Journal of Engineering and Technology
The Open University of Sri Lanka (JET-OUSL), Vol. 10, No.1, pp. [63-72], 2022

A Defect Detection System for Logos Print on Elastic Materials Using Image Processing Techniques

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Abstract – *Quality control in the elastic manufacturing industry is crucial for ensuring the integrity of printed logos. However, current methods for evaluating the quality of these prints rely on manual assessment, which is time-consuming, costly, and prone to errors. In this study, we propose an automated image processing-based technique for quality control in elastic logo printing. Our approach uses morphological transformation and normalized correlation to extract features of the logo and identify defects. We demonstrate that our algorithm can inspect a logo in approximately 8 seconds, with an accuracy of 99% in software simulations and 97% in a real-time hardware prototype. This technique has the potential to significantly improve the efficiency and accuracy of quality control in elastic logo printing, while reducing the workload and stress on workers.*

Keywords: *Image processing, Morphological Transformation, Normalize correlation, Quality control systems*

1 INTRODUCTION

In the production line, automation is necessary to reduce human errors and improve customer satisfaction by providing non-defective products. Currently, plant managers rely on a round-robin system of workers to manually inspect defects on the printing line, which is costly, time-consuming, and prone to errors. This method can also lead to worker fatigue and missed defects. In elastic printing, accurate and timely detection of defects during the quality control process is critical for maintaining high standards and minimizing waste. This paper presents an automated defect detection system for improving the quality of logo prints in the manufacturing process and an automated defect identification and tagging system. This system is designed to seamlessly integrate with the current conveyor system and operate in sync with the conveyor timing. The current logo printing and quality control system is shown in Figure 1.

2 RELATED WORK

Several systems are currently used for fabric defect detection using image processing. These systems mainly focus on identifying defects in the raw material used in the textile industry. The fiber scan inspection system is related to elastic defect detection on elastic texture. Logo print on elastic is named as a value addition to the raw elastic, and research on defects in value addition of elastic is more vulnerable for the field of textile manufacturing. Some systems currently used to identify defects in fabrics are explained subsequently.

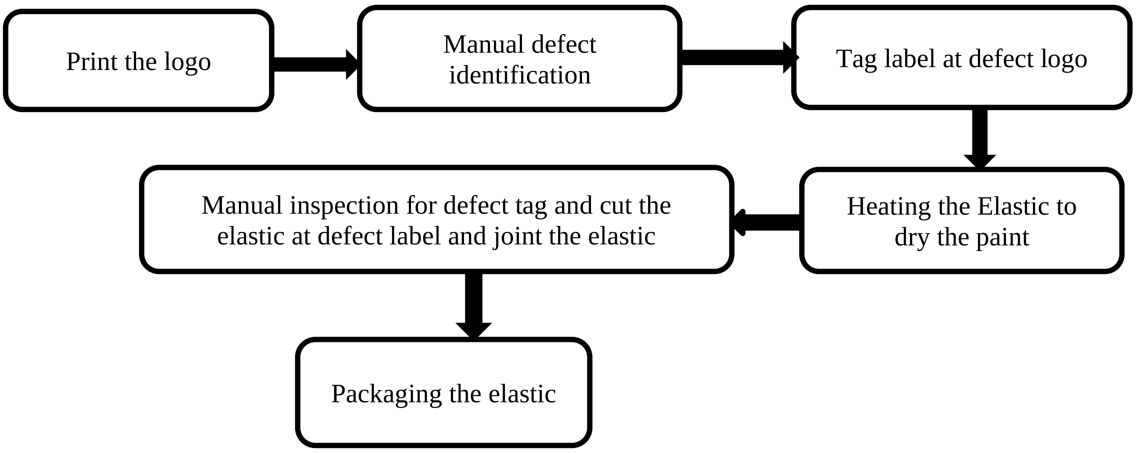


Fig. 1. Existing elastic printing and quality control system

2.1. On loom surface inspection systems for narrow fabrics

The patented system (SARI-SARRAF, 2001)algorithm is based on Wavelet transform, and the correlation is on the loom inspection system. This system inspects narrow fabric, such as woven loom state fabric, such as seat belts, lashing straps, tapes, and lifting and load securing belts. This system is used to capture defects of uniform textured fabrics. The automatic inspection system detects weft defects, warp defects, missed picks, and other deviations.

2.2. Wise Eye fabric defect detection system

This system is used to detect defects in fabric rolls. The CCD camera captures the total length of fabric by using a moving arm. Then analyze the image using the algorithm and find defects. This system can reduce 90% (Wong, 2019) of the loss and wastage in the fabric manufacturing process.

2.3. Fabre scan inspection system

This system applies to the elastic industry. It has the ability to inspect elastic texture at a speed of 280m/min (Anon., 2017). It also provides a tension mechanism to avoid fiber crease. However, that speed can be reached only for regular elastics. Usually, this defect detection system uses in elastic manufacturing process to avoid defective elastic coming to the logo print process.

3. PROBLEM STATEMENT

One major challenge in the elastic value-addition process is the difficulty of accurately detecting defects through manual inspection. This can be time-consuming and costly for manufacturers, who often need to re-inspect entire lots or even reject them due to low quality prints. In order to maintain the quality of their products and retain their export business, manufacturers must ensure early detection of defect prints and prevent the shipment of defective elastic.

Elastic print defect happened due to, Defect in the screen-printing template, Misalignment of blades, Conveyor belt timing issue, and Stretching of elastics.

Defects in elastic prints can occur due to issues such as defects in the screen-printing template, misalignment of blades, conveyor belt timing issues, and stretching of the elastic. Quality control and defect detection are performed after the screen-printing process, at which point workers manually tag any defects using a label tagging gun. However, this manual inspection process is prone to errors and does not allow for the identification and correction of repeated errors. Therefore, automation is necessary to improve the efficiency and accuracy of defect detection and minimize elastic waste.

4. METHODOLOGY

Fig. 2 illustrates the proposed system design for defect detection, which involves a series of operations on images captured by a camera. In the first stage, the image is cropped using a morphological transformation to remove the unwanted areas and isolate the letters. The image is then resized and denoised to improve its quality for comparison with a template. Finally, the test image is compared to a set of reference images using normalized correlation in OpenCV to identify defects.

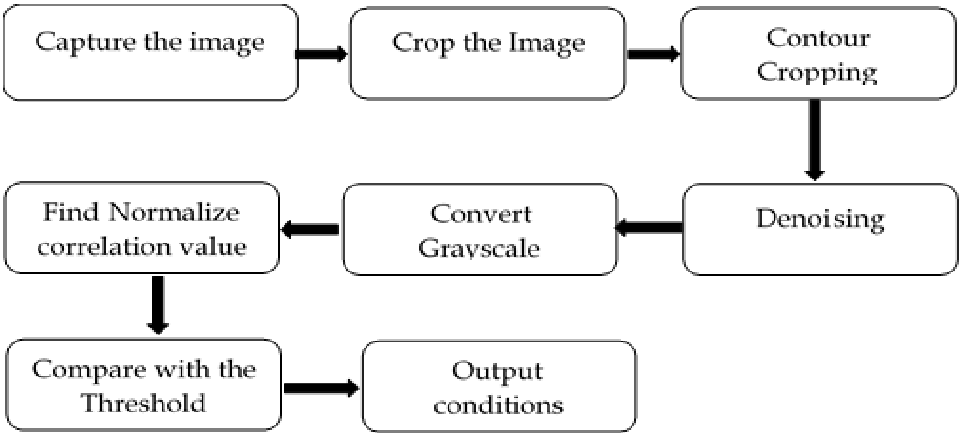


Fig. 2. Flow diagram of the proposed system

4.1 Block diagram of the system

The proposed system operates as follows: the conveyor belt feeds the elastic into a chamber where an image is captured by a camera and sent to a raspberry pi for processing. A rotary encoder provides feedback to the system, which uses a L298 motor driver to position the motor for image capture. If the system detects a defect in the logo, a relay driver activates and a solenoid operates to tag the defect. In cases of repeated errors, the conveyor stops automatically to prevent further waste.

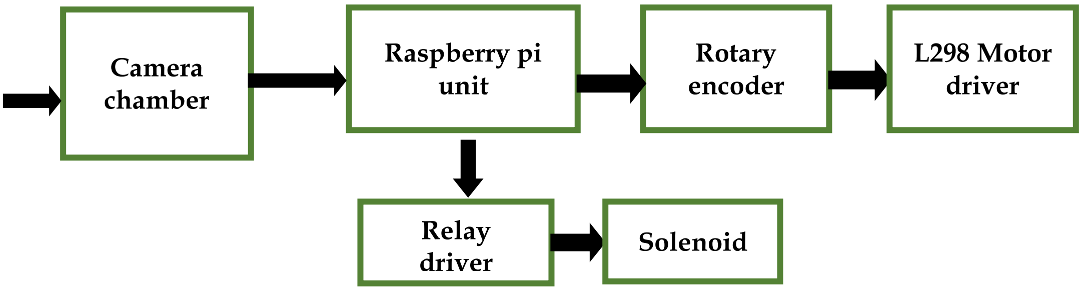


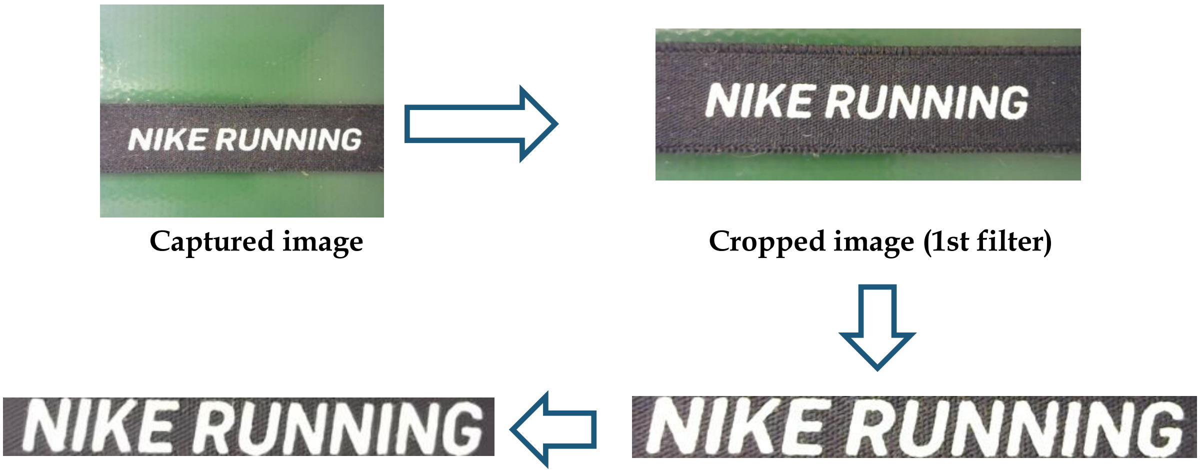
Fig. 3. Overview of the machine

4.2 Algorithms

4.2.1 Image Capturing and Preprocessing

Input – Captured image
Output- Contour cropped denoising image
Steps:

- Capture image
- Cropped image to the predefined size to remove unwanted data
- Crop along the contour of the letter using Morphological Transformation.
- Resized image to the predefined pixel value
- Denoising the image



Captured image

Cropped image (1st filter)

Resize and denoised image

Cropped along the Contour

Fig. 4. Image Processing Steps

4.2.2 Normalized Correlation Matching

Input: denoised image
Output: matching coefficient
Steps:

- Convert image to grayscale
- Perform match operation using corresponding method (Normalize correlation)

These methods multiplicatively match the template against the image so that a perfect match will be prominent and deficient matches will be small.

$$R_{ccorr}(x,y) = \sum(x',y')\ [T(x',y').I(x+x',y+y')]^2 \quad (1)$$

To reduce the effect of lighting differences between the template and input image, the normalized correlation method (Feng Zhao, 2006), is shown below.

$$R_{ccorr\_norm}(x,y) \quad = \frac{R_{ccorr}(x,y)}{Z(x,y)} \qquad (2)$$

Where ,

R_{ccorr} - Correlation Result

T – Template

I - Image

Z- Zero mean normalized correlation

4.2.3 Histogram Matching

$$\mathrm{d}(H1,H2)= \frac{\Sigma I\big(H1(I)-\bar{H}1\big)\big(H2(I)-\bar{H}2\big)}{\sqrt{\Sigma I\big(H1(I)-\bar{H}1\big)^2\big(H2(I)-\bar{H}2\big)^2}} \qquad (3)$$

Where, $\bar{H}k= \frac{1}{N}\sum_j Hk(J)$

Two histograms ($H1$ and $H2$)

N is the total number of histogram bins.

5 GUI IMPLEMENTATION

Tkinter, or "Tk interface," is a Python module that provides an interface to the Tk GUI toolkit, which was developed using TCL (Tool Command Language) and is supported on multiple platforms, including Linux, macOS, and Windows (Anon., 2021). Tkinter is used to implement a user-friendly graphical user interface (GUI) for the operator of the system. GUI design is shown in Fig.5.

6 RESULTS AND DISCUSSION

Each template captures a slight deviation of the image inside the camera chamber to normalize the template. The comparison result of good images with each template is shown is show in Fig.6 and Fig.7. Normalize correlation method used to find matching coefficient.

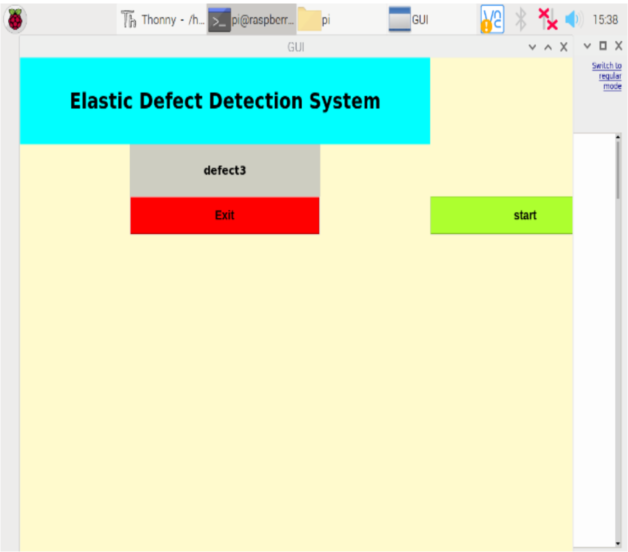


Fig. 5. GUI window

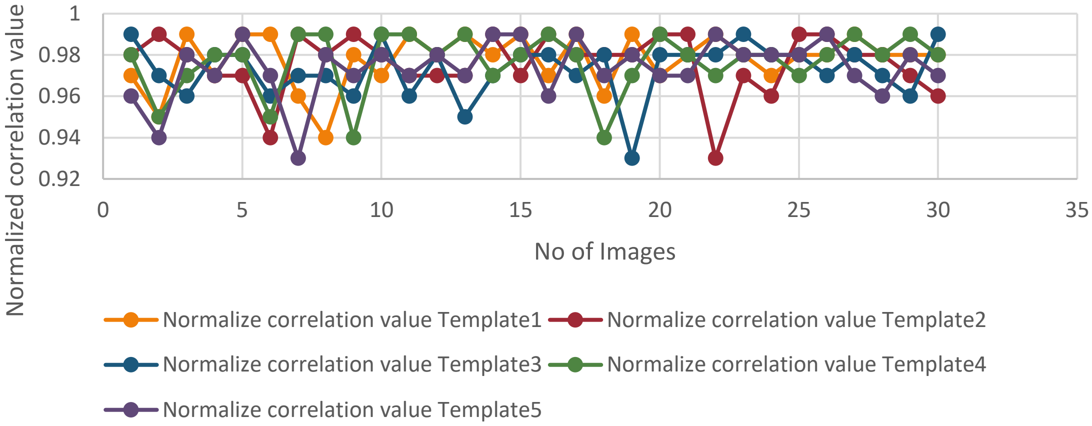


Fig. 6. Normalize the correlation value of the non-defect Logo with each template

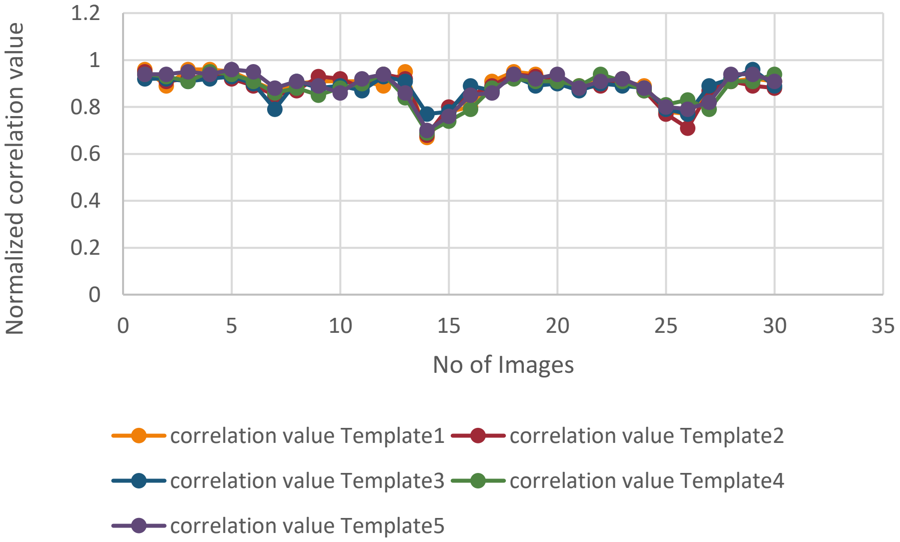


Fig. 7. Normalize the correlation value of the defect logo with each template

The same analysis is carried out with the histogram comparison method. Results are shown in Fig.8 and 9.

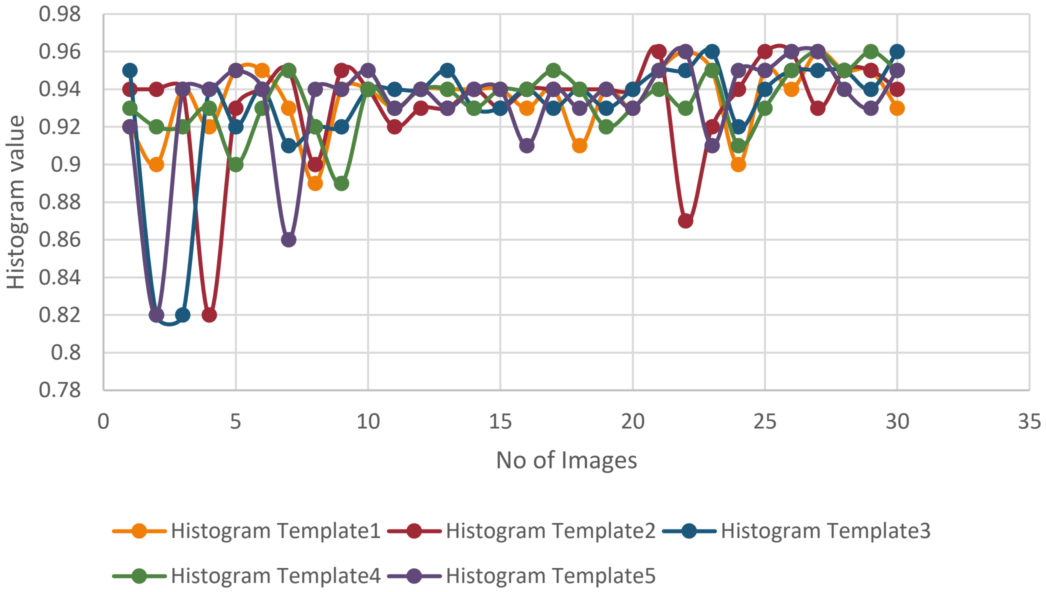


Fig. 8. Histogram comparison value of Non-defect logos with each template

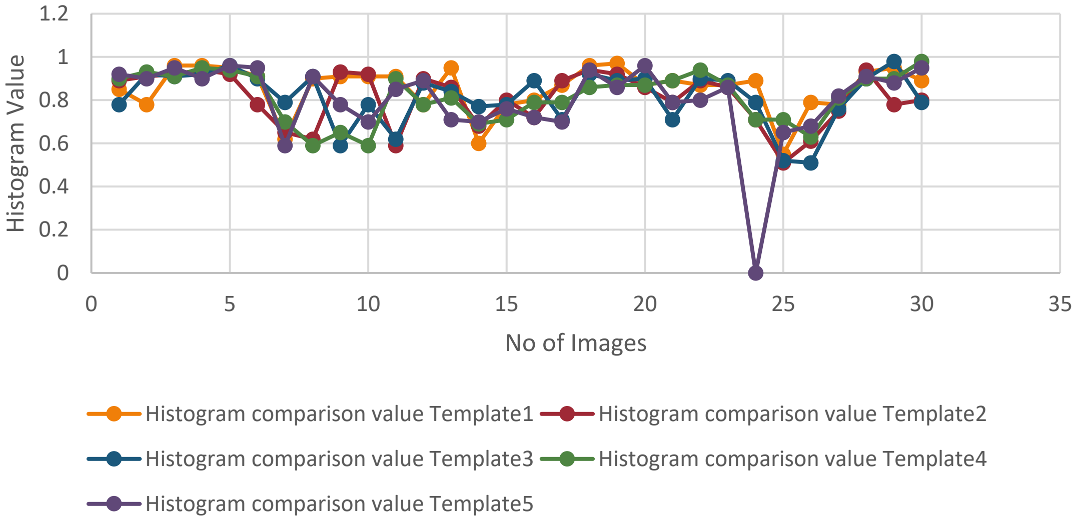


Fig. 9. Histogram comparison value of defect logos with each template

6.1 Mean value of each scenario

30 samples from non-defect and defect images were expereimented and mean value of different methods are shown in below Table 1.

Table 1- Mean value of results

Scenario	Mean value
Normalize correlation – Non-defect	0.9754
Normalize correlation – defect	0.88
Histogram comparison – Non-defect	0.93
Histogram comparison – defect	0.82

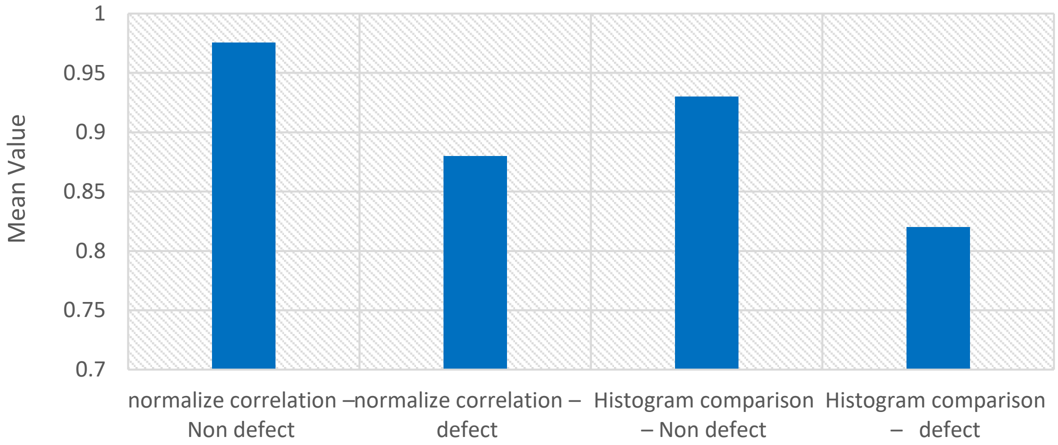


Fig. 10. Mean Value of the results

Our results indicate that normalized correlation is an effective method for detecting defects in elastic logo prints. Using this method, we obtained a matching value of 99% for non-defective images. We set a threshold of 0.98 for identifying good images, and any image below this threshold was considered defective. To confirm the accuracy of our system, we used five templates to check the matching coefficients. If all template values were below 0.98, the image was classified as defective.

This system can accurately detect defects in logos and prevent repeated errors, thanks to a feedback system that helps maintain the proper distance between logos. Normalized correlation is a particularly useful method for analyzing defects because it allows for easy thresholding to compensate for lighting differences between the template and input image. In addition, normalized correlation has minimal variation in values and is fast for comparison.

To improve the torque of the conveyor, we coupled a DC motor with a rotary encoder. A bearing was used to smooth the operation of the roller. One of the main challenges was accurately holding the elastic print in place within the chamber. We initially attempted to use the timing of the belt and physical restraints to hold the print in place, but this proved unreliable as any variations in torque could cause the image to shift by centimeters. To overcome this issue, we implemented a feedback system using a 20-step mini rotary encoder. For even greater accuracy, an industrial-type rotary encoder with micro steps could be used. To further reduce image shifting, we captured five templates with small shifts within the chamber to obtain the normalized result.

7 . CONCLUSION

This study presents an image processing technique and its application for automating inspection and defect detection in the elastic value-addition industry. While various research and automated machines have been developed to identify defects in fabrics and elastics, image processing techniques offer an effective means of automating human inspection in the industry. Our proposed algorithm for detecting defects in logo prints on elastics, tagging defects, and preventing repeated errors has the potential to replace manual inspection in the elastic defect detection process of the production line with suitable industry-level equipment. By implementing this automatic inspection system, we aim to reduce elastic waste and improve the accuracy of printed logos.

In the prototype, we used a roller shutter camera and a conveyor belt to capture images, which introduced a speed limitation. To overcome this limitation, we recommend using a global shutter camera that can capture images on the go. Additionally, the prototype needs to be redesigned and developed according to industry standards. The mechanical structure and label tagging system should be upgraded to meet industrial standards. When deployed in a real-world environment, the system should include an industrial-standard defect tag attachment system.

8. ACKNOWLEDGEMENT

The authors would like to express their gratitude to Mr. Amila Nuwan Amarasinghe, Plant Manager of the Value Addition section at Strechline Pvt Ltd, for providing insights into the real issues and automation needs at the plant.

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