IJCTA, 8(3), 2015, pp. 1071-1080

Image Based Faults Inspection of Cigarette Packets on LabVIEW Platform

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Abstract: This paper presents faults inspection scheme on cigarette packet on LabVIEW platform. The objectives of the proposed work are: (i) to count the number of cigarettes in an open packet, (ii) to check defect in the barcode, and (iii) to check defects on the label of the packet. A smart camera (from NI, India) is used to capture images from the required parts of the cigarette packets. These images are processed using various image processing techniques to achieve the above objectives. The proposed scheme is subjected to off-line testing on 300 sets of images of cigarette packets. The results obtained are found to be acceptable with an accuracy of 98.33% and hence the objectives of the present work are fulfilled. The accuracy of fault detection scheme can be improved by proper lighting arrangement.

Keywords: Automation; Barcode detection; Cigarette; Counting; Image processing; Label identification; LabVIEW; Smart camera.

1. INTRODUCTION

The packaging of a product plays a vital role; the basic purpose of packaging is to protect the items inside. A packet also provides a lot of information to the user like brand, ingredients, price tag, and most importantly the span of usage. These information are provided in two ways; one by using a printed note and other by coded information in the form of a barcode. A manufacturer should check for the correctness of these information on the packet before dispatching for marketing.

It is very important for a cigarette industry to conduct both quality and quantity testing before launching any product in market, as any above said deficiencies would result in huge dissatisfaction among the users and may lead to market loss. Thus, it is very important to design an automated system for fault detection in packets.

A number of techniques are available in the literature that can be adopted for fault detection in cigarettes packets. The domain of automated inspection for industrial products is found to be populated mostly by vision based applications. Many researchers have reported on cigarette packet inspection in particular, such as HU Fang-xia *et al.* [1] proposed vision based inspection system for flaw detection in external packaging of cigarette packets using fast Hough transformation and based on support vector machines. Yue Cui *et al.* [2] proposed a vision based inspection system which can detect incorrect number of cigarettes; improper placing and paper handle defects for cigarettes on in an open tin container using K means clustering. Zhou Ping *et al.* [3] designed a capacitance based technique for detection of improper number of cigarette packets in box utilizing back propagation neural networks. M. Park *et al.* [4]-[5] reported identification of individual cigarette and paper spoon in the tin packing using morphological operations of image processing. He Wenping *et al.* [6] proposed a method for detection of faults utilizing machine vision and its implementation on a microcontroller. Malamus *et al.* [7] surveyed the applications

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and state of art tools and techniques related to vision based industrial inspection systems. A. Sarkar *et al.* [8] demonstrated a procedure to detect the defects regarding cigarette packet label using image processing in LabVIEW platform. Color and size based automated visual inspection system was discussed for detection of missing or broken tablets by D. Joze *et al.* [9]. Automatic off line counting of cigarettes in cigarette packets using image processing in LabVIEW was discussed [10]. An automated egg crack detection system using LabVIEW was reported [11]. A. Sarkar *et al.* [12] proposed a technique for an automated process for fault diagnosis in cigarette packets. Real time barcode detection method [13]-[16] and its implementation on chip [17] were reported in literature. Applications related to quality inspection of thermal fuses using artificial neural network [18], pharmaceutical tablets [19], bearing seals [20], bulb filament [21], PCB boards [22], bottle printed labels [23], food products [24] were also reported.

From the survey of the reported works above, it is revealed that although automated inspection is a research trend, but relatively less work has been reported in the area of faults inspection of cigarette packets. In this paper an image processing based algorithm on LabVIEW platform is designed to count the number of cigarettes per packet as well as detect defects in barcode and label for each packet. Counting of cigarettes, barcode evaluation and label faults detection are tested simultaneously using image processing.

We could not find any reported works where faults in various parts of cigarette packet are considered simultaneously. Our earlier conference papers [8], [10], and [12] were dealt with off-line inspection of cigarette packets for defects in label, barcode, and number of cigarettes, respectively. This paper is an improvement of earlier ones as this paper deals with off-line inspection of defects in label, barcode, and number of cigarettes simultaneously. This paper also presents an exhaustive performance evaluation of the scheme of fault inspection which were absent in earlier works.

The paper is organised as follows: After Introduction in Section 1, Section 2 discusses the associated problem. Section 3 deals with the proposed solution. Results and discussion are given in Section 4. Finally, Section 5 concludes the paper.

2. PROBLEM DESCRIPTION

Faults inspection of packets is very essential feature in the cigarette industry. Different techniques are extensively applied to check the quality of finished product. In this paper, cigarette packets containing cigarettes are needed to be inspected for (i) incorrect number of cigarettes, (ii) defects in the barcode, and (iii) defects in the printed label. If a packet is found to have any of the above defects, a fault alarm is to be generated so that the faulty packet can be removed from the production line. So, the problems to be solved can be categorised into quantitative and qualitative inspection. Quantitative inspection counts the number of cigarettes present in a packet and whereas qualitative inspection checks barcode and label.

3. SOLUTION APPROACH

The proposed solution addresses the problem discussed in the previous section by using image processing techniques available on LabVIEW platform [26]-[30]. The flowchart for the counting of number of cigarettes, barcode validation and label identification are shown in Fig.1, Fig. 2, and Fig. 3, respectively. The common steps in the flowchart include image acquisition and define an ROI in the image and extract ROI from the image.

3.1 Image Acquisition

The images of cigarette packets are acquired with the help of a smart camera NI-1744 [25] in laboratory environment under a table lamp of 60 W. In off-line inspection, all the images are stored and called consequently by the program. For acquisition, "***NI Vision Acquisition Express***" VI is used.

3.2 Region of Interest

ROI is that portion of an image which contains the desired information. The rest portion of the image is discarded to reduce the processing burden. ROI can be strictly defined to contain only the individual cigarettes/barcode/label as the case arises. Here we use rectangular type ROI. For extracting ROI from the image, ***ROI Descriptor***, ***IMAQ Select Rectangle*** and ***IMAQ Overlay rectangle*** are used.

3.3 Pre-processing

The Pre-processing for counting cigarettes includes filtering, thresholding, and morphological operations. Filtering is the preprocessing steps for barcode validation. Simultaneously, thresholding and morphological operations are performed for label identification.

3.4 Detect Counting Objects

After pre-processing step shown in Fig. 1, processed images are ready for counting cigarettes in a packet. "***IMAQ Count Object***" VI is used on the corresponding images containing objects to count the numbers. Predefined radius is chosen for detecting number of cigarettes.

3.5 Read 1D Barcode for Barcode Evaluation

The images after passing through the pre-processing step shown in Fig. 2 are ready for barcode detection. "***IMAQ Read Barcode***" VI is used on the corresponding images containing barcode on cigarette packets to detect the barcode. In this paper, barcode of flake packet, i.e. 8901725139018 is used as a predefined template. Learning and recognition are the two phases used to validate the barcode.

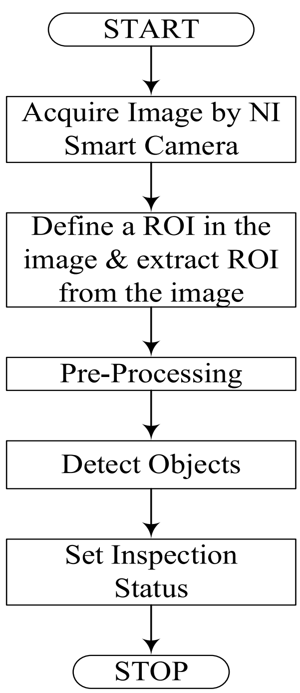

Figure 1: Flowchart for counting of number of cigarettes

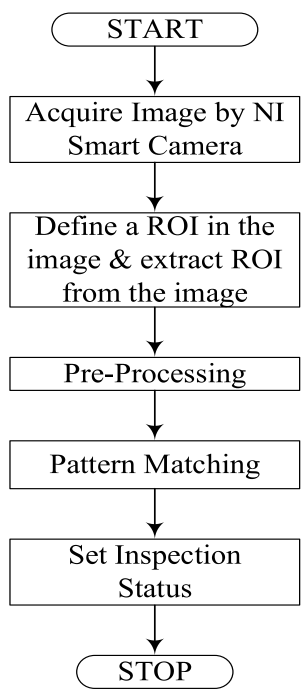

Figure 2: Flowchart for barcode validation

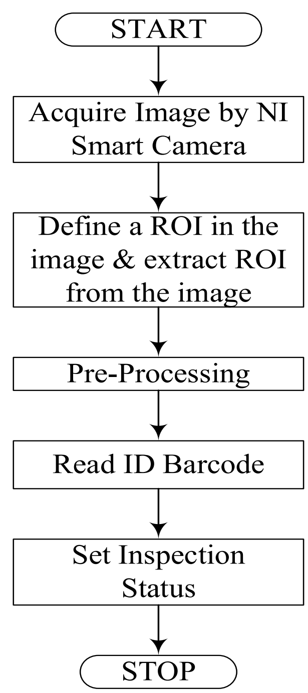

Figure 3: Flowchart for label identification

3.6 PATTERN MATCHING FOR LABEL IDENTIFICATION

The images after passing through the pre-processing steps shown in Fig. 3 are ready for identification of label. Pattern matching is used to check the presence of a template in the entire image based on its intensity.

In this paper, label of flake packet made in Munger is used as a predefined template. For pattern matching, "***IMAQ Find Pattern***" VI is used. Normalised cross correlation is used to find the template in an image for label identification.

The flowchart for faults inspection is shown in Fig. 4. Block diagram of the proposed system is shown in Fig. 5. Results and discussion are presented in the next Section. On completion of counting, "***IMAQ Count Object***" VI matches the count with a predefined value which represents the true number of objects, the packet should contain. If there is a mismatch, a fault alarm is raised. In the same way, the detected barcode and the label are matched with predefined templates representing true situations. On deviation, fault alarm is raised. The inspection of a particular packet is passed only when all the three inspections (viz. count, barcode, and label) detect no fault.

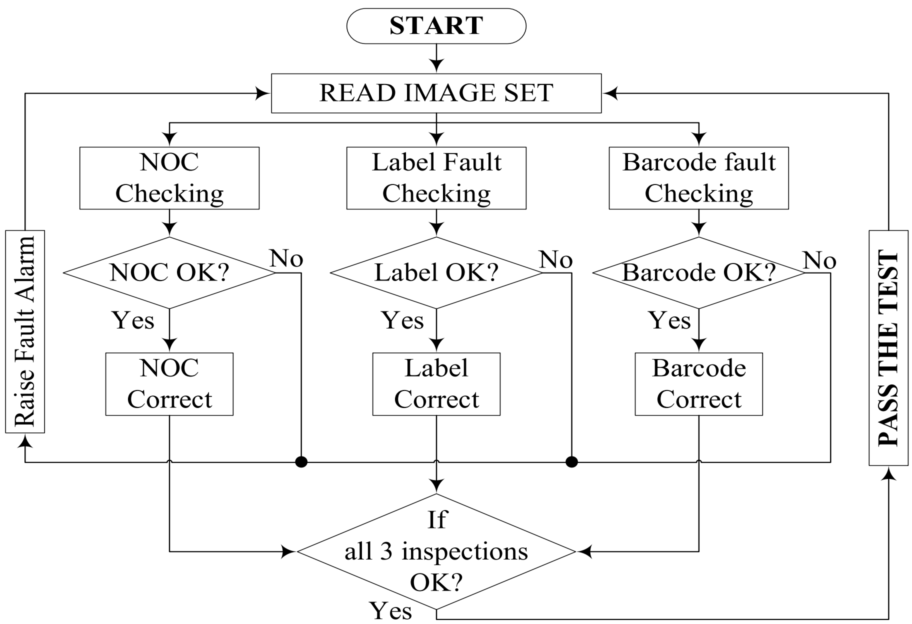

Figure 4: Flowchart of the proposed off-line system

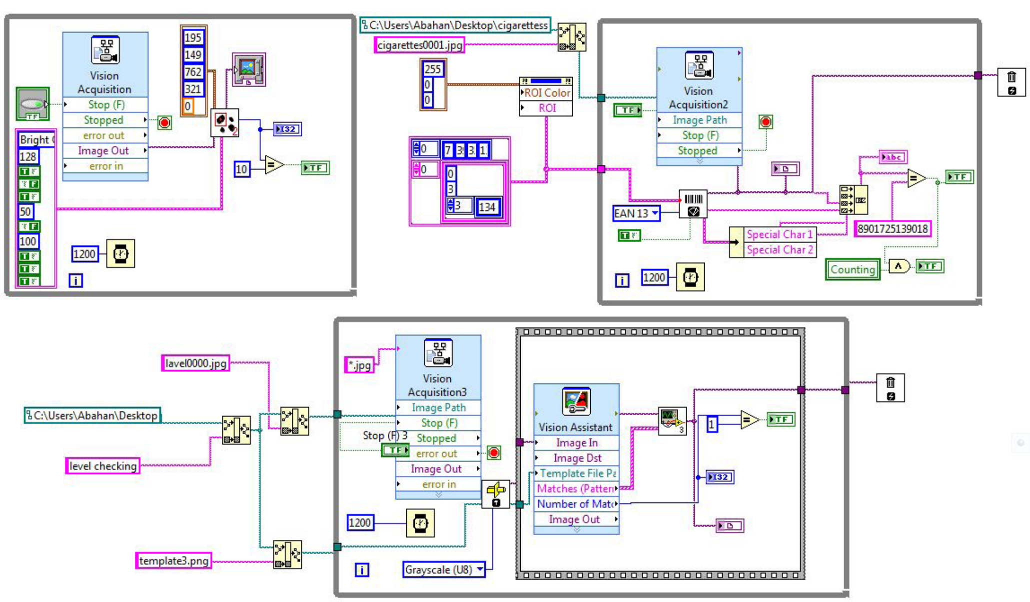

Figure 5: Block diagram of the proposed system

4. RESULTS AND DISCUSSION

This proposed work is tested on cigarette packets in our laboratory. The inspection process takes into account the barcode, label and the number of cigarettes in a packet to generate the necessary control decision either to pass or fail. An off-line inspection process is designed for simultaneous processing of label identification, barcode evaluation and counting of cigarettes.

Off-line testing consists of four boolean indicators which display the inspection status. Boolean indicator one indicates the desired number of cigarettes in a packet; the second one indicates matching of barcode, and third one indicates the desired label in packets and fourth one glow if all three fulfill the required conditions. Three numerical indicators are used to display number of cigarettes, barcode, and label of every packet, respectively. Three displays are used to display the actual image containing cigarette, barcode, and label. Results of off-line inspections are shown in Fig. 6 to Fig. 13.

Set of 300 images of cigarette packets having different number of cigarettes, barcode and label are tested for performance analysis of the proposed technique. The results obtained are shown in Table 1.

Table 1

Results of the proposed technique

	Detected as defective cases	*Detected as good cases*
Defective cases (40)	40 (True positive, TP)	0 (False negative, FN)
Good cases (260)	5 (False positive, FP)	255 (True negative, TN)

Performance measures as precision, false discovery rate (FDR), sensitivity or recall (TPR), fallout (FPR), specificity (TNR), accuracy, prevalence and F1 measure of the proposed technique are calculated using the data of Table 1. Various performance measures are as given below in Table 2.

Table 2

Performance measures of the proposed technique

Performance Index	*Formula Used*	*Results*
Precision	TP/(TP+FP)	0.8889
False Discovery rate (FDR)	FP/(TP+FP)	0.1111
Sensitivity/ Recall (TPR)	TP/(TP+FN)	1.0000
Fallout (FPR)	FP/(FP+TN)	0.0192
Specificity (TNR)	TN/(FP+TN)	0.9808
Accuracy	(TP+TN) /(TP+FN+FP+TN)	0.9833
Prevalence	(TP+FP) /(TP+FN+FP+TN)	0.1500
F1 measure	(2*Precision*TPR)/(Precision+TPR)	0.9412

A low value of false discovery rate, fallout, and prevalence & high value of precision, sensitivity, specificity, accuracy, and F1 measure indicate that the proposed method is working satisfactorily. There is no such similar paper found, to be best of the knowledge of the authors, that’s why comparison of the present results could not be done.

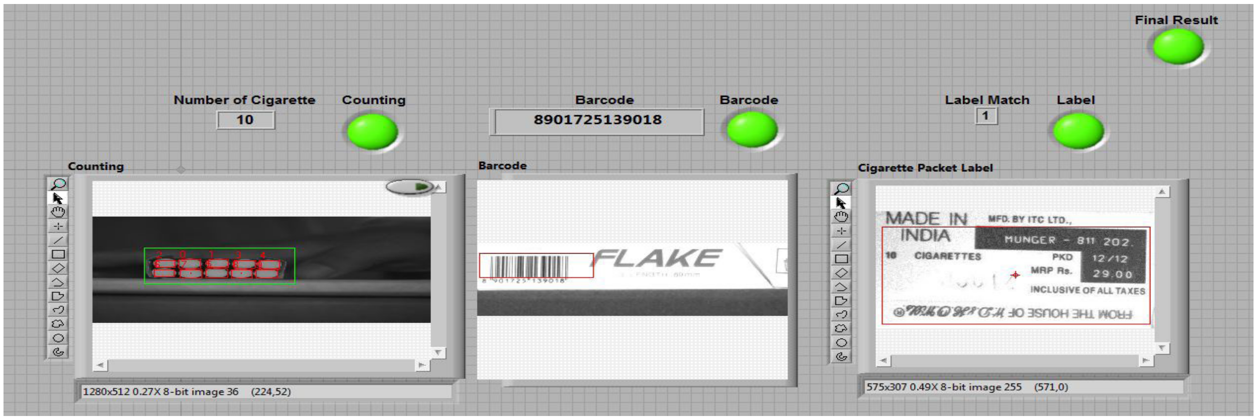

Figure 6: Off-line inspection of cigarette packets (accepted)

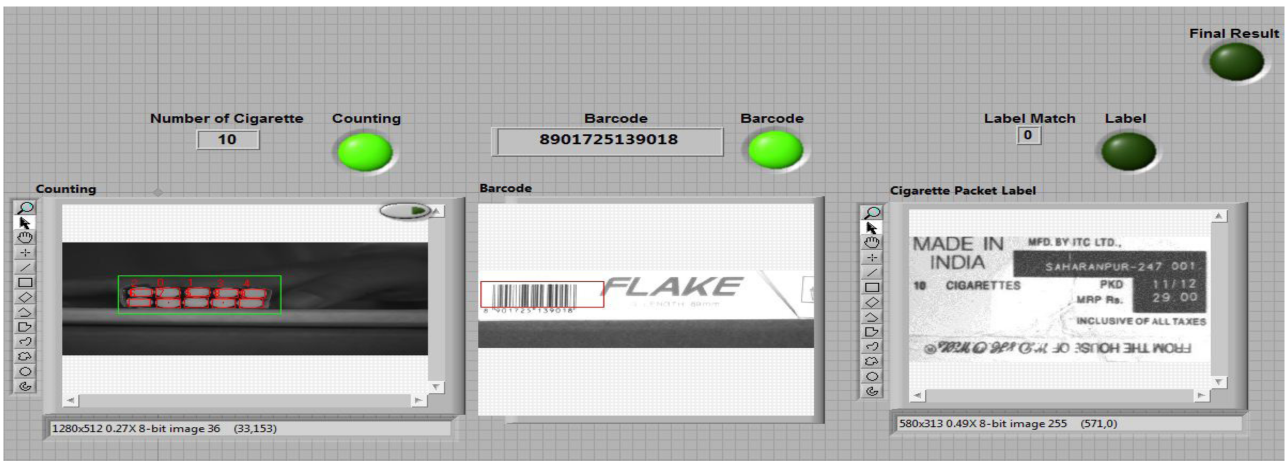

Figure 7: Off-line inspection of cigarette packets (fault in label)

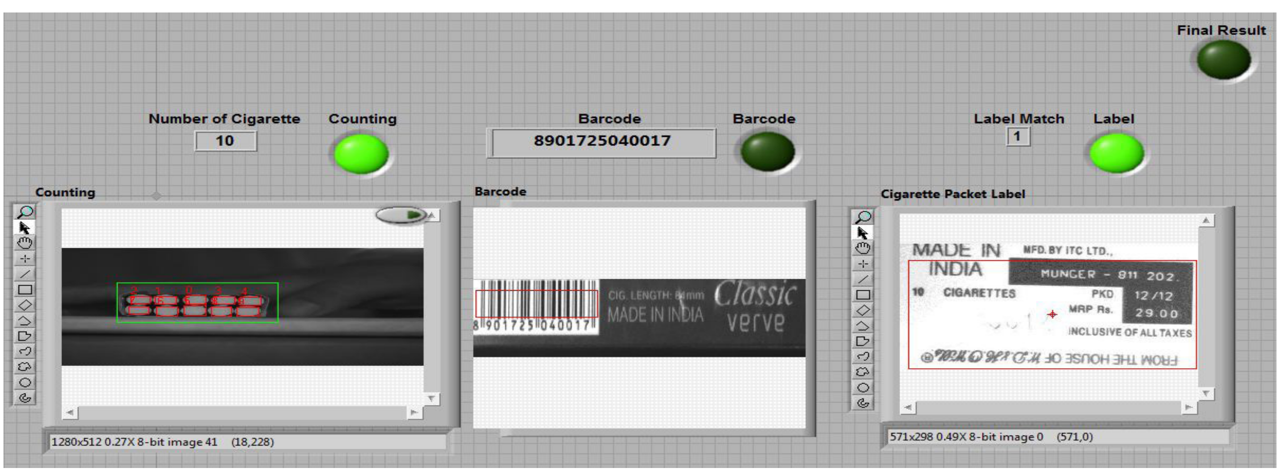

Figure 8: Off-line inspection of cigarette packets (fault in barcode)

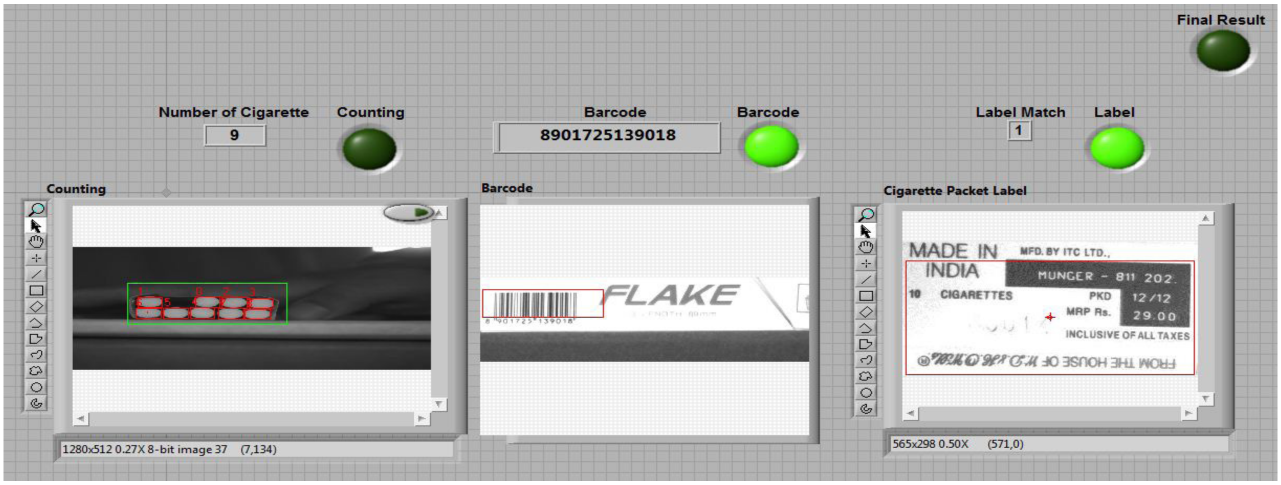

Figure 9: Off-line inspection of cigarette packets (fault in number of cigarettes)

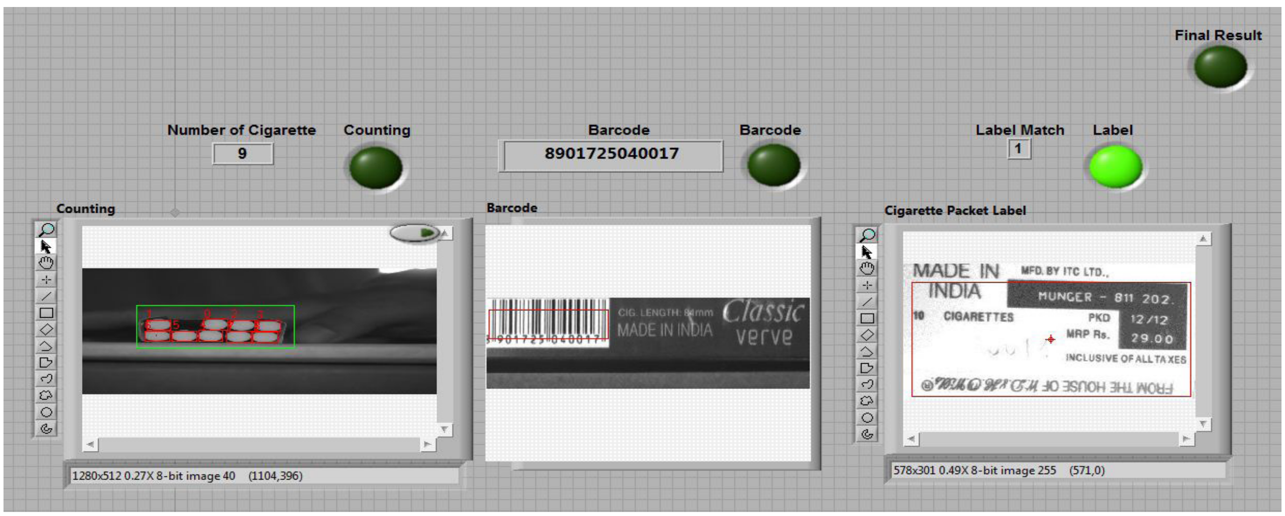

Figure 10: Off-line inspection of cigarette packets (fault in barcode and number of cigarettes)

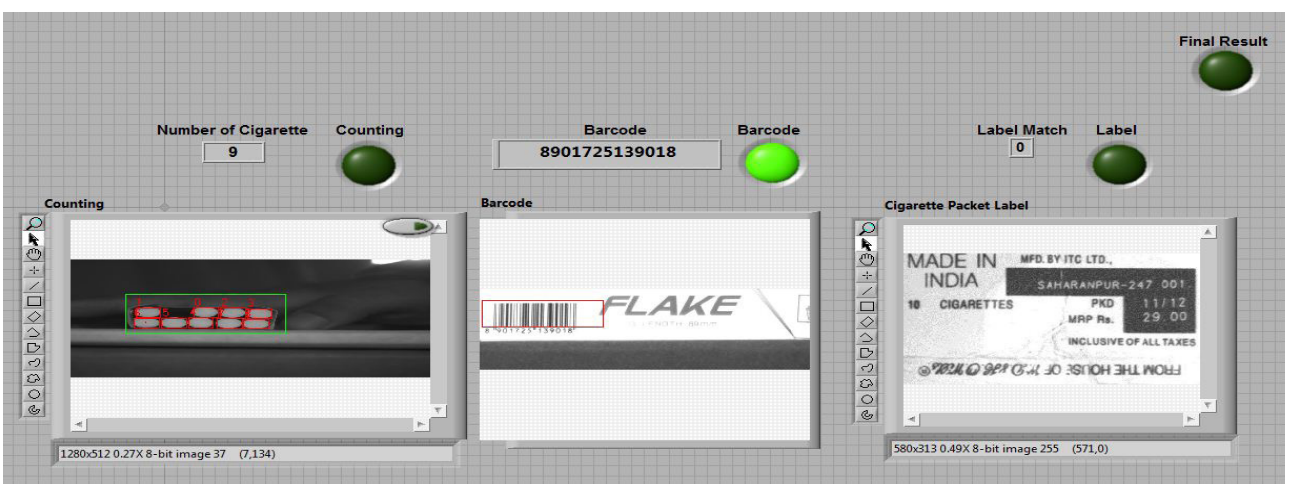

Figure 11: Off-line inspection of cigarette packets (fault in label and number of cigarettes)

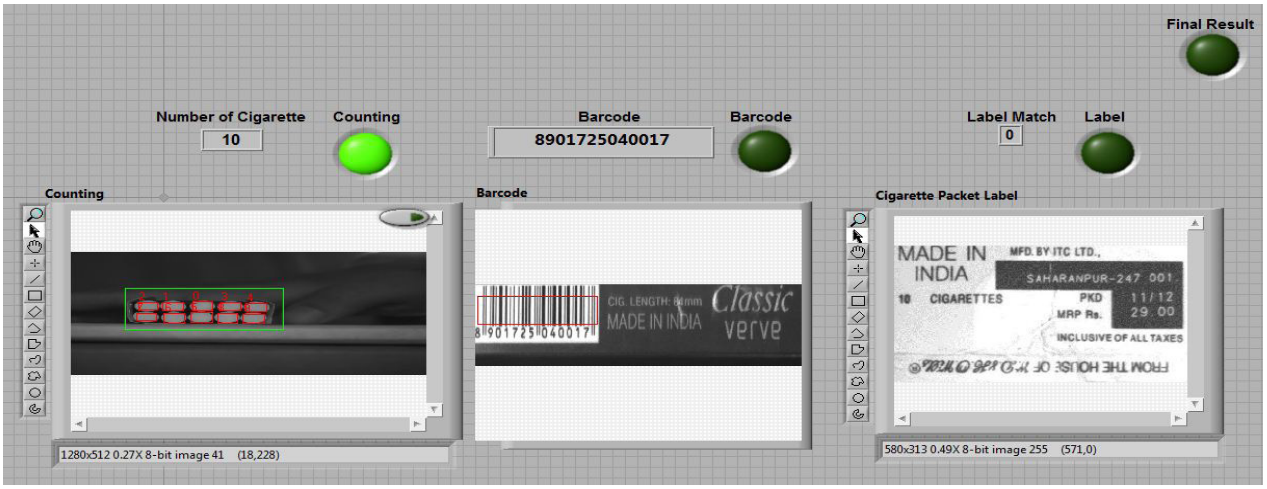

Figure 12: Off-line inspection of cigarette packets (fault in barcode and label)

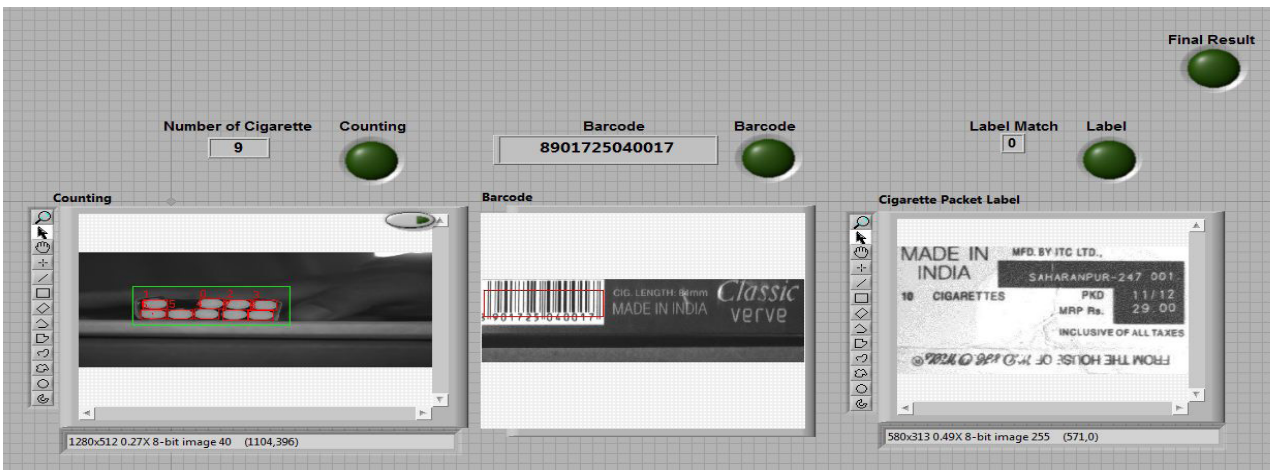

Figure 13: Off-line inspection of cigarette packets (fault in label, barcode and number of cigarettes)

5. CONCLUSIONS

In this paper, an image processing based faults detection scheme is designed and implemented on LabVIEW. The scheme efficiently counts the number of cigarettes and detects defects in barcode and label successfully. Hence, the proposed scheme has achieved the objectives. Since the entire processing is carried out on software, modification and extension for applying the proposed scheme on similar FMCG products can be implemented easily.

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