The Seventeenth International Symposium on Artificial Life and Robotics 2012 (AROB 17th '12),
B-Con Plaza, Beppu, Oita, Japan, January 19-21, 2012

Study on the development of the log scaling system based on the machine vision

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Abstract: The conventional log scaling, which is measured with a ruler by manual operation in order to get higher precision, is carried on by more workers working hard for a longer time. With the new developed technique, it is possible to use the machine vision for the log scaling. In order to get satisfactory results for that scaling process, the distance between the log and camera should be measured accurately. At the same time, the environment conditions for image capture will be considered carefully. In this paper, the laser rangefinder is developed to determine the distance between the log and camera automatically. The log scaling based on the machine vision was developed, and its properties were tested with various experiments.

Keywords: Machine vision, Log scaling, Image processing

1 INTRODUCTION

Log scaling is the measurement of the gross and net volume of logs. The primary purpose of scaling is to determine the volume of logs that will be charged at a different price. For the conventional scaling, it is necessary to measure log diameters and lengths first, and some defects will be considered based on an approved set of rules. Generally, a given number of logs will be determined for the gross and net volume in that scaling process. Although there are many methods to scale the volume of a log, such as weight scaling that is frequently used on low value materials or when the weight difference is very small for the similar logs, most of the scaling still performed manually by measuring the diameter and length of the log with a tape measure. The working conditions and physical labor intensity can be improved, but most operations sometimes have to be done in the high places, hot or cold environments. If we can change the manual log scaling operation with some machine operation, the efficiency and accuracy will be improved.

In the railway freight, the logs before scaling are loaded in the carriage as shown in figure 1. Two or three bundles of logs are laid on each carriage with height about 4 meters. Their diameters are different in different carriages. For the big diameter log, there are about ten pieces of logs in each bundle. There will be more than twenty or thirty piece of logs in each bundle if the log diameter is smaller. No matter what type of the log diameter, the height of each bundle is nearly the same (about 4 meters high). Compared with the small diameter log scaling, the scaling is easier for the big diameter log. When a log will be scaling, both sides need be done and the smaller one will be chosen as the scaling result. If it is a small diameter log, it is difficult even to find both sides for that log in that bundle. Moreover, many workers have to climb to higher place to measure. Generally, more than 200 operators work at the same time more than 12 hours for a freight train. The scaling results will also be influenced by human factors etc.

1) Bigger diameter

2) Both bigger and smaller diameter

Figure 1 Illustration of logs with different diameters

Aimed at the various problems of manual log scaling, many researchers try to use machine visions to substitute manual scaling. Although some researchers have applied the image processing technique to the log scaling, the best operation will be the scaling process of machine vision that is the same as manual operation. Because many logs' interface can be taken in an image, we can scale more logs at the same time from one captured picture. If necessary, we can also scale the log one by one based on the machine vision technique. The scaling efficiency can be improved remarkably. Moreover, the captured images can be saved in a database for the systematic management. Certainly they can also be used as the certification for later application. There are many advantages for the machine vision scaling, but the scaling accuracy is determined by such as lighting conditions, video image quality, etc.

When we use machine vision for log scaling, the distance between camera and the log interface should be determined first. Then the log diameter of its interface can be calculated based on the camera focus and previous distance. Now the distance generally is determined with infrared sensors or ultrasonic sensors, etc. Because the distance is longer than the effective range of such sensors and there is a gap among the log interfaces, those sensors can not work robustly. The laser rangefinder sensor can satisfy our requirements, but it is generally expensive. In the machine vision scaling, the image processing technique is used to determine the geometric dimensions of measured objects. Therefore, we can also determine that distance based on the image processing with point laser.

For the manual scaling, workers can find the shortest interface diameter fast based on their experience. If we develop some algorithms of image processing, the process will be complicated and its result will not always be reliable. Because the computer is good at calculation, many diameters in different angles of each interface will be measured and the smallest will be selected as the final result. The experiments showed, it is possible to replace the manual scaling with the computer vision scaling.

1. 2

2 DISTANCE CALCULATION BASED ON IMAGE PROCESSING

For the machine vision scaling, the first step is to decide the distance between the camera and the measured log. Although there are many sensors can be used to get the distance, considering the working conditions, we will use the image processing technique to get that distance. The conventional distance calculation based on image processing should use two cameras. That technique is not appropriate to our applications. In order to get the distance, here a point laser is used.

The relationship between the camera and pint laser is shown in Figure 2. Here, we assume the camera view angle in width direction is λ_x , λ_y is in the height direction, the length between the lens center and laser center is L, the coordinates of the laser center in image plane is P(x,y), θ is the angle between the lens center line and the vertical line from camera center to the laser center line, the image dimension is 2w×2h. Thus we can get the angle β, which is the angle between the connection line from camera center to P(x,y) and the optical axis of the camera.

$\beta=arctan(tan(\lambda_y)*(y-h)/h$

Then the distance between the camera and the object point will be:

HY $=L*tan(\theta-\beta)$

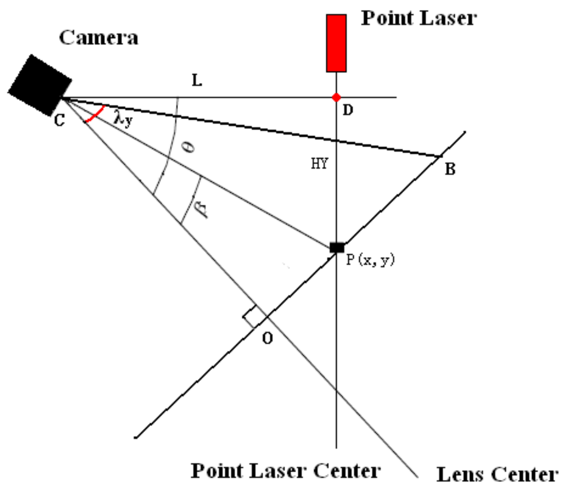

Figure 2 The illustration of distance calculation for image processing

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3 EXPERIMENTS

In order to test the system whether it is appropriate for the application of the log scaling, the flowing experiments were carried out.

3.1 Experiments on the distance calculation based on image processing with point laser

If we want to proceed the log scaling based on the image processing, the first step is to get the distance between the camera and some target cross section. According to practical applications' requirements, the distance from 30cm to 300cm is tested.

In the experiment, seven groups of data were verified. We fixed the camera first, then marked seven points which are the distance of 30cm，45cm，85cm，100cm，150cm，300cm to the camera respectively. The test sample and point laser is shown in figure 3. The sample size is w0×h0=15mm×7.6mm. At each marked point, we will calculate the distance from camera to the sample. At the same time, we will also calculate the width and height respectively based on the distance gotten from image processing. Moreover, the relative error will be calculated. All results are listed in the table 1.

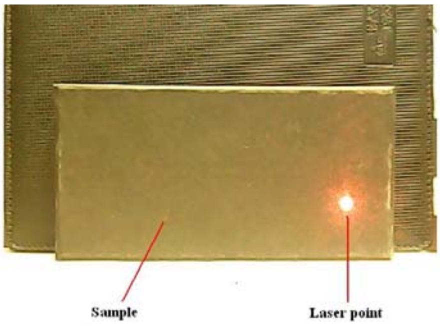

Figure 3 The illustration of the test sample and laser point

Table 1 The comparison between image processing and manual measurement (Unit: cm)

Manual d0	30	45	85	100	150	200	300
Camera d	29.93	44.34	84.16	98.60	146.49	193.54	285.29
(d-d0) /d0	-0.2%	-1.5%	-1%	-1.4%	-2.3%	-3.2%	-4.9%
Width w	14.81	14.75	14.64	14.53	14.91	15.06	14.68
(w-w0) /w0	-1.2%	-1.7%	-2.4%	-3.1%	-0.6%	0.4%	-2.1%
Height h	7.56	7.54	7.51	7.49	7.53	7.67	7.37
(h-h0) /h0	-0.5%	-0.8%	-1.2%	-1.4%	-0.9%	0.9%	-3%

Because the captured image size is 640×480pixels, the resolution is not high enough for objects far from the camera. When the object is put on the 300cm mark, the calculation accuracy of the distance, sample width and height is lower than the near marks to the camera. For our experiment camera, if the distance between camera and sample is controlled less than 100cm, we can get better calculation results based on the image processing. Although the results are also good for the distance from 100cm to 200cm, the edge points of the sample can not be extracted accurately.

3.2. Experiments on the log scaling based on image processing

In order to simulate the practical log scaling, the log cross sections are laid as shown in figure 4. First the distance between the camera and the log cross section is calculated based on the image processing, and its result is 84.76cm.The manual measurement is 85cm, and the relative error is 0.28%.

Figure 4 The illustration of log scaling experiment for distance calculation

The log scaling of the cross section is shown in figure 5. In order to get a more accurate calculation result, the whole cross section is divided equally by six angles, so six diameters can be calculated at the same time. In our experiment, the defect on the cross section will not be considered. Our experiment purpose is to verify the accuracy of the machine vision scaling. Each diameter is calculated based on two intersection points of each line. The initial length of each diameter is shown in the bottom of the figure 5, which are calculated only based on the coordinates on the image plane. When we consider the distance between the camera and log section, the real length will be calculated. The real length is shown in the right upper part of figure 6, which is transformed from the shortest one after the comparison among the above six calculation results. The manual result is 22cm. The image calculation result is 22.096cm, so the relative error is 0.4%. The manual result is also an approximate dimension.

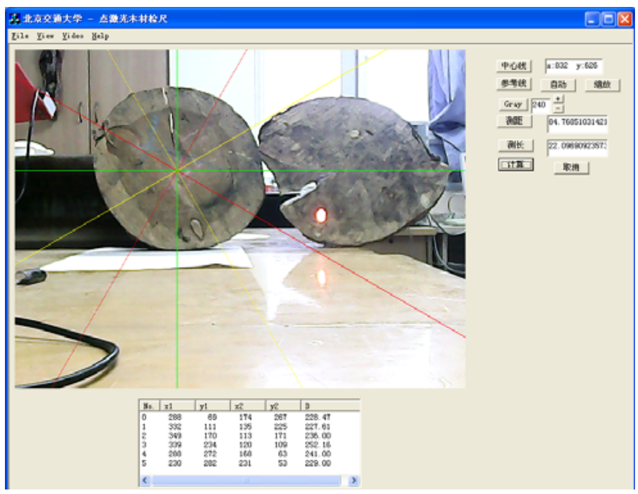

Figure 5 The illustration of the cross section scaling for left sample

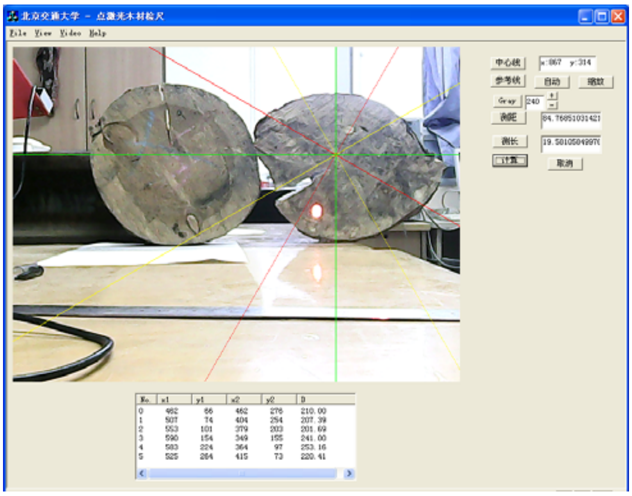

Figure 6 The illustration of the cross section scaling for right sample

In order to verify the machine vision scaling, another similar operation is done with another sample. The manual result is 20cm, and the image processing result is 19.58cm. The relative error is 2.1%. The big error is caused by the irregular cross section. It is difficult to get the shortest diameter by manual scaling.

4 CONCLUSIONS

According to the experiments on the distance calculation and log scaling based on the image processing, we can get following conclusions:

With our designed device, the distance between camera and target object can be calculated. If we want to get more accurate result, the distance can not be too far and the camera should have high resolution.

We can carry out the log scaling with machine vision. With this technique, the single log can be measured automatically, and multiple logs also can be measured in a same image. When we scale multiple logs in one image, their accuracy will be higher if their cross sections are in the same vertical plane. On the other hand, it is better to use camera with higher resolution.

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