

Background

Various types of analog meters are installed in Japanese factories to monitor conditions and detect abnormalities in the manufacturing process. Therefore, human inspectors have to go around the factory and visually read the values of the meters, record the data, and take proper actions if needed. This work is done manually, which puts a heavy burden on the inspector and is prone to human error. The purpose of this study is to automate the manual process by using deep learning models of object detection and image processing.

Our proposal

Our proposed method consists of six steps using the object detection method SSD (Single Shot Multi-Box Detector) and image processing. SSD is trained to detect flow and float. Image processing is used to normalize the image and improve the reading accuracy.

Below are the basic steps for automatic reading (see Fig. 1):

1. Detect the flow meter using SSD
2. Image normalization
3. Detection of flow meter scale range by image processing
4. Detect the float using SSD

5. Estimate the coordinate of the float by image processing
6. Estimate the value of the flow meter

Reading experiment

We performed experiments to measure the accuracy of our reading method. We performed the reading process on 100 images of each scale (1~10) and the results are shown in Table 1.

The error for each value is basically within the range $[-0.2, 0.2]$, which is within the tolerance for practical application. The brightness in the image could cause image processing to fail and errors to increase. Therefore, it is better to use the average or median value as the reading result in multiple frames.

Table 1: Reading experiment result

| True Value | Average | Max error | MeanAE | MedianAE | MeanSE |
|------------|---------|-----------|---------|----------|---------|
| 1 | 0.99509 | 0.09689 | 0.02392 | 0.00589 | 0.00096 |
| 2 | 2.09011 | 0.15242 | 0.09252 | 0.10631 | 0.01020 |
| 3 | 3.04961 | 0.14007 | 0.06852 | 0.06596 | 0.00593 |
| 4 | 4.03442 | 0.13864 | 0.05850 | 0.05069 | 0.00453 |
| 5 | 5.00306 | 0.16627 | 0.04311 | 0.01757 | 0.00313 |
| 6 | 5.93219 | 0.19298 | 0.07418 | 0.05133 | 0.00871 |
| 7 | 6.98281 | 0.21068 | 0.04376 | 0.00362 | 0.00395 |
| 8 | 7.92566 | 0.28974 | 0.08971 | 0.07806 | 0.01168 |
| 9 | 8.98525 | 0.22726 | 0.06038 | 0.01034 | 0.00525 |
| 10 | 10.0087 | 0.17091 | 0.09072 | 0.04698 | 0.00942 |

Schematic diagram of the proposal

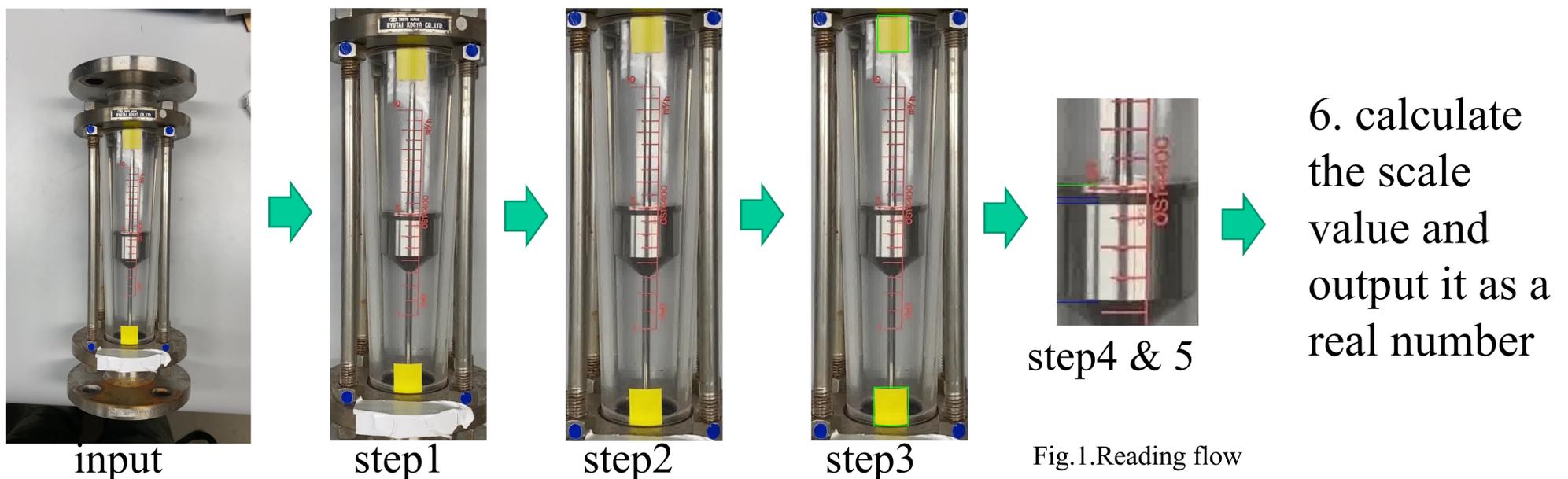


Fig.1. Reading flow