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Fault Detection In Bottle Caps And Label Alignment Using Convolutional Neural Network

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***Abstract*—Quality control is one of the most crucial phases in the creation of any product. Product quality is the degree to which a product lives up to expectations. Due to flaws in bottle caps and label alignment, the quality of beverage products suffers. To overcome this problem, detection of fault via computer-based methods is a developing trend across many industries. In this paper by using Convolutional neural networks, image processing is used to detect fault in bottle caps which include loose caps, tilted caps, and missing caps and edge detection method is used to detect fault in label alignment which includes misplaced or tilted labels and inverted labels. The proposed model will improve precision and speed of fault detection. Due to the accuracy and time concession the adaptability of this machine learning method, the system can operate in a variety of lighting and backdrop conditions.**

Keyword—Convolutional neural network; image processing; Computer vision; quality control.

I.INTRODUCTION

On an average the bottle manufacturing Company produces billions of bottles every day and about 19,400 bottles are produced every second. Since the production and the demand of product is increasing day by day. The industrialists are unable to provide good quality product to consumers efficiently and the damaged product brings down the reputation of the company, especially in pharmaceuticals and consumer goods. In order to overcome such obstacles many manufacturers build specific frameworks to control each of those defective products in order to reduce any risk in the financial and packaging fields.

There are several problems in quality control such as unequal level of liquid, accident immersion of foreign particles in bottles. Among this the defective bottles caps and misaligned labels reduces the quality of the product among consumers. In general, several industrialists tried to create various flaw detection algorithms, including Image Processing, CNN and Deep Learning, to address this issue.

The CNN-based algorithm is one of these techniques that improve image processing accuracy. It is a kind of network architecture for analysing existing datasets to update new data sets algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. Its capacity to manage a big volume of data makes it effective instrument. Traditional methods are no longer as popular, especially when it comes to pattern recognition. Convolutional Neural Networks are among the most well-liked deep neural networks.

In the suggested model, CNN is utilised to quickly and accurately identify bottle cap flaws while also checking label alignment using a variety of datasets. Additionally, because this is a light weight model, the computer vision examination of bottle caps and label misalignment doesn't require a lot of computing power and is neither slow nor heavy with many characteristics that slow down production. The cameras in this type are employed to collect data that will be given to the system. system must promptly compute and identify the fault after receiving the image. We can enhance production rates and decrease human workloads due to excellent accuracy and speed of this model, it will ultimately save companies money and time. We can lessen the workload and stress on the human quality control expert by automating the quality control procedure. It has been shown that automating your production processes can improve efficiency while reducing errors. Huge machinery and various specially designed equipment are used in the industries to produce their own goods. Convolutional neural networks, however, allow us to build and train a model that can find label alignment and cap faults in any industry.

II. RELATED WORK

We have reviewed prior research on the bottle cap inspection method. Many academics have attempted to solve this issue. Below is a list of some of this field's significant research.

[1]By applying the image processing-based approacha deblurring improvement and edge sharpening technique is applied based on the Prewitt method to repair the image blur caused by the high-speed operation of conveyor belts, which helps to increase accuracy. The automation processes photos at a high-speed rate of 120/min and stresses the detection of caps in large-scale production.

[2]In this paper By using an image processing system a prototype developed for an automated bottle cap visual inspection system. The efficiency of the automated bottle cap visual inspection system prototype that was built was tested using different conveyor speeds for six hours each, and the results showed that the prototype had an average accuracy of 96.77%.

[3]This paper researches on a vision-based inspection system that can inspect bottle caps and detect any flaws they may have. Image-processing methods like pattern recognition, object detection, line detection, and clustering are used to complete the operation. In this proposed model it considers images from top view and recognizes whether the cap of bottle is over fitted or not.

[4]The liquid level in amber glass bottles was detected in this study using a vision-based method. For preprocessing and image processing, the proposed system uses Python and OpenCV. Additionally, the study was successful in identifying filled bottles and categorizing them into three groups: under-fill, within goal, and over-fill.

[5]This research provides an image preprocessing method that makes use of an additional skipped connection between the blocks to detect caps on bottles. In order to reduce the size of the parameters on caps, global average pooling is utilized.

Paper proposed by us will focus on detecting label alignment from taking images from side view in addition to detecting cap faults, making it more precise and effective than previous work.

III. PROPOSED SYSTEM

In order to identify errors in bottle caps and label alignment in this model, we developed a CNN-based method that includes image processing and edge detection, as shown below.

A. Convolutional Neural Network

CNN is a powerful algorithm for processing images. The best algorithms for automatically processing photographs are currently those mentioned. Industries utilise these algorithms frequently to perform tasks like item recognition in photos. Images contain RGB combination data. The computer can't see images; it can only see a list of numbers. CNN is generally used for segmentation, object detection, and image recognition tasks in image analysis applications. Convolutional, pooling, and fully connected layers are the three types of layers found in convolutional neural networks.

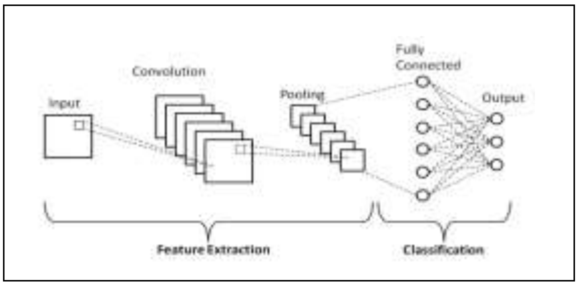

Fig.1 CNN model

B. Adam optimizer

Adam is a Adaptive moment estimation. In proposed model Adam optimization algorithm is used. Adam is the optimizer which is used to reduce the training time in order to increase the process speed. Adam optimizer is combination of RMSprop and momentum.. The Adam optimizer produces results that are generally superior to those of conventional optimization methods, takes less time to compute and needs fewer tuning parameters.

Adam additionally stores an exponentially decaying average of past gradients m_t, comparable to momentum, in addition to maintaining an exponentially decaying average of past squared gradients v_t, similar to Adadelta and RMSprop:

$$m_t = \beta_1 m_{t-1} + (1-\beta_1) g_t$$

$$v_t = \beta_2 v_{t-1} + (1-\beta_2) g_t^{\,2}$$

Where is m_t a mean and v_t is a uncentered variance. The authors of Adam note that m_t and v_t are skewed towards zero because they are initially initialised as vectors of zeros, especially in the first few time steps and when the decay rates are low.

By creating first and second moment estimates that have been corrected for these biases:

$$\hat{m}_t = \frac{m_t}{1-\beta_1^t}$$

$$\hat{v}_t = \frac{v_t}{1-\beta_2^t}$$

After updating parameter in adadelta and RMSprop updated adam rule can be obtained:

$$\theta_{t+1} = \theta_t - \frac{\eta}{\sqrt{\hat{v}_t} + \varepsilon} \hat{m}_t$$

C. Description of a dataset

A dataset is a grouping of different kinds of data that has been digitally preserved. The most important element of any CNN-based project is data. To address numerous AI difficulties, such datasets often include photos, texts, numerical data points, etc. We need a dataset with lots of photos for the AI method. Each image is studied by the system for its explicit details because variation in information will aid in learning. To recognise photographs of bottles with the cap linked or separated and the label on the bottle in alignment or misaligned that are excluded from the dataset, or to have the choice to delete cap and label fault, it is implied that the machine needs a large number of diverse images. For the learning strategy, the size of dataset is extremely important.

For detecting errors in the position of the bottle cap and label alignment, there are essentially two datasets: a training dataset and a testing dataset. The primary distinction between training data and testing data is that the training dataset is a subset of the original data used to train the machine learning model, while the testing dataset is used to verify the accuracy of model. In general, the training dataset is bigger than the testing dataset. When testing dataset is added to training dataset, which comprises a more than 3000 images of faulty bottles and images of bottles without fault in various settings, accurate results can be predicted quickly and accurately.

Fig.2 Sample Images of faulty bottle cap from dataset

Fig.3 Sample Images of misaligned bottle label from dataset

The images in the present dataset are altered through data augmentation. Inversions, translations, image resizing, image reversed, Gaussian noise addition, and this is only the beginning of the adjustments that may be made. Changing the images and included them in the dataset results in the addition of a wider range of information. Performing data augmentation on the small-scale groupings of images during training is also completely expected.

IV. METHODOLOGY

A. Block diagram

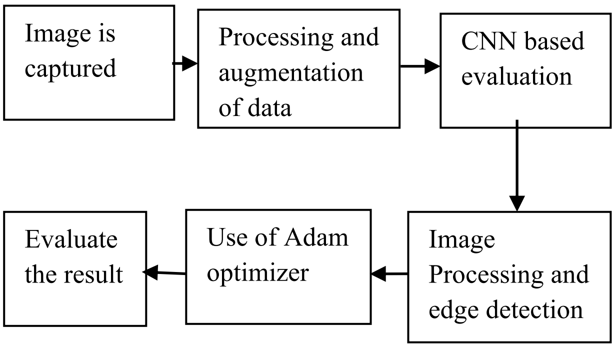

Fig. 4 Block diagram to show work flow of proposed model.

B. Flow of algorithm

Step 1: Image is captured and uploaded to testing dataset.

Step 2: Before dividing the dataset it is loaded. RGB is the format for the input images.

Step 3: Data augmentation and data processing is performed and captured images are compared with training dataset.

Step 4: CNN performs the operation of feature extraction and classification using its three layer model.

Step 5: The Adam optimizer reduces loss by incrementally increasing parameters like filter kernel values, weights, and neuronal bias.

Step 6: After performing all the necessary steps result is evaluated.

V. EVALUATION

Here we represent the graph for defect in bottles which include two conditions that is Good and Defective. It is about the fault that occurred in bottle caps and labels. Hence the below mentioned table. 1, and the graph as shown in fig. 4, estimate the results of fault detection.

TABLE I. Classification Report

Content	**Precision in %**	**Recall in %**	**F1-Score in%**	**Support**
Good	99	98	98.49	399
Defective	98	99	98.49	422
Accuracy			98.55	821
Macro Average	99	98	98	821
Weighted Average	98	98	98	821

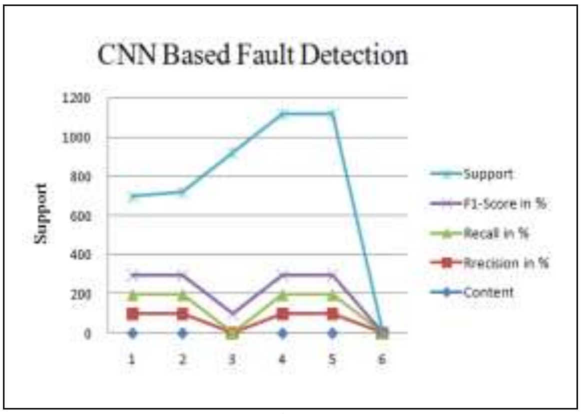

Fig. 4

VI. CONCLUSION

We have successfully created a system based on CNN that accurately distinguishes between good and bad bottle caps and labels. We have referred various model which worked on detecting fault in bottle caps like VGG-16 gives 92% accuracy, Resnet 50 model gives 91% accuracy, Inception model gives accuracy of 93% and apart from this models our proposed model attains 98.55% accuracy, as shown in fig. 5. This study will give bottle production facilities an alternative method for keeping an eye on the bottles as they move around the conveyor belts. By removing human inspections from the process of inspecting for defective caps while still delivering quick inspections, increasing the sector's profitability.

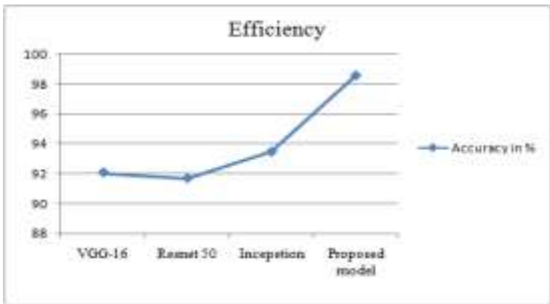

Fig. 5

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