Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2015

Recognition of Instrumentation Gauge in the Nuclear Power Plant

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1. Introduction

Tokyo Electric Power Company, Inc. (TEPCO) have released investigation videos of the isolation condenser (IC) system located on the 4th floor of the Unit 1 Reactor Building of the Fukushima Daiichi Nuclear Power Plant [1],[2]. An IC is an alternative core cooling system, provided for the failure of an ECCS (emergency core cooling system) in a DBA (or severe accident, core meltdown) situation.

When the tsunami due to M9.0 earthquake settled down at the Fukushima Daiichi nuclear power plant, a MCR (main control room) operator went to the reactor building for the onsite inspection of the IC water level at late afternoon on March 11, 2011. However, the operator withdrew from the building entrance because the radiation level was unusually high.

Nuclear emergency robots were developed in 2001 as the countermeasure following the criticality accident at the JCO (uranium refinery facility) in Tokaimura, Japan in 1999. We assumed that these nuclear emergency robots were deployed (or put into) for a mitigation (or management) of severe accident, for example, occurred at Fukushima Daiichi nuclear power plant. In the case, the image understanding using a color CCD camera, loaded on the nuclear emergency robot, is important.

We proposed an image processing technique to read indication value of the IC water level gauges using the structural characteristics of the instrumentation panels (water level gauges) located inside the reactor building. At first, we recognized the scales on the instrumentation panel using the geometric shape of the panel. And then, we could read the values of the instrumentation gauge by calculating the slope of the needle on the gauge. Using the proposed algorithm, we deciphered instrumentation panels for the four water level gauges and indicators shown on the IC video released by TEPCO and Japanese Nuclear Regulatory Commission of Japan.

2. Instrumentation Panels inside Reactor Building

TEPCO have released five videos related to the investigation of the IC system located on the 4th floor of the Fukushima unit 1 reactor building. We analyzed two of these videos that displayed the pathway from the building entrance on the 1st floor, approaching the target location on the 4th floor, from the viewpoint of a robot. Figures 1 shows the instrumentation (IC water level gauge) panels located on the 4th floor of the unit 1 reactor building.

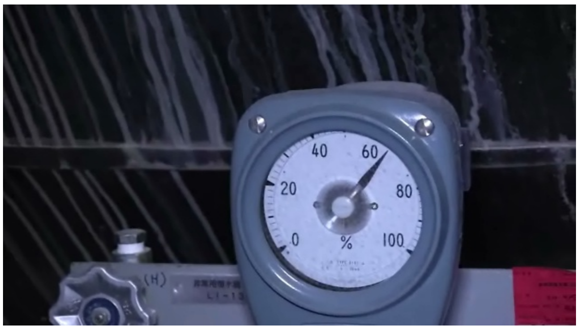

Figure 1. A water level gauge of an IC (Train A)

3. A Recognition of Instrumentation Gauge.

As shown in Fig. 1, the instrumentation (water level gauge) panel of the IC system is a mechanical type. The water level gauge is graduated with lines. In case of reading an indicator of the instrumentation gauge, shown in Fig. 1, by the naked eye, we can guess an indication value by counting the number of graduated lines in relation to the needle tip.

In this paper, in order to read an indicator of the mechanical-typed instrumentation gauge by an image processing technology, several suppositions were assumed as followings.

Supposition 1. The minimal and maximal scales of the instrumentation gauge are located below the midpoint (center) of the circular (or elliptical) typed gauge with reference to a Y (vertical) axis.

Supposition 2. The minimal scale of the instrumentation gauge is located below the midpoint (Y-axis) of the gauge, and at the minimal point of the X (horizontal) axis.

Supposition 3. The maximal scale of the instrumentation gauge is located below the midpoint (Y-axis) of the gauge, and at the maximal point of the X-axis.

Supposition 4. An indicator needle of instrumentation gauge is positioned between the minimum and maximum scale of the gauge.

The process of reading the instrumentation gauge is mainly divided into three parts. First, we obtain a center of the circular-typed instrumentation gauge. Second, we find the minimal and maximal scales, located on the gauge. Third, we calculate the direction (slope) of an indicator needle of the instrumentation gauge. The result of the image reading of the instrumentation gauge (IC water level meter) by the image processing technology, shown in Fig. 1, is shown in Fig 2.

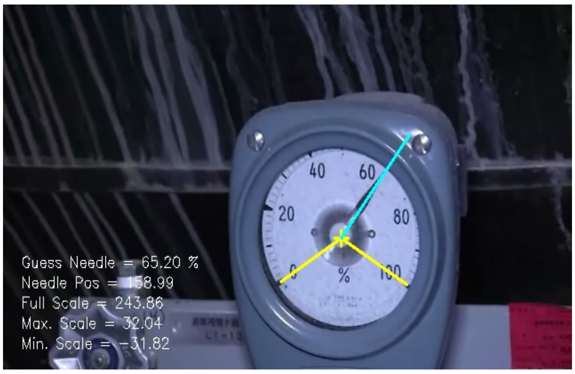

Figure 2. A recognition of the IC water level gauge (Fig. 1)

Figures 3-5 show the indicator reading results of the instrumentation gauges calculated by using the proposed algorithm.

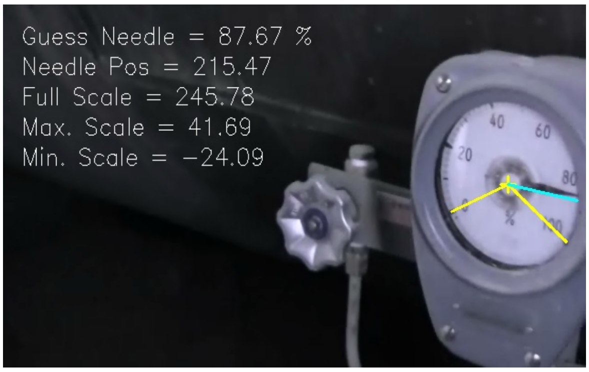

Figure 3. Recognition of an another IC water level gauge

Figure 4. Reading result of the pressure gauge

In Figs. 4 and 5, real pressures of the tank and D/W (drywell) are calculated as follows.

$$Pressure_{TANK} = Guess_{Needle} \times Scale_{MAX} = 0.4638 \times 15 \cong 6.96\, kg/cm^2 \quad (1)$$

$$Pressure_{DRYWELL} = Guess_{Needle} \times Scale_{MAX} = 0.3235 \times 0.5(\max - \min) - 0.1 \cong 0.06 \quad (2)$$

Figure 5. Recognition of the D/W (dry well) pressure

4. Conclusions

In this paper, recognition of the instrumentation gauges inside reactor building of the nuclear power plant by an image processing technology is described. The sample instrumentation gauges are IC water level gauges from the investigation images of the unit 1 reactor building at Fukushima Daiichi nuclear power plant, as released by TEPCO in Japan. The instrumentation gauges are mechanical analog type. We were able to recognize the indicator of the instrumentation gauges using their geometric structure.

REFERENCES

[1] Tokyo Electric Power Company, Inc., "The image of the situation inside the Unit 1 Reactor Building of Fukushima shown to the National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (recorded on October 11, 2011)," http://www.tepco.co.jp/nu/fukushima-np/
[2] Tokyo Electric Power Company, Inc., "Investigation image of the Unit 1 Reactor Building on the 4th floor at Fukushima Daiichi Nuclear Power Plant (recorded on November 30, 2012)," http://www.tepco.co.jp/nu/fukushima-np/