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Quality Control of Cigarettes Packaging using Convolutional Neural Network

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Abstract. The tobacco industry is a source of incomes for our country. Currently, cigarette consumers in Indonesia are already very high. Quality is considered as an essential point for every industry to satisfy its customers. However, some problems often occur in the Industry. Including the decline in cigarettes quality. One of the reasons for the decline in the quality of cigarettes is the lack of selection of the sorting system on cigarette packaging. The lack of quality of the packaging system makes the quality of cigarettes decreased. In a tobacco company in East Java, the fetching of defective products is still done manually. Based on the problem, the author takes that study case as the background of this research. In this system, the packs of cigarettes will be detected and selected using image processing. On the image processing will be implemented as a method of convolution neural network (CNN) this algorithm has a function to detect texture from cigarette packaging. If there is non-conforming or defective cigarette packaging, the rejector will be active and discard the cigarette packaging and it will not enter into the next packing process. The result of training data from this study had a success rate of 96.06%. When using real-time data, the system is able to classify 148 data from 154 existing data correctly. The real-time system success rate is 94,59%.

1. Introduction

Quality control for the packing product by machine vision is a kind of inspection method which has a simple system and didn't take a high cost to be applied into an industrial system. The inspection of external product-packing quality by machine vision is a no-damage inspection method that is arising in recent years [1]. In the industries of cigarettes in Indonesia, it has many inspection methods to check the cigarettes pack. The average company in Indonesia already uses an automated system. But in several cases, some industry still uses manual inspection and this method is very subjective. With Convolutional Neural Network (CNN) that will be applied into the image processing, the quality control of the system will be good and the system will be automated. Basically, CNN is from Neural Network with many developments inside it, and a Neural Network is commonly used artificial intelligence in many applications [2-4]. CNN has been performed in many researches. In 2017 J. Feng and his team have performed image processing defect identification of pipeline. The characteristics of general CNN have been well suited to deal with the problem on inspection pipeline. The proposed model can achieve higher accuracy and better robustness than the additional approaches [5]. CNN has recently succeeded in computer vision and pattern recognition. CNN has become the solution of an image object classification [6, 7] and object detection tasks [8, 9]. This method also goes into health research. The example is Automated ECG Classification [10], Fingerprint liveness [11], and



classification of breast cancer [12]. Another research is to distinguish between natural and computer-generated images. The accuracy of the data is over 80% [13].

Convolutional Neural Network [14, 15] is a kind of Neural Network that uses for image processing. In this research, the output of CNN will classify that packaging of cigarettes where it's accepted or rejected. This classification will combine with sorting system of cigarettes. So the system will work automatically, This paper contains 5 section. Section II will explain the architecture and design of the research system. Part III is the data analysis. Section IV is the conclusions. Moreover, Section V is the references for this research.

2. Methodology

The purpose of this project is checking the cigarettes packaging automatically. This project will be applied to the prototype of a sorting machine that designed like a real plan. The explanation about Hardware, Software and the overall steps of this research can be explained as follows.

2.1 Hardware Design

This project uses several Hardware. The hardware can be explained as follows.

1. Arduino Uno
This device is used to process sensor and actuator programs that will be used on this system. Arduino software includes a variety library for a run any program and any different purpose [16].
2. Personal Computer
This device is used to process the image with a convolution neural network method. Moreover, it will show the interface for this system
3. Logitech C170
It used to take an image as input data for training, and this device will be a sensor for classifying the output.
4. E-18 D50NK Proximity Sensor
This device is used to detect and count the object.
5. Motor DC 12V
It's used to drive the conveyor for object movement
6. Pneumatic Hydraulic
It's used for sorting cigarettes pack that have been classified by the sensor.

Figure 1 will show the diagram block of the system.

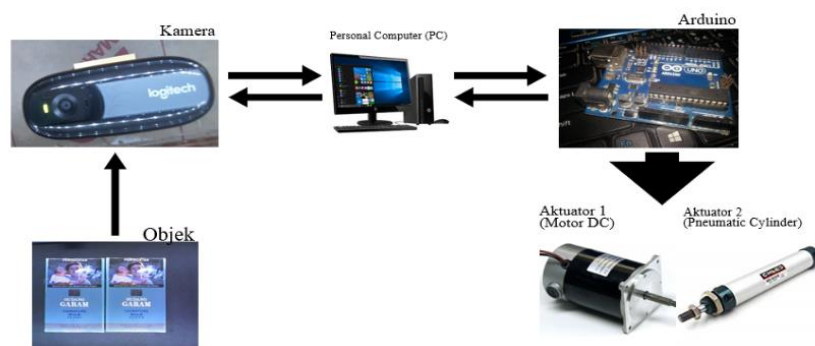


Figure 1. Hardware System Design

2.2 System Design

For the first step of the system design, make the step of CNN first. Figure 2 will show the steps of CNN process. The first step of CNN Process is making dataset. This step is significant, because this dataset will be the data for training with Neural Network. The second process is converted to grayscale. The program of CNN is only read grayscale image. Therefore it must change the underlying model which has RGB, and it must be converted into Grayscale. Next, we will go to the primary

process called Convolution. In the Convolution process all dataset will be processed automatically with the program, and in the last method, after Convolution is done, the dataset will be trained by using a neural network. After all the procedure, the system can classify the object.

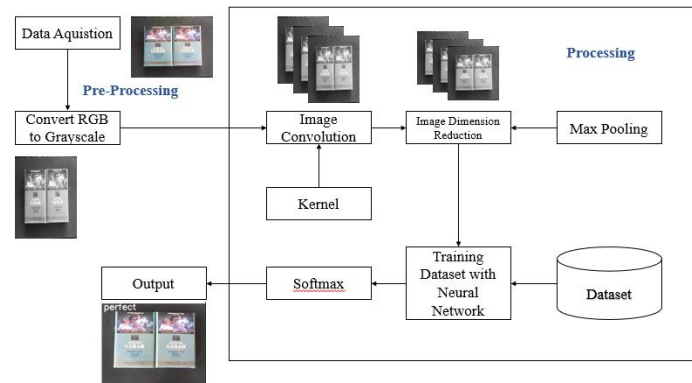


Figure 2. Process of CNN

There is 6 Step on this project, capture the purpose for the dataset, Convert the image from RGB to Grayscale, Image Convolution, Max-pooling process, Flatten Process, Training dataset with Neural Network, and Processing the Output. Before we create the steps of this project, we must create the architecture for the Image processing with CNN as shown in Figure 3.

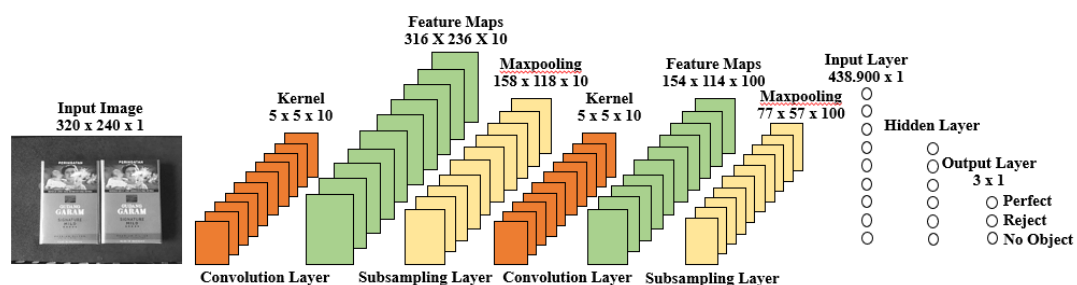


Figure 3. Convolution Neural Network Architecture

After we build the architecture of CNN, the step will be explained as follow.

2.2.1 Step 1 Capture the Object for Dataset. Image of the object is needed for Vector Input on Neural Network. So, we need to capture the object as much as possible. This project uses 320 x 240 resolution scale of the image. The system takes 3 classifications for the predicted output, the classification is perfect, reject, and no object. Every condition will take 100 datasets, so, the total is 300 for the dataset. Figure 4 will show several examples of the dataset.



Figure 4. Several Examples of Dataset

2.2.2 Step 2 Image Conversion from RGB to Grayscale. After capturing the object, we need to convert the image from RGB to Grayscale. This step is significant because CNN method is working in Grayscale Image [17].

2.2.3 Step 3 Image Convolution 1. In this Step, the grayscale input image will be combined with a Gaussian kernel. The function of this step is clear the noise. After combining input image array with Gaussian kernel array, this step will make a new variety called feature maps. Filter on this process is the step to repeat the image convolution until we got the best result. As shown in Fig. 3, the input image resolution is 320 x 240 x 1 pixels. That input pixel will be combined and processed with a Gaussian kernel which has 5 x 5 pixel with one stride and ten times of filters. This process will make a new array with 316 x 236 x 10. This process has the formula to get an array that will automatically process every single pixel on a dataset that we build. The Formula will be explained as follow.

$$\text{Convolution} = (A_n, B_n \times C_n, D_n) + \dots \dots \dots + (A_{n+x}, B_{n+x} \times C_{n+x}, D_{n+x}) \quad (1)$$

After the Convolution is done, the next step is Max-pooling process. This is the process that will reduce the feature maps from 316 x 236 x 10 to 158 x 118 x 10. It was changed because this process will take 2 x 2 pixels of the feature maps with 2 stride that will slide to all area of the feature maps and choose the most prominent pixel.

2.2.4 Step 4 Image Convolution 2. This step is similar to Image Convolution 1. The difference is the resolution of the input image. Feature maps which are the result of the Image Convolution 1 will be an input image for this process that has a smaller decision. It would be 158 x 118 x 10 pixel. An array of this input image will be processed with array of kernel 5 x 5 x 10. It will produced a new array; the result is 154 x 114 x 100. The produced image will go to the max-pooling process which is produced new array and resolution of the input image. The new image is 77 x 57 x 100 pixel.

2.2.5 Step 5 Flatten Process. Flatten Process is the process of an image that will make pixel to be vector input for training step on Neural Network. As shown in Fig. 3, the vector input would be 438.900 data. The last data of Max-pooling process is 77 x 57 x 100 pixel. It will change array from 2 dimensions to 1 dimension. Moreover, the result is 438.900 data. This data will be processed with Neural Network. In this case, this research is using several hidden layers with a different number of neurons. The selected number of neurons is a neuron that produces the best data for classifying the output. The output is divided into three classes (binary classification), there are :

- (1 0 0) = No Object
- (0 1 0) = Perfect
- (0 0 1) = Reject

2.2.6 Step 6 Fully Connected. After the vector input has been created, the process will continue to the training process with the python program. Moreover, the last step is Fully Connected. This step is used to classify the output of the image. The production is Perfect, Reject, and No Object. The production will be used to sort the cigarettes pack.

3. Test Result

The training process has several experiments. It uses much analysis to optimize the best data of an image. In this research, the number of used neurons are 24 neurons and 100 epoch for training the data.

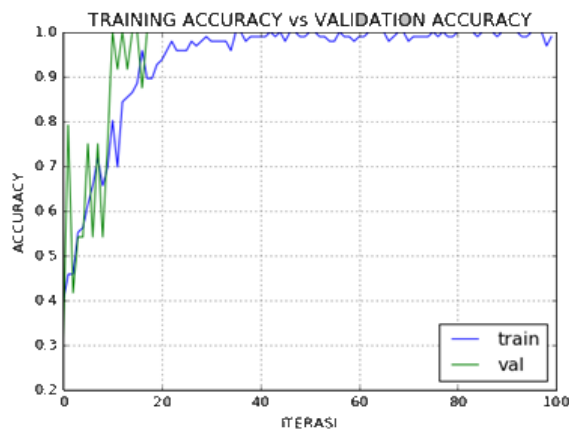


Figure 5. Mean Square Error Graphic

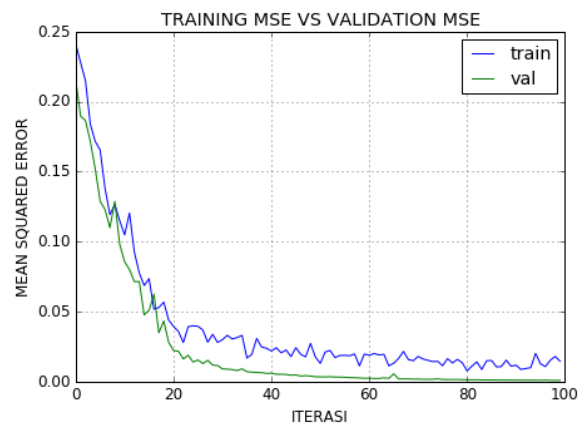


Figure 6. Accuracy Graphic

Figure 5, shows the performance of Mean Square Error. MSE training on the data begins at 0.23. When the iteration runs, MSE in Training data has decreased and its approaching to zero. In the 40th iteration, MSE in Training data starts to be constant at 0.04 - 0.02. While for Testing data begins at 0.21. When the iteration begins, the Testing data is decreased. When it reaches the 40th iteration, the Testing data starts to be constant at 0.01.

From the **Error! Reference source not found.**, the graphics show the line of the graph is stable when the iterations are over 40. The data is able to classify with the accuracy up to 100%. For this graphic, it has the formula to count it manually, and it will be shown as follows.

$$P = \frac{\sum \text{train}}{n_i} \times 100\% \quad (2)$$

As explained in the discussion of neuron analysis, Training data starts at 0.39 or 39%. In the 40th iteration, Training data values are stable at 0.98-1 or 98% - 100%. From the graph, the average training data is 96.06%, it means that from 96 training data, 90 data can be detected correctly. For the results of the Testing data, the first iteration has a value of 0.29 or 29%. In 20th iteration, the data is very stable at 1 or 100%. The Testing data obtained an average amount of 95.62%. Means, from 24 testing data samples, the system is able to detect 23 data precisely. Figure 7 will be shown the classification of CNN

TARGET	OUTPUT (BINARY OUTPUT)	INFORMATION	DISPLAY OUTPUT
PERFECT	PERFECT (0 1 0)	CORRECT	
REJECT	REJECT (0 0 1)	CORRECT	
REJECT	PERFECT (0 1 0)	WRONG	
NO OBJECT	NO OBJECT (1 0 0)	CORRECT	

Figure 7. Classification of CNN Result

4. Conclusion

Based on the experimental result of CNN architecture were almost perfect. From the results of architectural CNN analysis, kernel results are obtained according to the architecture; this is using 5 x 5 kernels with a total of 10 filters. The convolution process in this architecture occurs two times, and it produces 438,900 Input Vectors for the training process with the neural network. From this research, the number of Hidden layers that are suitable for this application is 24 hidden layers. If the method uses the existing data, then the accuracy percentage is 95.62% from 24 data tested. While in real time testing, the obtained testing percentage is equal to 94.59%.

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