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Analysis of Light Influence on The Camera Measurement for Better Calibration Process in Electronic Industry

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Abstract

Machine vision systems have been used in the automatic inspection of connector product in electronic industry. Everyday the condition of automatic inspection machine must be checked by using a master product to make sure that the result of measurement is according to requirement. When the result is out of specification, the inspection machine must be re-calibrated. Time that is required for once calibration is about 8 hours. Light is one of factor that influence measurement result. In this study first of all, this paper set up the experimental platform for measure dimension of object by using camera. Pixel equivalent that is got by calibration experiment is 0.044 mm / pixel with measurement range of 0.044 ~ 21.956 mm. Secondly, analysing experimental data of measurement result by changing light intensity. This paper try to find correlation between light intensity and dimension result of the machine vision result to get a better formula that can be used to calibrate a machine vision in order to make less frequency of calibration process.

keyword : camera, inspection, calibration, light.

1. Introduction

Size measurement is important at the stage of product inspection in the world of industry. Appropriately and accurately measurement on the inspection of a product is important that all products produced in accordance with the quality standards desired by consumers and provides benefits for producers by reducing production time and cost saving production may be done.

The inspection process which is usually done manually by the human senses, start from viewing, measuring and comparing the sample or a standard product and then record and documenting the result obtained. Those entire manual inspection is done by manually contact measurement.

For small size of product, manually contact measurement is easy to destroy the surface and change their relative position, thereby affecting the measurement accuracy. For mass production, sampling can only be used. In inspection process, using the quality of the sample can be used to be the standard of the entire batch product [1]. Meanwhile, a long-term work can cause the fatigue of the body and eyestrain, which in turn brings stability problems, and poor working condition will also affect health and mood the operator. thus in certain aspects, such as measurement speed, accuracy, automation and security, the limitation of traditional measurement method which is unable to meet modern manufacturing time online, non-contact measurement, high-speed precision development is needed.

Size measurement must be done by measuring tools, which have gone through several stage of mechanical, optical and electrical type and so on. Nowadays, digital image process by using camera inspection is applied widely in visual inspection method. The visual inspection using a camera inspection as a measurement tools offers several advantages over manual based inspection. There are

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advantages include minimize set up time, real-time scanning, reduce inspection time and more widely data saving capability.

2. Automated Visual Inspection

In the manufacturers of connectors in electronic industry have to conduct the inspection of the product. Machine vision will provide information OK if the results of measurements according to the limits specified dimensions and will provide information NG (Not Good) if the results of measurements outside the limits specified dimensions. Method checks are performed depends on the level of requirements expected by customers. Among the several existing methods of inspection performed should be measured one by one in certain parts of the product. This is necessary because it relates to the function of the product for example lead coplanarity inspection on connector for computer hard drive. Lead coplanarity is the the distance between the lead connector and the PCB to be soldered. The required distance is maximum 0.1mm. If the distances are greater than 0.1mm there is the potential occurrence of a failure in the soldering process performed by the customer, resulting in a product malfunction. Examination manually using a measuring instrument such as a projector or a measuring microscope is very time consuming and has the potential for measurement error due to be done by humans due to fatigue and condition factor of the human. Examples of machine vision applications are shown in Fig. 1.

![Figure 1. Example of automated visual inspection that is applied in electrical industry](image)

The surface shape of the measured lead connector is a flat field but on the edges are curved or radius field that is caused by cutting process of the connector lead through a stamping process. In the production process, machine vision that is used to measure the connector product must be verified daily to ensure that the conditions are still able to work in accordance with the checked by comparing the measurement results using the product master. Difference permitted ie 0.04mm or equivalent to two pixels as one pixel calibration measurements in machine vision is worth to 0.02mm. If the difference between the actual and the results dimension measurements using machine vision greater than 0.04mm machine vision then it should be recalibrated. The time required to re-calibrate approximately 8 hours so that this condition interfere production process.

Based on historical data of production in the PT. JST Indonesia, the average calibration process is done every single week. From the results of investigations and inspections conducted by the maintenance acquired that distance and the angle between a product with a camera no great changes, the maximum changes are only about 0.2 mm caused by linear bearings on a carrier product that is always moving back and forth during the examination process and clearance among the products with the holder of products to facilitate the process of laying and retrieval product during the process. Cameras is fastened using bolts firmly enough with a fixed position. Setting the camera focus was no change and locked in the starting position. The surface of the lens on the camera is in clean condition because cleaning process is carried out every day to avoid dirt or dust that may result in noise in the image when it is done by a machine vision process. One among several factors affecting the change in the measurement results that is done by machine vision is the light intensity factor.

3. Calibration system

The definition of calibration according to ISO/IEC Guide 17025:2005 and Vocabulary of the International Metrology (VIM) is a series of activities that establish a link between the value indicated by the measuring instrument or measuring system, or values represented by a material measure, with values already known relating the magnitude measured under certain conditions. The purpose of
calibration is to achieve measurement traceability. Calibration should be carried out periodically. The time interval is influenced by the type of calibration of measuring instruments, frequency of use, and maintenance.

The size in pixels is converted to the physical of the space. This process is completed by the system calibration. Specific steps are as follows:

- Select a standard part whose size has been known. Size is: $S$
- When the measurement system is working correctly and measurement of environmental is steady, this standard part is measured using the measurement system to obtain the size in pixels: $S_p$.
- Calibration factor is calculated according to the formula

\[
K = \frac{S}{S_p}
\]

4. Design of Experiment

Object that is used to check dimension result of machine vision is a bolt that has 17.76 mm length. Web camera with specification 2 mega pixels is set 35mm in front of the object for capture the object image. Light Emitting Diode (LED) is set 50mm behind the camera for giving light to object. Light controller is used to change intensity of light from LED. Digital light sensor type BH-1750 is set 55mm behind the object in order to measure intensity of light that exist in the system and connected to Arduino (single-board microcontroller) that receives input signal from light sensor. Intensity of light is then forwarded to computer by using serial communication between Arduino and computer. Equipment and setting position of design of experiment can be seen in figure 2.

![Figure 2. Equipment and setting position of design of experiment](image)

This experiment uses Qt application software for processing the image. First, image is captured every 100 ms. This original image then is processed by using a median filter. This filter is particularly useful to combat salt and peeper noise and has advantage of preserving the sharpness of the edges. It operates on a pixel's neighbourhood in order to determine the output pixel value. The pixel and its neighbourhood form a set of values and, as the name suggests, the median filter will simply compute the median value of this set, and the current pixel is then replaced by this median value [2].

Second, image after filtering is processed to find edges of the object. There are many method that can be used to find edges in image processing. In this experiment used Canny edge detector because it result sharp of edges better [3]

Algorithm in designing of this experiment can be made according to the step below:

1. Start
2. Define length of object and set it in front of camera.
3. Set light intensity until the object can be seen clearly between object and background.
4. Take size of object length in Pixels and calculate object length in mm by using formula to find calibration factor.
5. Input calibration factor in calculation for displaying the measurement result in mm.
6. Check stability of the system by taking data 10 times.
7. If result of the system is stable continue to set light intensity to find correlation between light and measurement dimension of the system.
8. If result of system is not stable back to step 3.
9. Set light intensity step by step from low level to high level.
10. Record the result of measurement for each step of light intensity level.
11. Find correlation between the change of light intensity and measurement result as a factor that must be included in calculation of calibration formula.
12. Input additional calibration factor of light in calculation.
13. Set light intensity step by step from low level to high level.
14. Record the result of measurement for each step of light intensity level.
15. If measurement result is stable it conclude that measurement system can work more stable although light intensity is changed.

Algorithm of QT programming can be seen below.

```cpp
Mat capture, smooth, edge;
timer->start(100);
// Blur the image so that edges detected by Canny due to noises will reduced
medianBlur(capture, smooth, 5);
for(int i = 0; i < 10; i++)
    medianBlur(smooth, smooth, 5);
// Edge detection
Canny(smooth, edge, 80, 80, 3);
int c=0;
int y=245;
for (int x=50; x<edge.cols; x++)
{
    if(x<550)
    {
        if(edge.at<uchar>(y,x)>240)
        {
            c=c+1;
            if(c==1)
            {
                o=x;
                p=y;
            }
            else
            {
                s=x;
                t=y;
            }
        }
    }
    countPixel=s-o;
dim=countPixel/22.69;
}
```

First this paper try to set light intensity that is received by light sensor at 14 Lux. Two edge points of object can be seen clearly. In the calibration environment of this experiment it found that length of object is 403 pixels. By using formula above we know that calibration factor of this system is $K = 0.044$ mm / pixel, it is used as pixel equivalent when it measure the length of the object. Second this
paper try to find stability of result from this measurement system by taking data every 100ms. Stability result can be seen in table 1.

Table 1. Stability result

<table>
<thead>
<tr>
<th>No.</th>
<th>Light Intensity (Lx)</th>
<th>Size in Pixel</th>
<th>Size in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
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<tr>
<td>5</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
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<td>402</td>
<td>17.72</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>403</td>
<td>17.76</td>
</tr>
</tbody>
</table>

5. Experiment Result

In order to know correlation between light intensity and measurement result of this system, object that has 17.76mm length is used. According to experiment result, when light intensity is less than 4 (Lx), size of object is less than 17.72 mm. This condition happened because light intensity is poor and it caused edges detection on the object become wrong or miss. The different conditions of light intensity can be seen in figure 3.

![Figure 3](image)

Figure 3. Light intensity 4 Lx (a), Light intensity 10 Lx (b), Light intensity 59 Lx (c).

According to trial that have been done, result of measurement is tend stable when light intensity is above 5 Lx. There is deviation about 1 pixel or 0.04mm when giving light intensity 40 Lx. Data of trial can be seen in Table 2.

Table 2. Measurement result of changing light intensity.

<table>
<thead>
<tr>
<th>No.</th>
<th>Light Intensity (Lx)</th>
<th>Size in Pixel</th>
<th>Size in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0.26</td>
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<tr>
<td>2</td>
<td>1</td>
<td>331</td>
<td>14.59</td>
</tr>
<tr>
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<td>2</td>
<td>392</td>
<td>17.28</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>397</td>
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<td>5</td>
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<td>17.76</td>
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<td>7</td>
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<td>403</td>
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<tr>
<td>10</td>
<td>59</td>
<td>403</td>
<td>17.76</td>
</tr>
</tbody>
</table>
6. Conclusion

Webcam, light sensor, light controller, arduino and PC are used to build the image measurement system. Based on Qt integrated development environment, the measuring interface is designed and the image processing algorithm is written. Length of object is measured based on the system calibration, and the accuracy of the measurement is within 0.09 mm range. Results of system is steady but still failed to get a correlation between the light intensity and the measurement results in this experiment. This research plans to continue by using objects that has radius at the edges, in order to create conditions that similar to actual measurements on connector product.

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References