Fault Detection Using Canny Edge Detection and Mask R-CNN in Injection Molding of Manufacturing Processes

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ABSTRACT

In various injection molding manufacturing plants, there are many difficulties in detecting defective products during production. Since there are limitations in detecting product defects with the human eye, this paper proposes a framework for detecting product defects in a human-free manufacturing environment. We detect product defects using Canny Edge Detection, a powerful edge detector, and provide reliability of products detected using Mask R-CNN, a neural network with excellent speed and accuracy. As the network, the ResNet101 network with the highest accuracy was selected, and the network was used as the backbone network of Mask R-CNN, and the image was resized and sized using LEDs when shooting to detect even small scratches.

CCS CONCEPTS

• **Computing methodologies**; • **Artificial intelligence**; • **Computer vision**; • **Computer vision tasks**; • **Scene anomaly detection**;

KEYWORDS

Canny, Mask R-CNN, Edge Detection, Injection Plant

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1 INTRODUCTION

With the rapid development of multimedia and network technologies, image databases are inflating, and a method of efficiently and quickly obtaining useful image information from image resources on the internet has become a core technology [1]. As the information technology (IT) industry in the 21st century expands rapidly, various machine learning technologies are being used. As many situations and problems arise in creating products in the manufacturing industry, many related studies have conducted to solve these problems, and convolution neural networks (CNN) has been helpful in solving various problems in the recent product manufacturing process. In the production of products, inspecting product defects through quality inspection of produced products is a great help in improving injection and molding manufacturing processes in industrial sites and saving time and money due to product defects. In particular, through inspection of product defects during injection and molding manufacturing processes, the product of the production line where defective products no longer generated replace, and the identified defective products and their causes identified, and the facility of the production line manage in real time. It can improve the reliability of the manufacturing site [2].

This machine learning image vision can apply by grasping the defects of numerous manufacturing processes such as mold, hopper, etc. from the most basic part of the injection and molding manufacturing industry. In the manufacturing process of injection-molded products in industrial sites, defects and defects include scratches, cracks, and imprints. Since there are irregular surfaces and patterns that occur during the manufacturing process of the product, it is difficult to distinguish between normal products and defective products. Defect inspection in industrial sites requires high accuracy and treatment compared to good products, but there is no proper countermeasure [3].

In addition, in the current smart factory manufacturing environment, products are produced by introducing various manufacturing systems such as enterprise resources planning (ERP), manufacturing execution system (MES), point of production (POP), and production lifecycle management (PLM). Among them, the POP System, which is quality control, ranks Rot_No for each production unit of each product during the manufacturing line and manufacturing process of the field sector, and when defective products occur during the quality inspection process of the product, all Rot_No products such as Rot from which defective products are disposed discarded. The

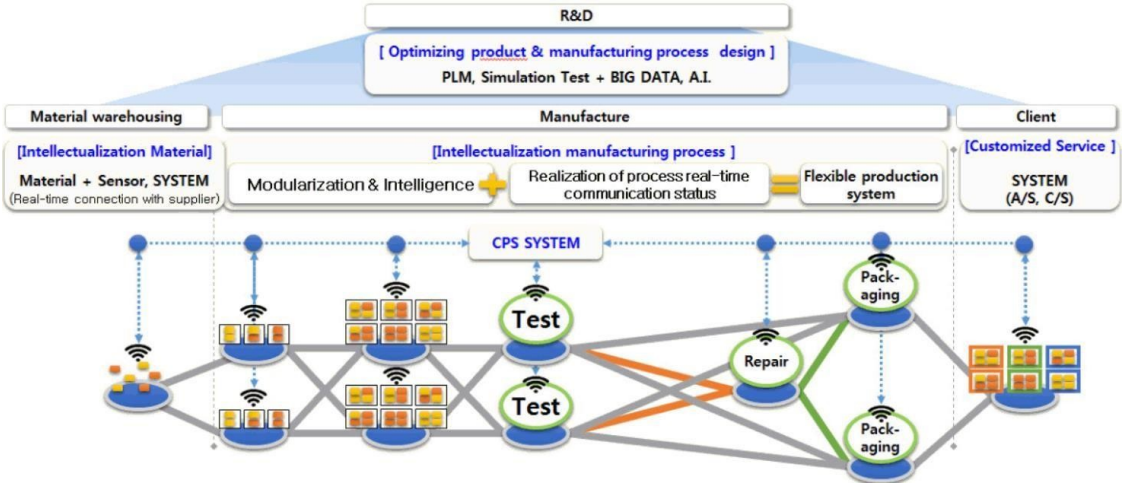

Figure 1: Smart Factory Construction

reason for the defective product may be due to various reasons during the manufacturing process of the product, such as fluff, press, and mold. There are many situations costs and time wasted. In industrial sites because products manufacture again from the start [4].

In this paper, we propose a method of detecting defects for defective products in the injection molding manufacturing process at industrial sites, and further propose a framework that aims to reduce costs and increase profits at manufacturing sites by improving product reliability through correct quality control. The canny algorithm of edge detection actually used for its excellent signal-to-noise ratio (SNR) and accurate edge detection [5]. By using Mask R-CNN, you can obtain a result with excellent edge detection accuracy.

In the next section, we will explain the related research that study prior to writing this paper. Section III provides a description of the proposed framework. Details of the experimental resources and results for the framework's process give in section 4, and section 5 is the conclusion of this paper.

2 RELATED WORK

2.1 Smart Factory Design

In recent years, the use of technology to accelerate smart analytics in the production industry has resulted in individual initiatives to improve fair overall performance, quality and controllability. It combines both data integration and analysis technology progress in a smart factory processed computer network, providing transparency to the factory [6].

Factory operation intelligence technology collection big data automatic analysis, performance added value, data generation work process optimization my back will and related technology through operation AI technology, ERP, MES, PLM and same design manufacturing solution, software, networking bag. Smart factory constructive sample applying automatic technology, plant operation intelligence technology, and business connection technology is shown (Figure 1).

2.2 Faster R-CNN

The convolutional layer of the pre-trained network in the RPN (Figure 2) follow by a 3 x 3 convolutional layer, which corresponds to mapping a large spatial window or accepting field. In the input image to a low-dimensional feature vector of the central stride, classifying all spatial windows and Two 1×1 convolutional layers add for regression branching [7].

The RPN uses a convolutional feature map as input and a small sliding network. Through the input map to generate a proposal with object regression boxes to generate a set of object proposals (Figure 3), and then the proposed region regresses the bounding box with various region of interest pooling methods to perform [8].

3 INJECTION MOLDING FOR DETECTING DEFECTS IN MANUFACTURING PROCESSES AND FRAMEWORK

Under the picture proposes in this paper injection molding in each manufacturing process in the factory produced product's images through bad detection and accuracy improve for framework indicate big thirds in part divided process proceeds (Figure 4).

3.1 Camera Image

In the first injection manufacturing process, this product is not affected by changes in the background brightness of surrounding objects when shooting 3 dog cameras, 1 dog product 90 degrees top 70 cm, left and right 60 degrees top 70 cm, which produced the product in real time from the top. We spend generation-by-generation camera shooting time to take pictures. Scratch of the product is the same when shooting led shoot. Fault detection has the advantage of being able to express more clearly on the side of back light reflection, refraction, and shadow.

3.2 Edge Detection

Second is canny algorithm processing. Canny edge detection most strong edge is a detector detection the steps image smoothing,

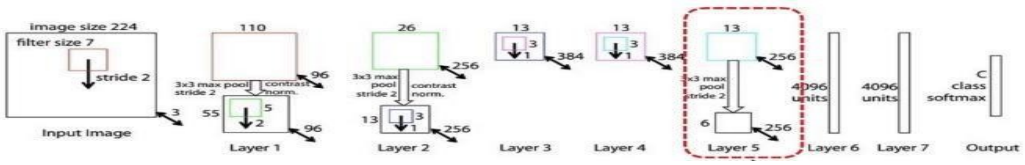

Figure 2: Faster R-CNN Header

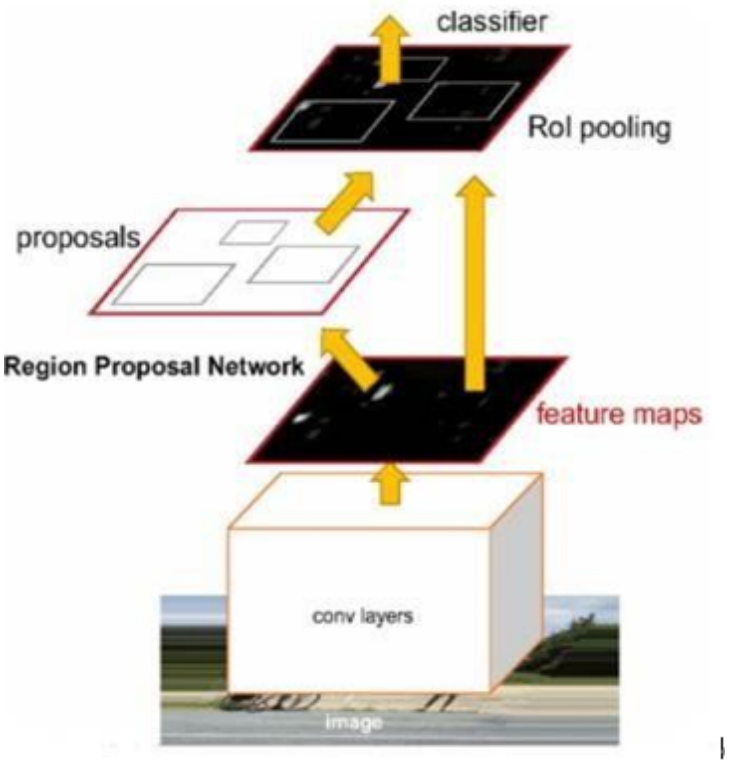

Figure 3: Faster R-CNN architecture

gradient size calculation, edge tracking proceed. First in the process extracted images canny algorithm through edge detection of to proceed. The process is next and same [9].

- ★ Convert the image to grayscale. In MATLAB, bits are set to zero to 255, and pixel intensity is set to 8 bits.
- ★ Image smoothing for Gaussian filter through bracket images derivative to do when occurring noise (noise) remove it.
- ★ Calculate the magnitude of the gradient vector using the sobel operator and use a 3x3 window (figure 5) to get a thinedge. Equations 1 and 2 show below.

$$\text{Edge\_Gradient } (G) = \sqrt{G_x^2 + G_y^2} \tag{1}$$

$$\text{Angle } (\theta) = \tan^{-1}\left(\frac{G_y}{G_x}\right) \tag{2}$$

- ★ At the edge maximum value have pixel in search of works maximum pixel true pixel keep it, yes if not pixel0 to set.
- ★ Connected edge to get for two critical values use. At this time high of value critical value using gradient in the direction low critical the value come out until tracking edge to connected hysteresis Critical hysteresis thread holding method use. After the repeat final processed images create for edge 0 to set (Figure 6).

3.3 Accuracy detection

The third improves the image accuracy of the R-CNN used through canny edge detection through the extracted image. Restricted RoIPool area size even if rounding CNN of through RolPool realm before decimal point R-CNN for fast R-CNN exact false detection position extraction mask No CNN of through RolPoolRealm. This RoI align called [C] inter-pixel motion faithfully preserve by the pixel party spatial communication itself. RoI functions, which are small maps of functions, should well aligned. A RoI align layer developed using a faster R-CNN of to perform the following task,

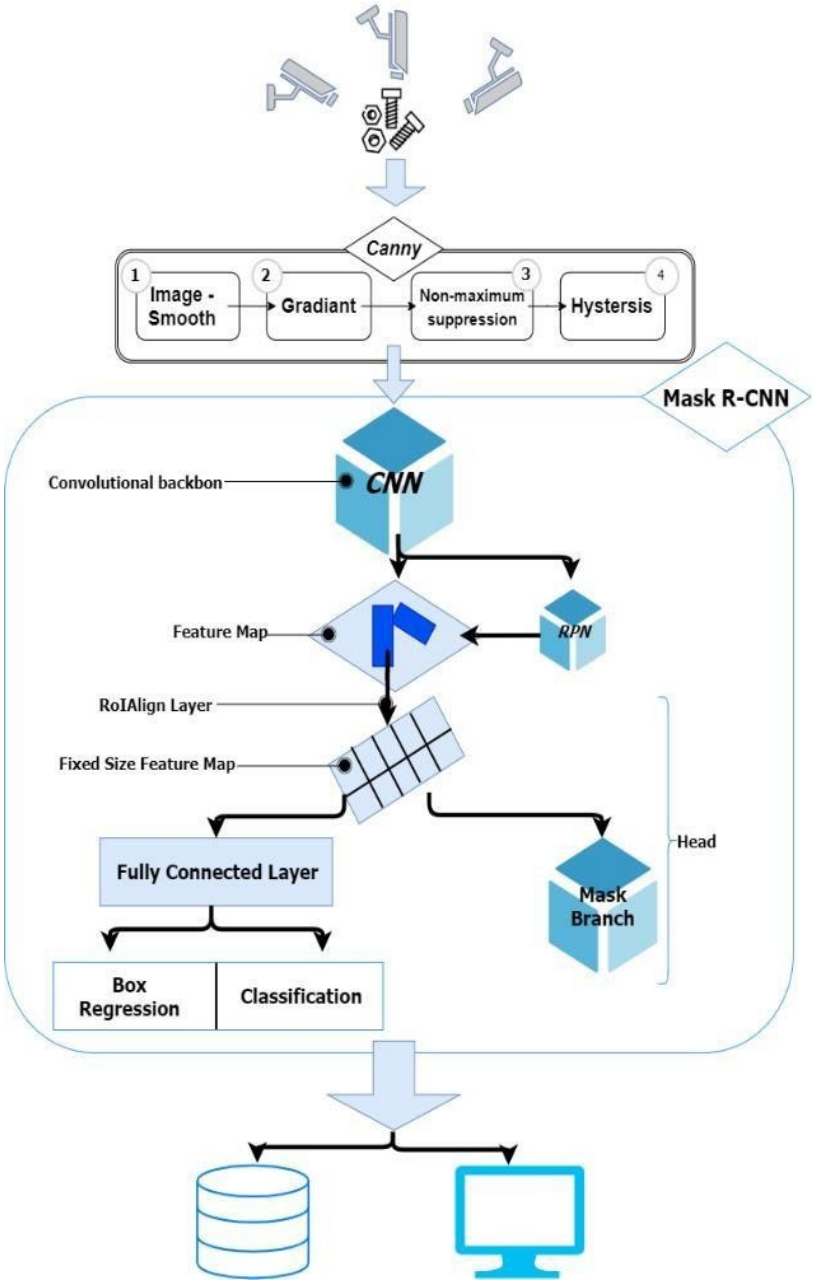

Figure 4: Injection molding manufacture process framework

which is a predictive core, which is a mask by the tooth, RoI on Fully Connect Network of Perform [10].

4 PERFORMANCE ANALYSIS

The experimental environment is GPUGTX1080TI 12gin, and the test data conducted will be 5000 images and 10,000 trained images. According to the characteristics of heterogeneous products in the image performance, we confirm this in the rescue and distribution of paper and select two kinds of product images. Classification network training on image blocks used. As far as possible under this table, ResNet101 uses ResNet101, so it has a different backbone than the highest accuracy in the network.

The batch size of Mask R-CNN is 64, the convolution layer is four, and the loss function express by equation 1 below.

Here L_{cls} softmax cross entropy, L_{box} Regression, L_{mask} Means binary cross entropy. Proposed the final performance of the framework measure by comparing the images learned through Mask R-CNN after edge detection. Measured values show in the form

-1	0	+1	+1	+2	+1
-2	0	+2	0	0	0
-1	0	+1	-1	-2	-1

G(x) G(y)

Figure 5: $G_{(x)}$ and $G_{(y)}$

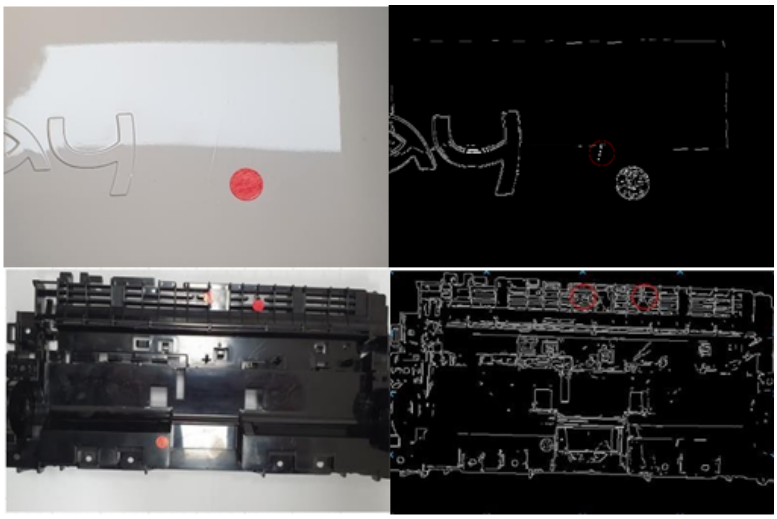

Figure 6: Canny origin (left) after (right)

Table 1: Backbone network's accuracy comparison

Network	Accuracy
ResNet32	0.9347
AlexNet	0.9441
ResNet101	0.9694

of IoU (overlapped area of predicted and actual values) and accuracy. From 3show. In order to minimize data confusion caused by various results of the measured values, only the results with the optimal measured values are checked and the last measured result is the original measured value compare and monitor the process of inspecting defective products in real time.

$$L = L_{cls} + L_{box} + L_{\text{mask}} \tag{1}$$

$$\text{IoU} = \frac{\text{Area (P)} \cap \text{nrea (T)}}{\text{Area (P) UArea (T)}} \tag{2}$$

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \tag{3}$$

The picture (Figure 7) shows the measure values for performance. If you check the above picture, you can see that the measured value of Mask R-CNN is better than the other two. When the product produced during the injection process measure using pre-trained good image data, about 6% better than Faster R-CNN and about 30% better than SVM, and the result compare with good quality data. Defective products detected (Figure 8).

5 CONCLUSION

In smart factory injection molding produce fair the process small sized From product with people similar sized products variety products produced middle product's in the production process people's with eyes to judge number do not have countless errors being detected such error to solve factory time and cost damage must be reduced do. Such damage cut down in order fair process smoothly to proceed bracket progress per course product's bad by detection fast time in bad cause grasp this to solve optimal framework need. This thesis strong edge detection algorithm using product's with scratch same bad detect new Mask R-CNN of using detected image data reliability enhance it. Finally bracket injection produce per process proposed framework to introduce furthermore inject molding factory only not variety manufacturing plant introduced fair process one step more improve number be as is expected.

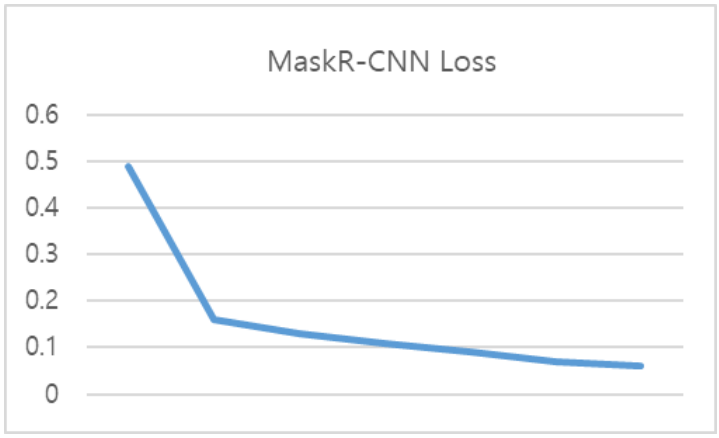

Figure 7: Mask R-CNN Loss Function

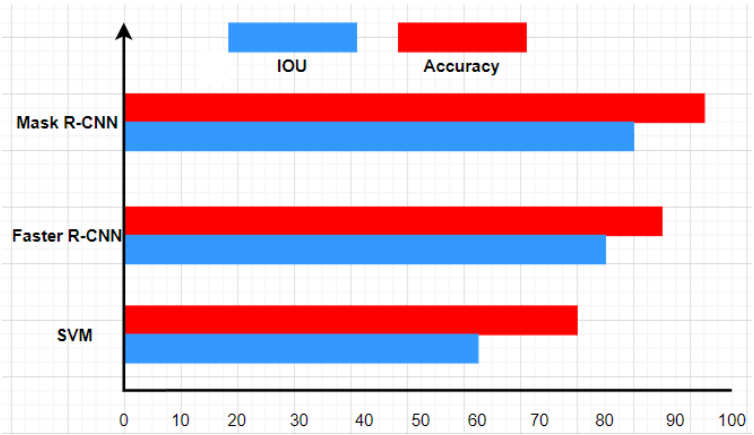

Figure 8: Comparison of IoU and Accuracy of SVM, Faster R-CNN, and Mask R-CNN

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