LASCAN – A LASER-BASED LOG-MEASUREMENT SYSTEM

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Abstract: KEBA - Sawmill-Automation and the Microelectronics Institute of the Johannes Kepler University of Linz developed a new low-cost-system for measuring the diameter of a log with mm resolution. The system utilizes two laser beams forming an angle of 90°. Each of them is scanned by a rotating polygon mirror towards a retroreflector located in a distance of about 2 meters. Each retro-reflected laser beam is detected by a large-area photo diode mounted near the polygon mirror. An object (log) hit by the scanning laser beams produces for a certain time a shadow on the two reflectors and, hence, on the photo diodes which in turn generate high/low/high-signals. A signal processor converts these signals into the required geometrical data. The system called LASCAN is capable of measuring diameter and position of a log at high speed. The obtained data enable the sawmill to deliver to the customer the requested log with an opimized cut at a low prize.

Keywords: Sawmill Automation, Measurement of Geometrical Quantities, Laser

1   INTRODUCTION

Accurate and fast measurement of the diameter of a log is of fundamental importance for sawmill automation and cut optimization. The system presented here is a low-cost-measurement-system well suited for reliable operation at sawmills. It is mechanically and electronically robust and yet exhibits both high accuracy and high measurement speed (1 mm at 1000 scans/second) exceeding those of presently available systems.

2   THEORY OF ANGLE - MEASUREMENT

In order to calculate the diameter of an object four angles are needed as illustrated in Figure 1. There, these angles are shown for an elliptic object – ab_L and ae_L for the left measurement system, ab_R and ae_R for the right measurement system.
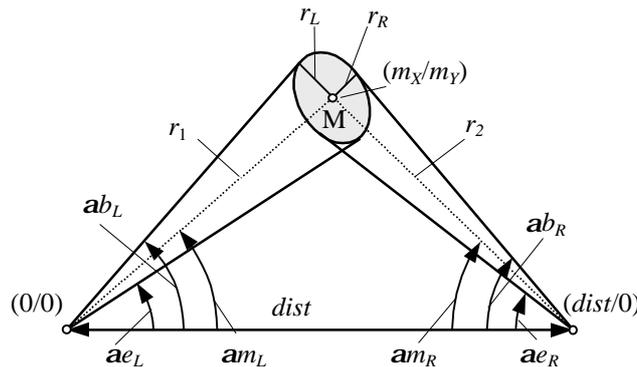

Figure 1. The angles needed for calculating diameter

The center point, M, of the object can be obtained by calculating the angles am_L and am_R using the equations (1):

$$am_L = \frac{ab_L + ae_L}{2} \qquad\qquad am_R = \frac{ab_R + ae_R}{2} \tag{1}$$

For calculating the radii r_1 and r_2 the coordinates m_X and m_Y of the focal point of the object are needed which can be obtained using the equations (2):

$$r_1 \begin{bmatrix} \cos am_L \\ \sin am_L \end{bmatrix} = \begin{bmatrix} dist \\ 0 \end{bmatrix} + r_2 \begin{bmatrix} -\cos am_R \\ \sin am_R \end{bmatrix} = \begin{bmatrix} m_X \\ m_Y \end{bmatrix} \tag{2}$$

Knowing the two radii r_1 and r_2 we also know the distances between the deflecting points ((0/0) and (*dist*/0)) and the center point of the object, enabling one to calculate the radii r_L and r_R of the object via equations (3):

$$r_L = r_1 \cdot \tan\left(\frac{ab_L - ae_L}{2}\right) \qquad\qquad r_R = r_2 \cdot \tan\left(\frac{ab_R - ae_R}{2}\right) \tag{3}$$

Note, that the two radii have to be equal for a circular object, but are different for an elliptic object (as it is obvious by inspection of Figure 1).

3   MEASUREMENT OF THE ANGLES

From the previous chapter it becomes clear that the measurement system has to provide the tangents to an object in order to enable diameter calculation. This is achieved by using a rotating mirror which produces a scanning laser beam over a range wide enough to cover the object. The laser beam is "retroreflected" back to a photo diode mounted in the vicinity of the light source.The signal produced in the photo diode is time dependent and, hence, carries the information on the various angles.

Figure **2** shows an oscilloscope shot (right side) for a circular object and (left side) how the time dependent signal is correlated to the various angles needed for computing the diameter(s) of the log.
Explanations of the variables used in

Figure **2**: t_{H1}: t-high1, t_{H2}: t-high2, t_{tot}: t-total, a_b: α-begin, a_e: α-end, a_{tot}: α-total, a_{ST}: α-start, a_{END}: α-end.
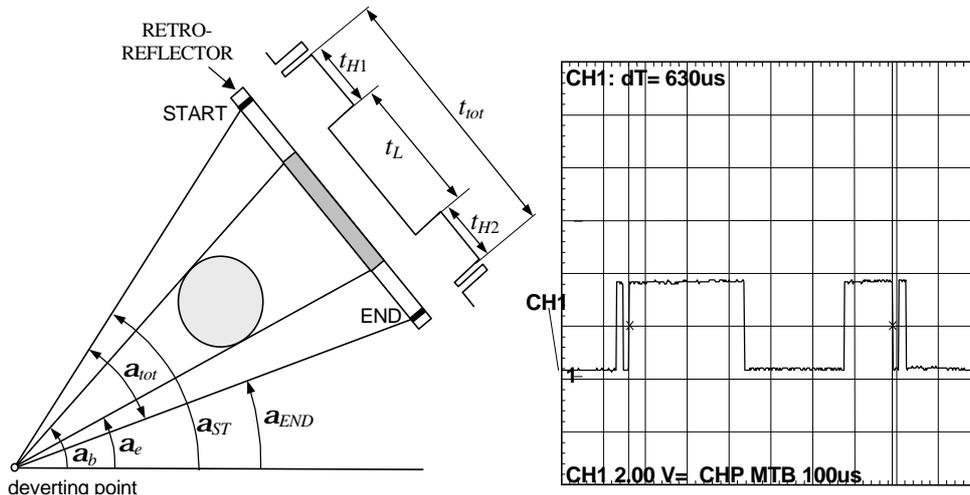

Figure 2. Left: Correlation between the time-dependent signal and the required angles; right: oscilloscope-shot of a typical signal

The two darkened zones named START and END in Figure 2 are assigned to the two ends of the retro-reflector and thus their positions (angles) are well defined during the measurement. If the times t_{tot}, t_{H1} and t_{H2} are measured, the angles a_b and a_e can easily be calculated using equations (4) thru (6):

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$$\boldsymbol{a}_{tot} = \boldsymbol{a}_{ST} - \boldsymbol{a}_{END} \qquad (4)$$

$$\boldsymbol{b} = \boldsymbol{a}_{tot}/t_{tot} \qquad (5)$$

$$\boldsymbol{a}_b = \boldsymbol{a}_{ST} - \boldsymbol{b}\ t_{H1} \qquad\qquad \boldsymbol{a}_e = \boldsymbol{a}_{END} + \boldsymbol{b}\ t_{H2} \qquad (6)$$

4   THE FUNCTIONAL MODULES OF LASCAN

The advantage of LASCAN is that all active components (both mechanical and electronic) are mounted in one single housing in contrast to conventional systems, where transmission and receiving units are usually separated. This facilitates adjustment of the system and avoids complex wiring. In

Figure *3* the block-diagram of LASCAN is shown. The gray field is the passive component (retroreflector), whereas white fields are active components.
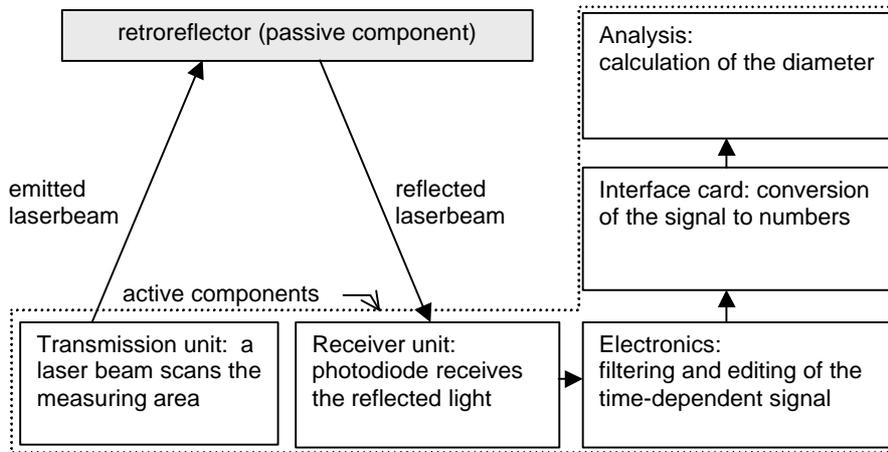

Figure 3. Block-diagram of LASCAN

Figure 4. Photograph of LASCAN

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4.1 Transmission unit

The transmission unit consist of a 7 mW semiconductor laser, pulsed at 10 MHz, which is scanned by a rotating polygon mirror at 6000 rpm.

4.2 Retroreflector

A standard retroreflector, similar to those used in the field of safety engineering, is employed.

4.3 Receiver unit / Electronics

The receiver consists of a large-scale photo diode and a lock-in-amplifier (frequency: 10 MHz).

4.4 Interface card

For the conversion of the time-dependent signal a modified camera interface card it used.

4.5 Calculation of the diameter

The calculation is performed by a standard PC and displayed on the monitor of the PC.

Figure 4 shows a photograph of the complete system in operation.

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