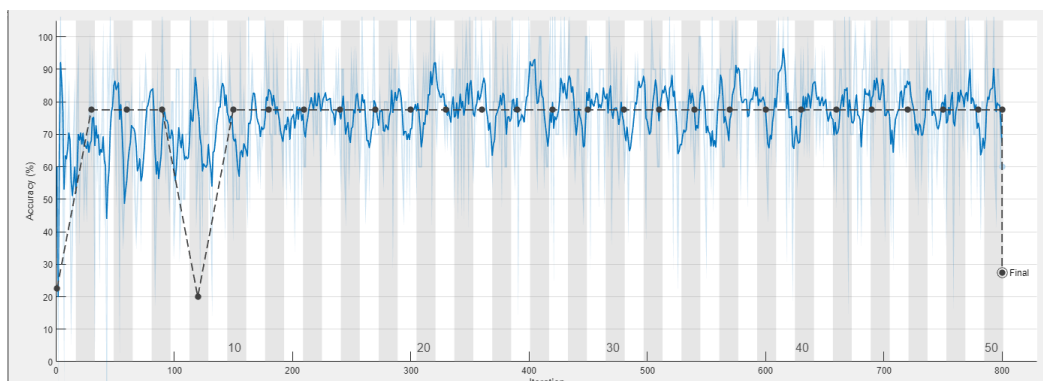
(a)
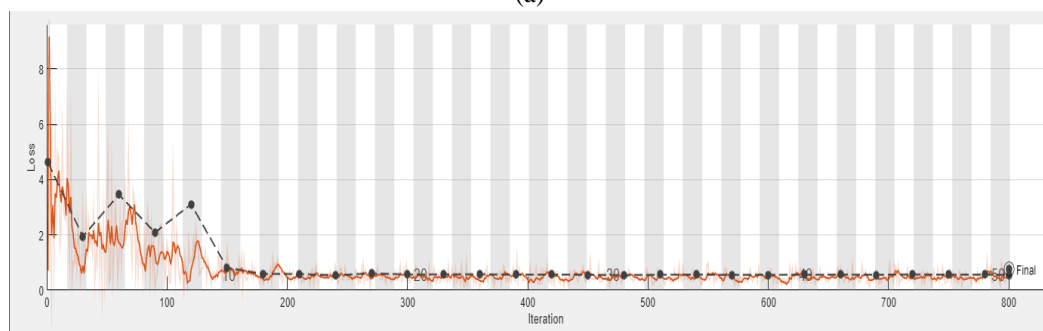
(b)

Figure 4: (a) Training and test accuracy (b) Training and test loss

The Graphical User Interface (GUI) is the last component of the system. The user interface was created to suit the requirements of the product quality inspection system. To show the research results, the data is put into the Graphic User Interface (GUI). The input image, pre-processing, segmentation, classification, and performance metrics are all controlled via buttons. By clicking the button, the user can see the outcome, which will display all the necessary information. Figure 5, Figure 6 and Figure 7 show the completed GUI before and after running the systems.
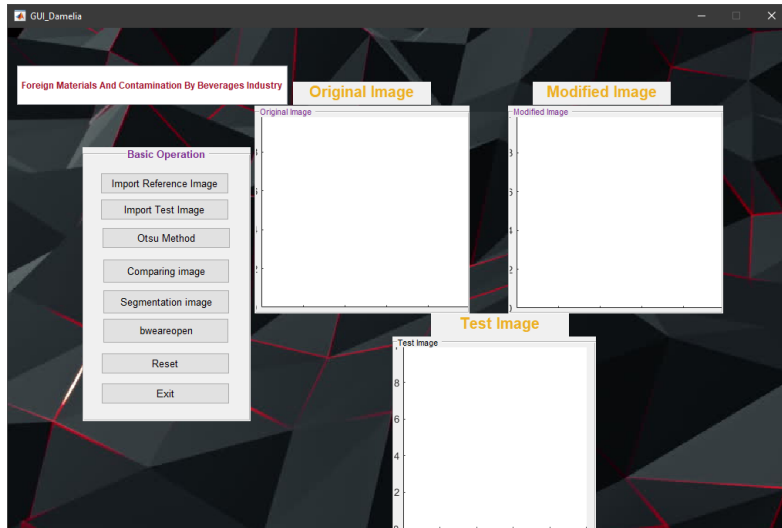
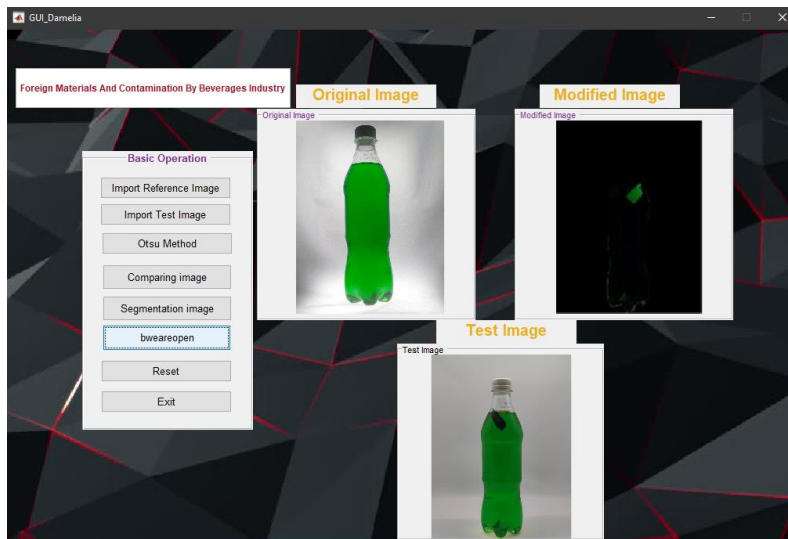**Figure 5: The completed GUI before running the systems.**

Figure 6: The completed GUI after running the systems.

The accuracy of the proposed technique has shown in Figure 7 which is the accuracy of the test image that has been using these systems. Based on this graph performance, there is a little performance between accuracy and error of the detections on the test image of the bottle which is the accuracy of the test image for purple, green, red, and orange are 98% while the error is only 2%.
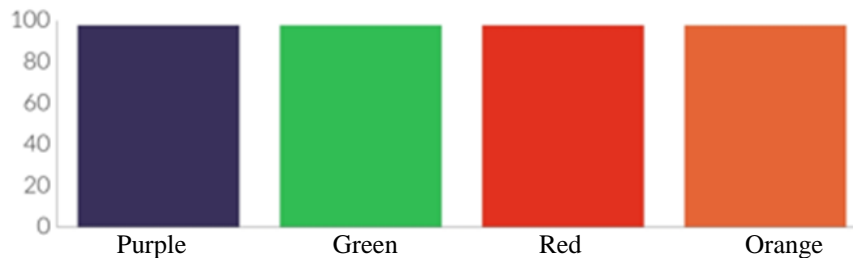

Figure 7: Graph on accuracy on a test image.

4. Conclusion

Pre-processing, segmentation, feature extraction, and classification processes are effective in building the foreign materials detection system for the beverages sector utilizing image processing tools in MATLAB R2016a software. The segmentation procedure was used to isolate elements of the foreign

materials from the picture to create a system that can identify them. The procedure of detecting the portion has been simplified by using segmentation from the image. To display the colour texture of the image, a GLCM cross-section and a GLCM contour plot were created using the GLCM process. To compute the distance between two colours, the RGB histogram is displayed from the GLCM contour. The colour of the picture was classified as pass or fail using a Euclidean distance classifier. Based on the results of the systems, it shows that the process to detect the part of the foreign materials on the bottle has been done successfully.

Acknowledgement

References

[1] G. Son, D. Kwak, M. Park, Y. Kim, and H. Jung, "U-Net-Based Foreign Object Detection Method Using Effective Image Acquisition System: A Case of Almond and Green Onion Flake Food Process," 2021.

[2] N. M. Saad, N. N. S. Abdul Rahman, A. R. Abdullah, and N. A. Rahim, "Real-time product quality inspection monitoring system using quadratic distance and level classifier," *J. Telecommun. Electron. Comput. Eng.*, vol. 9, no. 2–13, pp. 57–62, 2017.

[3] S. Raut and A. Fulsunge, "Plant Disease Detection in Image Processing," *Int. J. Innov. Res. Sci.*, vol. 6, no. 6, pp. 10373–10381, 2017, doi: 10.15680/IJIRSET.2017.0606034.

[4] M. Amirul, M. Yusof, and A. Nazari, "The Disease Detection for Maize-Plant using K-Means Clustering," Universiti Tun Hussein Onn Malaysia, vol. 2, no. 2, pp. 834–841, 2021.

[5] N. N. S. Abdul Rahman, N. M. Saad, A. R. Abdullah, M. R. M. Hassan, M. S. S. M. Basir, and N. S. M. Noor, "Automated real-time vision quality inspection monitoring system," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 11, no. 2, pp. 775–783, 2018, doi: 10.11591/ijeecs.v11.i2.pp775-783.

[6] S. Sural, G. Qian, and S. Pramanik, "Segmentation and histogram generation using the HSV colour space for image retrieval," *IEEE Int. Conf. Image Process.*, vol. 2, no. February 2002, doi: 10.1109/icip.2002.1040019.

[7] P. Mohanaiah, P. Sathyanarayana, and L. Gurukumar, "Image Texture Feature Extraction Using GLCM Approach," *Int. J. Sci. Res. Publ.*, vol. 3, no. 5, pp. 1–5, 2013.