Symbols of Control Logic Drawing Recognition Rate Improve

Dongil Lee [a*], Kyeong wan Kim [a], Jeong han Lee [b]
[a]*KHNP, Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, South Korea*
[b]*HUPEC,10 Dongtan-daero 21-gil, Hwaseong-si, Gyeonggi-do, South Korea*
[*]*Corresponding author: diturtle@khnp.co.kr*

1. Introduction

As digitalization accelerates in the field of nuclear power plants, the importance of software is increasing.

In order to verify software for nuclear power, V&V is being conducted based on IEEE1012-2004 [1].

Automation for V&V is difficult in reality, but many people have built and implemented V&V systems in various ways.

The Control Logic Drawing (CLD) of a nuclear power plant includes a designer's control logic diagram and a manufacturer's control logic diagram. Control logic drawings exist in various file formats (PDF, JPG, PNG, TIF, DWG, etc.) Based control logic drawing verification automation technology was developed.

nCLD is a technology that verifies the logic in AutoCAD (Computer Aided Design) by recognizing CLDs existing in various files as images and converting them into regular drawings (vector drawings) [2].

As a process that must be preceded in order to verify the drawings, the technology of converting original drawings in various forms into regular drawings must be preceded. YOLO (You Only Look Once) v3 was used to convert to a canonical drawing.

When symbols in the control logic drawing are recognized using YOLOv3, the recognition rate is different depending on the size of the symbols even if the symbols used in the control logic drawing are the same.

Determine the size of the bounding box to extract the characteristics of the symbol and change the size of the bounding box between -20 pixel and +20 pixel for optimal recognition of each symbol based on the experimental results.

In this treatise, we try to explain a method for obtaining high recognition rate and accuracy by changing the size of the bounding box for each symbol.

2. What is nCLD

It is a software that recognizes images in the form of drawings, generates the information in the drawings as vector-type normal-form drawings (AutoCAD), and verifies the control logic drawings with the output values for the input values in the created drawings [2].

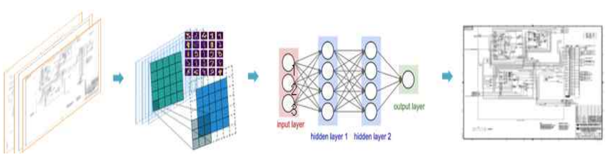

Fig. 1. Normalization of Drawing

2.1 Control Logic Drawing Recognition

Control logic drawing recognition recognizes drawings using YOLOv3, which is one of the representative methods of one-stage detectors. In this study, the default size of the control logic drawing used in a nuclear power plant is 4,478*3,308 pixels, which is much larger than the size of the bounding box used in YOLOv3 (default 418*418 pixels) [3]. Therefore, in order to recognize a symbol, the drawing is divided and recognized, the results are collected, and a single normal (vector) drawing is regenerated.

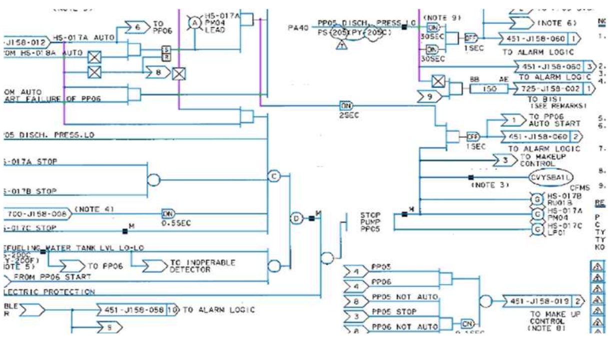

Fig. 2 Drawing Recognition Results

2.2 Calibration of the recognition control logic drawing

When recognizing a drawing, a recognition area and an exclusion area are divided and recognized in the drawing. If necessary, a specific line or symbol can be added.

After recognizing the drawing, it is necessary to correct the symbols and lines according to the recognition rate. Symbols with a low recognition rate are improved by the user's correction work.

2.3 Control Logic Verification

2.3.1 Input signal generation

By setting input values, you can verify changes in real time. Input methods include table input, real-time drawing input, and the like.

2.2.2 Drawing Verification (Simulation)

There are three (3) ways to check the output for the input value. (1) a highlight method that checks the output on the drawing in real time, (2) a table method that detects the output with respect to the sequential method of the input, and (3) a timing diagram method that verifies the change of the output according to the real-time input.

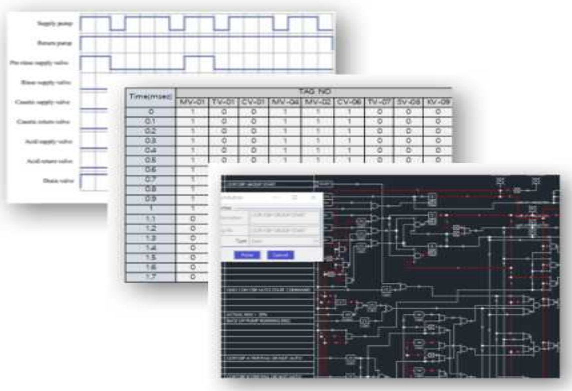

Fig. 3 Verification method

3. Decreased recognition rate according to symbol size

In the process of recognizing a symbol, even the same symbol has a great influence on the recognition rate depending on the size.

In the control logic diagram, even the same symbol has various sizes. A difference in the size of the symbol causes a recognition error. If the size of the smallest symbol or the largest symbol is used as a reference, the recognition rate is greatly reduced.

When the recognition rate of a symbol cut in the process of dividing a drawing is higher than that of an intact symbol, a problem arises in that the line connected to the symbol is disconnected due to the cut symbol. Also, if the truncated symbol recognition rate is high, the symbols cannot be recognized correctly by discarding intact symbols when merging divided drawings and selecting (mis-detection) truncated symbols.

4. Solution Method

In recognizing a drawing, five steps are followed to accurately recognize a symbol.

STEP-1, Recognize the divided drawing and get information on the size of the bounding box for all symbols.

STEP-2, All symbols have different bounding box sizes even if they are the same symbol, so find the maximum and minimum sizes for each symbol.

STEP-3, Correct the values of -20, -10, 0, +10, +20 based on the maximum and minimum values of the bounding box for each symbol to find a correction value with high accuracy.

STEP-4, Only the results within the range are recognized by applying the correction value with high accuracy to the range of the maximum and minimum values of the bounding box for each symbol. In this process, false positives for truncated symbols are eliminated.

STEP-5, When merging the divided drawings, all symbols except for the symbol with high recognition rate among the symbols overlapping with the same coordinate value are removed.

5. Test

In the experimental method, the recognition rate was obtained by doing -20 pixel to +20 pixel for the maximum and minimum values of the bounding box of each symbol.

Table I: Data on recognition rate according to symbol-by-symbol correction

	-20 px	-10 px	0 px	10 px	20 px	Real
OR (recognize%)	11 (40)	27 (100)	27 (100)	12 (44)	0 (0)	27
LINK_ON (recognize%)	15 (44)	33 (97)	34 (100)	6 (17)	4 (11)	34
LINK_OFF (recognize%)	6 (100)	6 (100)	6 (100)	6 (100)	1 (16)	6
CONNECTION (recognize%)	0 (0)	1 (1.9)	52 (100)	1 (1.9)	0 (0)	52
A (recognize%)	100 (92)	108 (100)	109 (101)	56 (51)	9 (8)	108
B (recognize%)	11 (100)	11 (100)	11 (100)	4 (36)	4 (36)	11
C (recognize%)	83 (86)	95 (98)	99 (103)	33 (34)	6 (6)	96
D (recognize%)	27 (75)	36 (100)	36 (100)	11 (31)	6 (16)	36
E (recognize%)	135 (79)	165 (97)	170 (100)	68 (40)	7 (4)	170
F (recognize%)	32 (100)	32 (100)	32 (100)	22 (68)	0 (0)	32
G (recognize%)	21 (100)	21 (100)	21 (100)	14 (66)	3 (14)	21
H (recognize%)	37 (100)	37 (100)	37 (100)	28 (75)	6 (16)	37

The recognition rate was different according to the correction of the size of the bounding box to recognize the symbols of the control logic drawing of the nuclear power plant. It can be seen that most of the symbols have a higher recognition rate between -10pixel and +10pixel.

6. Conclusion

If the correction value is too high, a problem occurs because it exceeds the recognizable height, and if the size is reduced too much, recognition itself is impossible. When recognizing a symbol in a scanned drawing, the maximum and minimum values of the symbol's bounding box should be determined according to the experimental results. For most symbols, it is recommended to set the size of the bounding box to a value of -10 pixels to +10 pixels. However, depending on the experimental results, the size of the bounding box should be different for a specific symbol. In the control logic drawing to be applied in the future, duplicate detection and false detection should be prevented by setting the maximum/minimum value of the bounding box in the following process.

REFERENCES

[1] IEEE Computer Society, IEEE Std 1012 for software verification and validation, 2004.
[2] D. I. LEE, Development of Digital Control Logic's Verification Technology based on Artificial Intelligence, Conference on Information and Control Systems, p397-398 ,2020
[3] J. Redmon and A. Farhadi, "YOLOv3: An incremental improvement", arXiv:1804.02767, 2018