Crop for Recognizing Control Logic Drawings

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1. Introduction

With the development of Artificial Intelligence (AI) technology, demand in technology engineering industries such as medical, aviation, defense, and Nuclear Power Plants (NPPs) is increasing.

Although digitization of NPPs is in progress, control logic drawings are stored in image or hardcopy format.

Control logic drawings include a designer's control logic diagram (CLD, Control Logic Diagram) and a manufacturer's control logic diagram (VLD, Vendor Logic Diagram).

From 2020, we have been developing a technology to convert CLD and VLD into normalization drawings (vector type CAD drawings) and verify logic through the "Development of Digital Control Logic's Verification Technology based on Artificial Intelligence" task [1].

YOLOv3 is based on Convolutional Neural Network (CNN). In addition to the advantages of YOLOv1 and YOLOv2, the backbone architecture has been changed from darknet-19 to darknet-53, and performance has been improved by introducing Feature Pyramid Networks (FPNs). It is the most representative algorithm of the One-stage object detection, which learns at multiple scales, predicts the boundary using the anchor box, and predicts the object through the boundary box.

The input resolution can be selected from 320 X 320, 416 X 416, and 608 X 608 pixels, and the resolutions are shown in numerical values in proportion to the recognition rate and speed. When set to 320 pixels, the speed was fast, but the accuracy was low, and when set to 416 pixels, the speed and recognition rate were excellent, and when set to 608 pixels, the recognition rate was the best, but the speed was very slow, so 416 pixels was used as the input value [2].

When recognizing an image with YOLOv3, an AI technology used for image recognition, if the image to be recognized is large, the YOLOv3 algorithm resizes the image arbitrarily. In that case, image cropping is essential for the task, as the resolution of the drawing becomes a problem.

This paper describes the problems that occur during image cropping for image recognition of the developed program and introduces solutions.

2. Cropping Problems

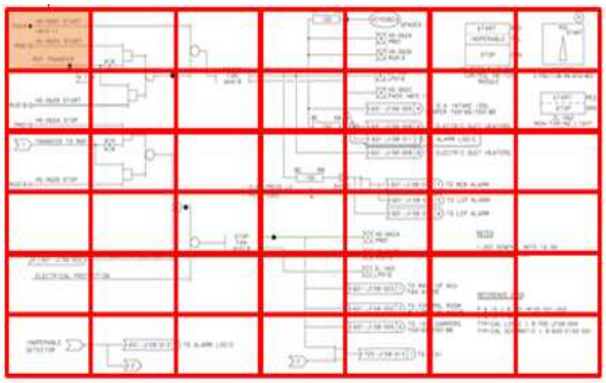

Fig 1. Crop drawings

2.1 Cropping Size

Because the size of the original drawing varies and the non-standardized drawing is cut to an arbitrary size, optimization is necessary.

2.2 Cropped Image Boundary Area

There is a problem that symbols on the cut boundary cannot be recognized.

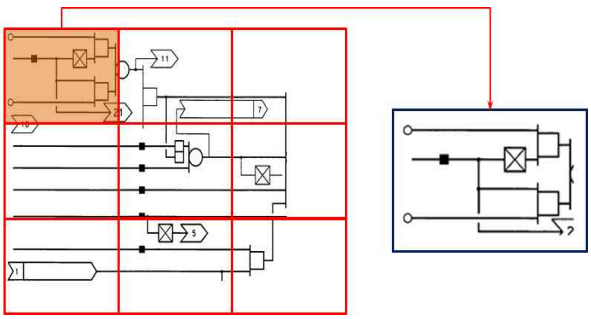

Fig 2. Crop Image boundary Break

2.3 Right End Drawing Loss Problem

Due to the difference between the original drawing size and the crop size, images remaining at the right end are created.

Since the loss has to be dealt with, an unnecessary process is implemented, which slows down processing.

3. Solution

The original drawing size was standardized as 4678X3308 based on the contents of "Line Recognition Method in Control Logic Diagram" [3].

3.1 Crop Size Optimization

After cropping to various sizes, the recognized result values are compared to find the optimal size.

3.2 Modified Sliding Window Method

Usually sliding window method is finding a specific object[4].

Modified Sliding Window (MSW) method is recognizing some section image using a similar sliding window way.

The MSW method is a way of recognizing by shifting 150 pixels, the largest value among symbols, to the x-axis, y-axis, and x-y-axis.

If the symbol located on the boundary of the cropped image is cut, the symbol cannot be recognized, so the MSW method must be used.

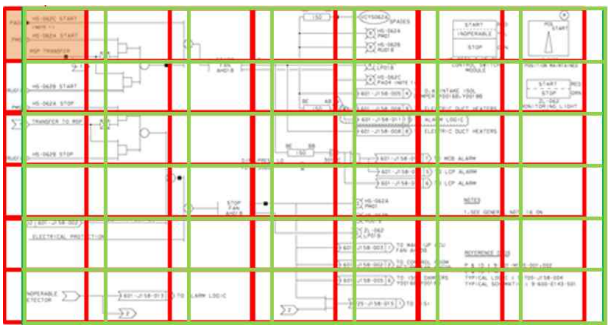

Fig 3. MSW method

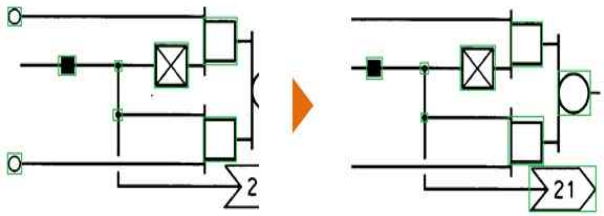

Fig 4. Result of MSW method

3.3 Right End Drawing Processing

3.3.1 White Padding

If the remaining area based on the preceding crop image is smaller than 150pixel, it is recognized while performing the MSW in the next process, so the blank area is processed for the corresponding area in the first process.

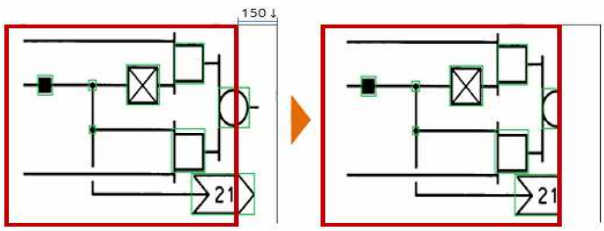

Fig 5. White Padding

3.3.2 Cropping Shift

If the remaining area is larger than 150pixel based on the immediately preceding cropped image, crop from the right end of the drawing.

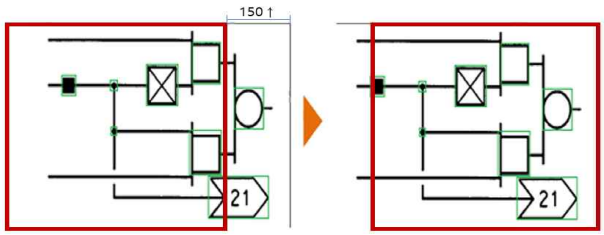

Fig 6. Cropping Shift

4. Test

4.1 Experiment Environment

After preparing 10 original drawings (4478X3308), only the drawing recognition part was extracted in the nCLD program to create an experimental environment.

4.2 Experimental Method

The original drawing is cut to a certain size by using the function in nCLD, and the data that has been recognized is compared with the naked eye to quantify the recognition rate to make a data set.

The data uses the following six (6) cases.

a. (500X300) Cropped Image
b. (200X200) Cropped Image
c. (300X300) Cropped Image
d. (300X500) Cropped Image
e. (500X1000) Cropped Image
f. (500X300) Cropped non-MSW

4.3 Crop Size Optimization Test

Compare the results according to cropping from ‘a’ to ‘e’ among the six (6) cropping sizes in 4.2.

4.4 Using the MSW

To see if the MSW function introduced to solve the boundary line problem is effective, we compare the recognition rate when using the MSW function and when not using it. (Compare a, f)

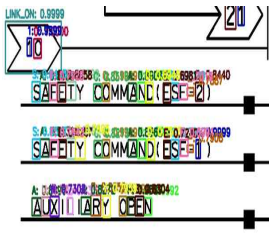

Fig 7. Not use MSW

Fig 8. Using MSW

5. Result

5.1 Crop Size Result

Table 1: Crop Size

No	500X300 Recog.(ACC)	200X200 Recog.(ACC)	300X300 Recog.(ACC)	300X500 Recog.(ACC)	1000X500 Recog.(ACC)
A	2,069(89%)	2,081(90%)	2,267(98%)	1,269(55%)	725(31%)
B	2,260(92%)	1,727(70%)	2,415(98%)	1,541(63%)	831(34%)
C	1,511(93%)	971(60%)	1,581(98%)	961(59%)	636(39%)
D	1,786(93%)	1,098(57%)	1,854(97%)	1,197(63%)	693(36%)
E	2,000(94%)	1,592(75%)	2,117(99%)	1,215(57%)	693(32%)
F	2,527(90%)	2,177(77%)	2,704(96%)	1,570(56%)	806(29%)
G	1,826(86%)	1,590(75%)	1,984(94%)	1,265(60%)	567(27%)
H	1,483(90%)	1,129(68%)	1,575(95%)	977(59%)	589(36%)
I	1,166(91%)	876(68%)	1,236(96%)	767(60%)	465(36%)
J	2,727(89%)	2,104(69%)	2,891(94%)	1,853(61%)	1,087(36%)

The recognition rate is about 90% higher when the image is cropped than when the image is not cropped.

In initial recognition, all symbols and all text were recognized. The size of the 500X300 was cropped to accommodate the recognition of the largest "link-off" symbol among the symbols, but the "link-off" symbol was recognized as a separate (850X600) during the feature update process.

Therefore, in this experiment, it seems to recognize best when cropping with 300X300.

5.2 MSW Result

Table 2: MSW (500X300)

No.	MSW (Recog. (ACC))	Non MSW (Recog. (ACC))
A	2,069(89%)	1,846(80%)
B	2,260(92%)	2,083(85%)
C	1,511(93%)	1,411(87%)
D	1,786(93%)	1,655(86%)
E	2,000(94%)	1,831(86%)
F	2,527(90%)	2,282(81%)
G	1,826(86%)	1,656(78%)
H	1,483(90%)	1,407(85%)
I	1,166(91%)	1,084(84%)
J	2,727(89%)	2,486(81%)

When there is a MSW function, it shows a recognition rate that is about 7.4% higher.

6. Conclusions

In this paper, in the drawing recognition technology development project using AI, an experiment was conducted on a technology that can increase the accuracy when recognizing symbols and text lines.

According to the experimental results, the image crop size should be changed from 500X300 to 300X300 to increase the accuracy of drawing recognition.

Also, the MSW method must be introduced essential for boundary recognition.

REFERENCES

[1] D. I. LEE, Development of Digital Control Logic's Verification Technology based on Artificial Intelligence, Conference on Information and Control Systems, p397-398 ,2020

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[4] Adrian Rosebrock, Sliding Windows for Object Detection with Python and OpenCV, 2015
(link : https://pyimagesearch.com/2015/03/23/sliding-windows-for-object-detection-with-python-and-opencv/)