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ANALYSIS AND VISUALIZATION OF DEFECT DETECTION USING DEEP LEARNING MODELS

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ABSTRACT: The detection of product defects are crucial in internal control in manufacturing. This study surveys state of the art deep-learning methods in defect detection. First, we classify the defects of products, like bottles, toothbrushes, leather, capsules, hazelnut, screws into categories. Next, recent mainstream techniques and deep-learning methods for defects are reviewed with their shapes and sizes described. Next, we summarize and analyze the application of deep learning, machine vision, and other technologies used for defect detection, that specializes in these aspects, namely method and experimental results. To further understand the difficulties within the field of defect detection, we investigate the functions and characteristics of existing equipment used for defect detection. The core ideas and codes of studies associated with high precision, high positioning, rapid detection, small object, complex background, occluded object detection and object association, are summarized. Lastly, we outline the achievements and limitations of the prevailing methods, together with the present research challenges, to help the research community on defect detection in setting an extra agenda for future studies.

Keywords: [Deep Learning, CNN, Defect Detection, VGG16, Quality control object detection.]

1. INTRODUCTION

Image Processing

It is a process that performs few operations on an image, and to get the correct image or to extract some main information from that image. It is also a type of signal processing, in which input is an image and output might be an image or some features classified with the image. Nowadays image processing is rapidly increasing technology and also It forms a core research area within the computer science and engineering disciplines too and it basically consists three phases:

- Using image acquisition tools the image will be Imported.
- Analyzing the image and manipulating the image.
- Output in which the result can be changed image.
- Analogue and digital image processing are two types of image processing
- Analogue image processing can be useful for hard copies like printing the printouts and photos. The analysts use different fundamentals of explanation by using these visual techniques.
- Digital image processing techniques are useful in manipulation of the digital images by make use of computers. The three phases are pre-processing, enhancement, and display, information extraction.

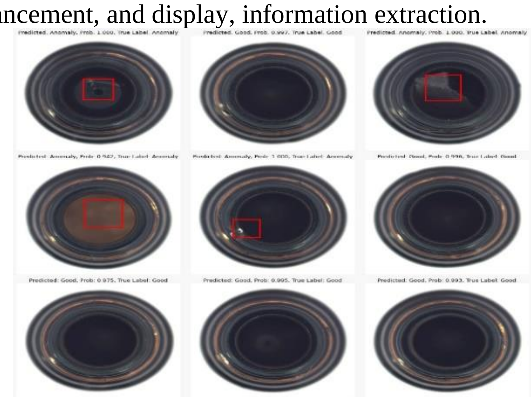

Figure.1: Image of defect detection of bottles dataset

Image Vision

Image vision normally deals by removing few important visual features to append its shape, texture, and colour from the image and it uses those information, with textual information to find resemblance and much more meaningfulresults.Computer vision derives from modeling image processing by using machine learning techniques. It applies machine learning to identify patterns for the clarification of images. Like the visual reasoning process of human vision; we can differentiate between the objects, and classify them, then sort them in ascending order by size. It is like image processing, that takes images as input and that gives output in the basis of information on size, color width etc.

Image Analysis and Data Analysis

Image analysis concerns processing an image into the fundamental components to extract the correctful information. It can include some tasks such as finding the shapes, detecting the edges, removing the noise, counting the objects, and calculating statistics for the texture analysis or imaging the quality. Defect analysis is the study of the properties of defects in that, as opposed to the methods for expecting the number and nature of the defects based on different properties of software, like complexity models. It often is one of the first types of the data that all the software organizations collect.

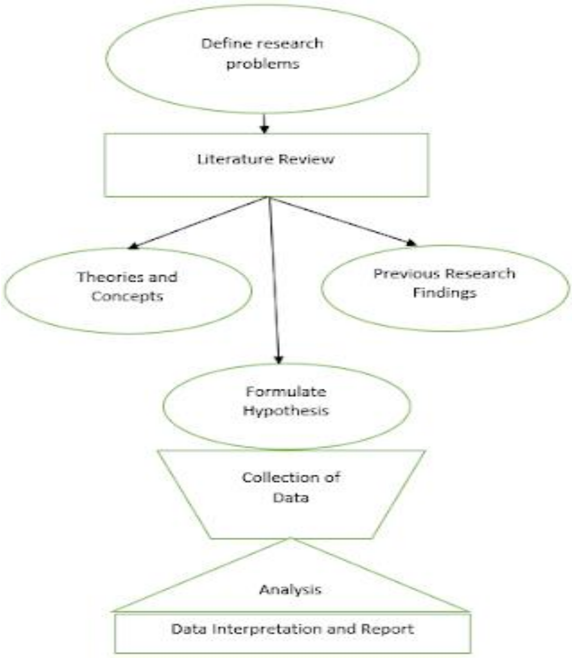

Figure2: Basic Flowchart of Image Processing

2. RELATED WORK

Product defect detection technology is principally to detect the surface and internal defects of products. The defect detection technology refers to the detection technology of spot, pit, scratch, color differences and defect on the merchandise surface. Internal defect detection technology mainly includes internal flaw detection, hole detection and crack detection. At present, several methods are wont to detect product quality, including deep learning, ultrasonic testing, and machine vision detection methods. Machine vision detection mainly consists of image acquisition and defect detection and classification. thanks to its fast, accurate, non-destructive and low-cost characteristics, machine vision is widely used.Machine vision identifies objects mainly supported the colour, texture and geometric features of objects. the standard of image acquisition determines the problem of image processing. In turn, the standard of the image processing algorithm directly affects the accuracy and error detection rate of defect detection and classification. The deep-learning method is additionally a defect-detection method that's supported image processing, which is widely want to obtain useful features in massive data.

CNN is a variant of deep learning model for processing the data which has a grid pattern, like images, and which is inspired by an organization of animal visual cortex and it is designed to automatically and flexible learn spatial hierarchies of the features, from min to max level pattern . It is a mathematical construct that is generally composed of three ways of layers: pooling, convolution, and relevant layers. Convolution and pooling layers that performs feature extraction, whereas the third, relevant layer, maps are those extracted features into the final output, like classification. A convolution layer plays a main role in CNN, as composed of a stack of mathematical operations, like convolution, and also a specialized type of linear operation. While In digital images, pixel values are as stored in a two-dimensional (2D) grid, i.e., an array of the numbers, and a small grid of the parameters called kernel, and an optimizable feature as extractor, which is applied at each stage of image position, which makes CNNs highly efficient for all image processing, a feature may occur anywhere in the image. As one layer feeds its output into next layer, extracted features can hierarchically and progressively become more complex to that . The process of optimizing the parameters such as kernels is known as training, which is executed so as to minimize the distinguish between outputs and ground truth labels through an optimization algorithm called backpropagation and gradient descent, among others.

The deep residual network appends a residual module which is based on convolutional of neural network. Residual network is characterized by simple optimization and that can improve the accuracy by slightly increasing the network depth. CNN, Generative Adversarial Networks etc. By the depth of the network slightly increases, the extraction feature increases, but it is simple to cause the activation function that not to converge.The main purpose of the deep residual network is to evaluate the increasing number of network layers with residual while increasing the network structure, so that the output and input element dimensions ofthe convolution layer in the residual unit are the same, and then through the activation function to reduce the loss.

Full convolution neural network: The fully connected layer, is a layer that connected between any two nodes or between two adjacent layer and a fully connected neural network also uses a fully connected operation, then there will be more weight values, that also means that the network will take up the more memory and calculations . While calculation of the fully connected neural network, the feature map generated by the convolution layer is mapped into a fixed-length feature vector[4,5].

The full convolution neural network can accept the input image of any size, and use the deconvolution layer to sample the feature map of the last convolution layer, it can recover to the same size of the inputimage.so that a prediction can be generated for each of the pixel, while retaining the special information in the original input images, and finally classify the feature map of the upper sampling pixel by pixel.

Recurrent neural network recursively from the evolution direction of sequence data and all cyclic units are connected in a chain manner, and the input is sequence data [10,11]. The CNN model mainly extracts the feature information of input layer test samples through convolution and pooling operations. The recurrent neural network uses the recurrent convolution operation to replace the convolution operation on CNN. The difference is that the recurrent neural network does not performthe pooling layer operation to extract the features after the recurrent operation to extract the input layer features,but uses the recurrent convolution operation to process the features of the samples.

Algorithm

VGG16 is nothing but a CNN architecture as it is remembered as the one of the better vision model architecture. It is a better architecture for standard on particular task. For various applications it can be useful out in box and it is freely available on the internet as they are pretrained networks. It is also known as OxfordNet. It predicts the output dimension.VGG also performs outside of imagesetdataset.VGG mainly used for imageNet , a maximum of visual database uses in visual recognition research.

Literature Survey

Deep-learning technology has evolved slightly and had the great achievement in object detection, intelligent robot, saliency detection, parking garage sound event detection, sound event detection for smart city safety, UAV blade fault diagnosis and other fields. Deep learning incorporates a reasonably deep neural network structure with multiple convolutions layers[2,3]. By combining low-level features to create a more abstract high-level representation of attribute categories or features, the info will be better reached in abstract ways like edge and shape to boost the effectiveness of the deep-learning algorithm, Therefore, many researchers attempt to use deep-learning technology to defect detection of product and improved the merchandise quality. It abstracts the benefits and drawbacks of deep-learning methods commonly employed in product defect detection. It mainly includes convolutional neural network (CNN), autoencoder neural network, deep residual neural network, full convolution neural network, and recurrent neural network.

By using CNN it is used to detect the defect in object. CNN could be a feedforward neural network. CNN accommodates one or more convolutional layers and fully connected layers, further as associated weights and pooling layers . Literature may be a very fashionable LeNet convolution neural network structure[6]. LeNet network structure will be accustomed detect defects in two situations: one is to style a complex more than one layer in CNN structure, and uses different network structures to add extra image features, and complete end-to-end training to detect defects in images ; the opposite is to mix CRF model CNN with, train CNN with CRF energy function as constraint or optimize network prediction results with CRF[7,8]. And to attain the detection of product defects.

The product defect-detection technology is totally based on the neural network. The Autoencoder network includes two steps: coding and decoding. In codingstage, for feature extraction the input signal is converted into a coding signal; while in the decoding step, the information is converted into a reconstruction signal, and then the reconstruction error is miniute by adjusting the weight and bias to realize the defect detection [9, 10]. The difference between autoencoder networks and some machine learning algorithms is the beginner goal of the autoencoder network is not for the classification, but for feature learning. It also has a strong ability of autonomous learning and highly nonlinear mapping. It can learn nonlinear metric functions to solve the problem of segmentation of complex background and foreground regions.

Problem Statement

The project "Analysis and visualization of defect detection using deep learning" detects defects efficiently based on vgg16 in CNN model and apply the model on image data to detect defects.

In this project, we are going to show you the way to beat this explainability limitation for Convolutional Neural Networks. And it is by exploring, inspecting, processing, and visualizing feature maps produced by deep neural network layers. we are going to undergo the approach and discuss the way to apply it to a real-world task Defect Detection.

providing support for network configuration in a highlevel language, and providing better visibility and control over tasks for performing network diagnosis and troubleshooting.

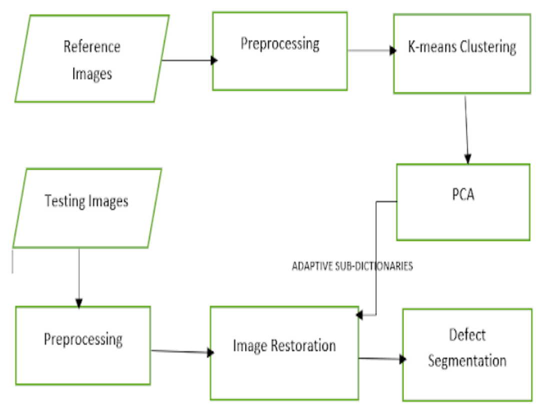

Figure3: Flowchart for process of Defect Detection

Dataset

- Dataset Used - MVTEC Anomaly Detection Dataset.
- Images resized to 224x224.
- Train/Test split - 80/20 in stratified manner by defect types.
- Evaluation was performed on a few subsets from the MVTEC Anomaly Detection Dataset like Hazelnut, Leather, Cable, Toothbrush, and etc. A separate model is going to be trained for each subset. The model is to train for at most a few epochs with early stopping if train set accuracy reaches 98%.

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Subset Name	N Images (Train / Test)	Test Set Ac curacy	Test Set Balanced Accuracy
Hazelnut	408 / 100	95.0%	96.8%
Leather	290 / 72	97.0%	94.8%
Cable	299 / 75	93.7%	89.8%
Toothbrush	87 / 20	92.8%	84.8%
Bottle	347 / 87	83.8%	85.6%

3. EXPERIMENTAL RESULTS

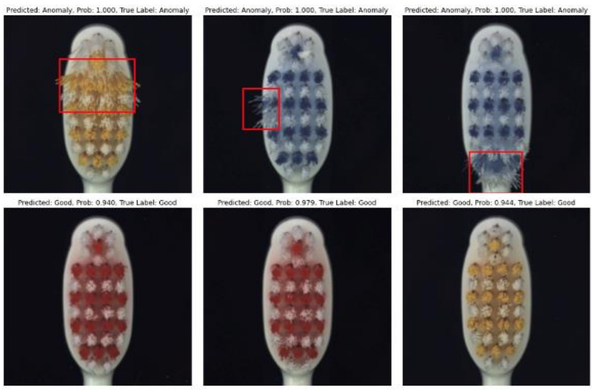

Figure 4: Output image of Toothbrush

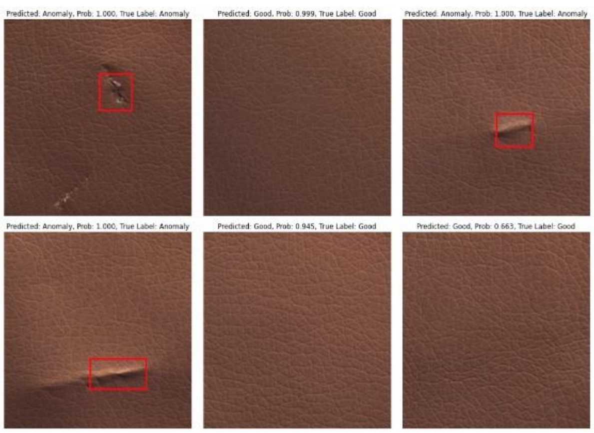

Figure 5: Output image of Leather

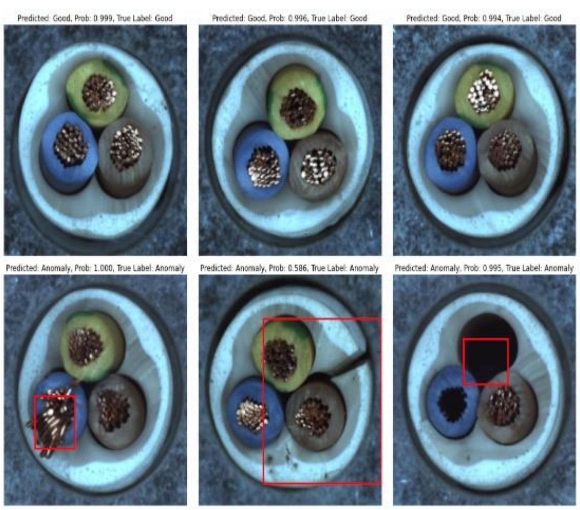

Figure 6: Output image of Cable

CONCLUSION

Industrial product quality is a crucial part of product production, and therefore the research on defect-detection technology has great practical significance to confirm product quality. The text gives a comprehensive overview of research status of product defect-detection technology in complex industrial processes. We've compared and analyzed traditional defect-detection methods and deep-learning defect-detection techniques, and comprehensively summarized the experimental results of defect-detection techniques. Meanwhile, combined with the particular application requirements and therefore the development of AI technology, the defect-detection equipment was investigated and analyzed. Through investigation, we found that 3D object detection, high precision, high positioning, rapid detection, small targets, complex backgrounds, detection of occluded objects, and object associations are the hotspots of educational and industrial research. We also got wind that embedded sensor equipment, online product defect detection, 3D defect detection, etc. are the event trends within the field of business product defect detection. We believe that the investigation will help industrial enterprises and researchers understand the research progress of product defect-detection technology within the field of deep learning and traditional defect detection.

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