Photo Analytical Method for Solid Wood Content Determination of Wood Stacks

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Abstract—The industrial wood assortment is not measured one by one but the whole stack. The stacks could be very different depending from the diameter the length the site quality (the place where the timber have grown) the wood specie even the standards quality of the stacking work. Photo analytical method was developed and implemented for determining the individual solid wood content of each stack. The image processing was done by the methods of statistical image analysis in Hue, Saturation, Value (HSV) colors. The Hue value was classified between 0° to 360° and the distribution was investigated and analyzed. According to the result of this developing project the solid wood volume become measurable. The accuracy of the new photo analytical method is significantly higher than that of the traditional methods.

Index Terms—image analysis, photo analytical measurement, solid wood content, stacked wood

I. INTRODUCTION

In the European forestry praxis high amount of cutting wood is produced as stacked assortment especially in case of broad leaved wood species. The ratio of this stacked wood can be reach the 40-70% depending on the species the age of the stand class, the increment- selection thinning or final harvest and the quality of the soil the climate condition of territory the quality of the harvester workers and some other parameters.

The stacked wood used widely such as raw material of particle board fiber board paper round firewood pit wood. Almost every stacked assortment had an own prescription related to the diameter shape and other parameters. According to these prescriptions the forest companies produced separately each assortment. There are two main methods to determine the value or amount of the industrial wood transport. The first one is the volume methods the second one is the weight methods. There are different measurement or estimation solutions for both of them. Present investigation focused to the determination of solid wood volume by photo analytical method. The assortment had the evaluated exchange ratio between stacked volume and solid volume [1]-[3].

The determination of this individual rate related to the given stack type was investigated by [4]-[7]. In the earlier time the technology could not ensure the opportunity to work out an automatic high level solution that is the

reason they used the statistical average of high number of measured stacks.

In consequence of decreasing producing costs of stacked wood the number of separated assortment was reduced to only one or few type of stacked wood. There are consumptions that can tolerate the presence of bark on the stacked wood such the power plants contrasted with others which would have used the debarked stacked wood like paper industry. In the letter case the buyers do not pay for the bark and calculate the volume without bark. On the other hand the power plants can burn the fuel wood in the same way as the bark. Although the ash content of bark is considerable higher than the wood and the fuel value is lower related to the volume.

The mixing of different stacked wood assortments causes the uncertainty of exchange rate calculated earlier. In addition the quality and dimension of forest stands was changed in the last five decades also and the determination of the bark content is also desirable for some industrial participant. These changes influenced rather detrimental the quality of wood and parallel the exchange rate and with a higher accuracy demand from the companies. For the interest of buyer and seller alike it is desirable to know the exact amount of transported wood for reliable accounts and some participant want to know the bark ratio too.

Next to the mentioned influencing factors the informatics technology developed very fast in the last decades. There are high tech equipment's available on the market which can help to evaluate a newer wood stacks volume measuring method. The remote sensing image technology is used for similar goals also for estimating wood quantity on the site [8], [9].

It is true that the oven-dry mass is widely used for accounts, but the measurement of moisture content comprises failures and sometimes it takes longer time.

The present study aimed to develop a new and faster way of measuring solid cubic meter of stacked wood. To know the massive quantity are needed two important information: the exact loose volume of the stack and the exact exchange rate related to the current stack.

II. METHODOLOGY

The wood assortment to be measured is given either on the field of forest or on the track during transportation. The developed system presented in this paper related to the measurement stacks on a track but the system is

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suitable for measuring stacks on the log yard for inventory purpose.

Generally the end of the stack in the butt edge is plane in both case mentioned above. Since the butt edge is like a cross section of the stack it is presumable that wood surface ratio corresponding with the ratio of solid wood content in the whole volume. Principally the cross section ratio can change along the stack, but the measurements shows quite low differences in case of one meter length. In case of fuel wood it is used longer stacks increasingly for the sake of reduce the production loading and unloading expenses. The longer stacks can be reached even the four meter length. In this length the surface ratio can be highly different between the two butt edges of the stack. However two third of stacked wood intended for industrial use is shorter length in Europe.

On the basis of all these the determination of solid wood content is confined to determination of wood surface ratio what is analog with the cross section of the stack. Presently it is practicable to take high resolution pictures of butt edge of the stack and the computer technique provides the effective image processing. As a first step it has to make a scale right image from the photo has taken the butt edge surface of the stack. The scale right photo means that the units on the picture are correct and same on the whole picture in other words the pixel sizes are known. The transformation can be made by base points which coordinate is known (Fig. 1). Because the system was developed for measuring stacks on truck the measurement can be made repeatedly on a same site e.g., in a gate of the factory. For this reason the camera was fixed outside in an appointed place.



Figure 1. Transformation of the pictures

Tracks have to stop before the camera next to a designated line providing the same distance between the camera and the surface of the stack. After setting the base points on the transformation parameters they are saved to the computer in a configuration file. During the measurement it is not to be necessary to indicate the base points again it can be used the saved transformation parameters set before.

By the transformation process it is reduced the errors of the camera and the lens by means of precise base points.

To the realization of measuring method on truck should install a suitable camera to the place where can stopped the trucks loaded with wood assortment. The truck has to stay on a designated space what mean a given distance to the camera. The camera is controlled by the computer placed in the office, so the operator takes the picture from the office. For precise measurement result the accuracy of track position is important.

If the track stays ten twenty or thirty centimeter closer or farther from the designated position than geometrical error will be occurred (Fig. 2).



Figure 2. Position error of the truck causes measurement error

The degree of the error depends on the position difference and from the distance between the camera and the image plane. The further the camera is fixed the smaller is the relative error (Table I).

 TABLE I.
 EFFECT OF THE POSITION ERROR ON SURFACE DIFFERENCE

 (%) IN CASE OF DIFFERENT CAMERA DISTANCES

Camera distance from the image plane [m]	Position difference [cm]							
	-30	-20	-15	-10	10	15	20	30
10	5.9	4.0	3.0	2.0	-2.0	-3.0	-4.0	-6.1
15	4.0	2.6	2.0	1.3	-1.3	-2.0	-2.7	-4.0
18	3.3	2.2	1.7	1.1	-1.1	-1.7	-2.2	-3.4
20	3.0	2.0	1.5	1.0	-1.0	-1.5	-2.0	-3.0
25	2.4	1.6	1.2	0.8	-0.8	-1.2	-1.6	-2.4

In Table I is visible the measure of errors in dependence of camera distances and the position errors. In case of 25 meter camera distance the 10 cm position error causes 0.8% surface difference. If the real image plane is further from the right position the camera sees smaller the same surface size than it is; consequently it will measure 0.8% less amount of solid wood. This error related to the surface, the linear error is much less close to the square root of 0.8%.

If the position error raises to 20 or 30 cm the surface difference will raises also to -1.6% or -2.4% in case of 25 meter camera distance. The camera fixed only 10 meter from the image plane causes 2% surface difference what is much higher in 10 cm position error. The measure of surface difference is extreme high if the position error achieves the 30 cm. The difference is not the same in both position error directions. If the stuck surface is further with 30 cm than the designated position the surface difference is higher in percentage than the stuck would be closer to the camera.

Summarizing the facts explained above it is much advantageous to fix the camera further from the designated truck side position.

The measurement on the site can be done the mobile device developed in the frame of this project. The mobile device can transform the image by measuring the actual distance of the stack from the lens by using a built in laser distance measurement device. In this case the distance error is significantly lower by taking the picture and measuring the distance in the same second.

Existing of this scaled right image, the second step is the image processing and analyzing the pixels on the right scale image. For achieving the best accuracy measurement, the colors of the pixels were analyzed by classification of pixels according to the coordinate of color decide which ones belonging to the wood surface and which one to the space between wood logs. Generally the butt surface is brighter than the parts between logs. We have developed algorithm which can divide the pixels belonging to the butt surface from the pixels belonging to the holes. The pixel ratio belongs to the wood surface gives the correct exchange rate. In case of high resolution image with a good contrast there is possible to determine the bark ratio too. The bark has generally darker or browner surface than that of the wood particularly the sapwood. The small difference can be enough to classify the pixels belonging to the bark to an individual color class.

The system contains an intelligent algorithm what is able to examine the color range of all pixel of the image and select automatically the pixels belong to the wood or bark surface. This algorithm is very precise if the contrast is high between the wood surface color and the other parts of the pictures. The high contrast is achievable in case of fresh cut wood assortment and by good lighting conditions.

The image processing was done by the methods of statistical image analysis in HSV colors inside the designated shell showing the butt surfaces. The conversion algorithm from *RGB* (Red, Green, Blue) to HSV the algorithm is shown below:

$$R' = R/255; \quad G' = G/255; \quad B' = B/255$$
 (1)

$$C_{\max} = \max(R', G', B'); \quad C_{\min} = \min(R', G', B')$$
 (2)

$$\Delta = C_{\max} - C_{\min} \tag{3}$$

$$H = \begin{cases} 60^{\circ} \cdot (((G' - B') / \Delta) \cdot \text{mod } 6) & C_{\max} = R' \\ 60^{\circ} \cdot (((B' - R') / \Delta) + 2) & C_{\max} = G' \\ 60^{\circ} \cdot (((R' - G') / \Delta) + 4) & C_{\max} = B' \end{cases}$$
(4)

$$S = \begin{cases} 0 & , \quad \Delta = 0 \\ \Delta / C_{\text{max}} & , \quad \Delta \neq 0 \end{cases}$$
(5)

$$V = C_{\max} \tag{6}$$

The *H* value was classified between 0° to 360° and the distribution was investigated and analyzed.

III. RESULTS

One of the results of image processing is shown in Fig.



Figure 3. Automatic wood surface detection

The painted pixels were detected as wood surface by the method. The high majority of wood surface pixels detected correctly however there are painted points out of the surface which point removable easily from the image by using other methods e.g., by size of the painted stain or by the shape. Inside the butt can be found points without painting that shows there are pixels which were not detected as wood by the algorithm. Fig. 4 shows the distribution of H values on the whole image.



Figure 4. H value distribution

The higher bars show the higher number of pixels with the same color. For detection of wood surface was chosen the middle bars on the left side signed by red arrow on Fig. 4. If there is too much undetected pixel inside the butt than it have to take other bars next to the chosen ones. Generally the wood color range is between red and yellow.

IV. DISCUSSION

The intense development of forest and wood industry lays the claim for optical determination of wood solid content with higher accuracy and shorter processing time. The result shown above seems to be possible methods for fulfilling this task with some defects which has to be eliminated in the future. The processing time of the pixel H value analysis was a really short; depending on the image size last 0.1 to 0.5 seconds which time is close to the observation time of the eye. The processor was i5 with 4 GB RAM on the computer the image processing was done. According to the processing time the algorithm is fast enough. The accuracy of the results has a strong dependence on the contrast rate of image. There are butt surfaces turned to grey or black which color is similar to the bark color. In this case the accuracy is lower. If the brightness is quite low than the saturation difference is

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low either consequently to much pixel is in one color class. According to the accuracy test the presented method determine the solid wood content of the stacks in 2-3% accuracy in case of fresh cut wood.

Results shows higher accuracy than the method shown by P ásztory [10]. There are methods using mobile phones and special applications which can determine the positions of the stacks on the map and can produce a panorama picture in case of long stack. The other similar solution to the present publication can be seen in the web also (www.dralle.dk) where the distance is determined by using double camera.

V. CONCLUSION

The accuracy of the new method is higher than that of the traditional survey at least 2-3 times and faster 5-10 times in case of appropriate image contrast and colors. With comparison of the traditional method this system is significantly faster because of the automatically process steps and the fast algorithm. System is controlled from the office what is more comfortable for employee. The measured stack data are in digital form from the beginning of process related to the pictures and other data of transportation. The advantageous and disadvantageous of the photo analytical method listed below.

Main advantages of the photo analytical method:

- Higher accuracy,
- Faster survey method,
- Easier documentation,
- Stock registering opportunity,
- Easy statistical report.

Disadvantages of the photo analytical method:

- Higher technology level and higher prices,
- Need of educated operator.

It is needed further investigation to eliminate the defects in the image and find the optimized parameters for all light conditions and determination of the minimal contrast rate of the pictures.

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