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Laser for Measuring Morphologic Crop Parameters

Knowledge about site specific morphologic parameters, like crop biomass density or plant height, provides an important basis for optimising crop management and harvest processes. Sufficiently accurate, low cost sensors for measuring crop parameters are the prerequisite for practical realisation. In recent years laser distance sensors have been developed and successfully applied in many industrial applications. This paper investigates to what extent laser distance sensors can contribute to measuring morphologic crop parameters.

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Keywords

Crop parameters, measurement principles, laser distance sensor

The crop biomass density and the crop height are important morphologic parameters in agricultural and horticultural production processes for assessing crop stands. These parameters may provide a basis for the appraising crop yields as well as for optimising fertiliser and pesticide rates in site specific crop management. Further, working parameters of harvesting machines like velocity or the rotation speed of working tools can be adapted to the specific crop situation.

Measuring method

In the last years new laser sensors were developed for the distance measurement in industrial applications, predominantly based on the triangulation principle. Some of these are low cost sensors, having small light beam cross sections in the millimetre range and are working at high frequencies.

Therefore, important prerequisites are given for penetrating crop stands and getting clear reflection signals at a sufficient rate. For measuring morphologic parameters of crop stands such as crop biomass density or crop height, the sensor should be moved in a constant distance above the ground. During a horizontal movement the beam will be reflected from crop surfaces or from the soil. From a statistical evaluation of the measured reflection distances, conclusions can be drawn about the morphologic dimensions of crop stands for an optimised crop management. With a high statistical probability, it can be assumed that the measured reflection distances will decrease basically in the case of increasing crop biomass densities and plant heights (*Fig.1*).

Selection of laser sensors

Using the Internet, the availability of laser distance sensors was investigated. The selection in respect to their potential suitability for the acquisition of crop parameters was based on the technical specifications. The sensor types which were chosen for further assessments are listed in *Table 1*.

Results

For a systematic assessment of the principal suitability of selected laser distance sensors for measuring morphologic crop parameters (according table 1), investigations have been conducted since the vegetation period 2003. Due to the opto-electronic measuring principle and the extremely irregularly shaped reflecting surface of crops, failure measurements were expected. Each of the sensors was mounted in front of the basic vehicle (tractor, tool carrier) inclined and focussed on the outdoor crop stands. The mounting height for each sensor was within the specific maximum measuring distance range. The investigated sensors perform a measuring frequency in the kHz-range, resulting in a high amount of data and short test time.

The Baumer electric OADM 20i6481/S14F was not tested within own experiments. This sensor has an output canal for identification and elimination of failure measurements. First published test results of the sensor confirm an acceptable function for velocities up to 10†km h-1. After the elimination of the failure measurements, the exact estimation of a height profile of an oat population was demonstrated [1].

Table 1: Synopsis of selected laser sensors

Provider	Type of sensor	Measuring distance mm	Wave length nm	Measuring frequency Hz	Laser-classification	~ Price
Baumer electric	OADM 20i6481/S14F[1])	200-1000	675	1000	2	1200,-
Waycon	LAS-Z-800-A[1])	50-800	675	100/1000	2	950,-
LASE	ODS 1400 HT[1])	700-2100	670	1000	2	7100,-
MEL	M7L/400[1])	80-480	675	17000	3b	7500,-
Eltrotec	LDS400[2])	300- 4000	665	100/500	2	1800,-

[1]) triangulation principle   [2]) light delay time measuring principle

Literature

[1] *Thösink, G., J. Preckwinkel, A. Linz, A. Ruckelshausen und J. Marquering*: Optoelektronisches Sensorsystem zur Messung der Pflanzenbestandesdichte. Landtechnik 59 (2004), H. 2, S. 78-79

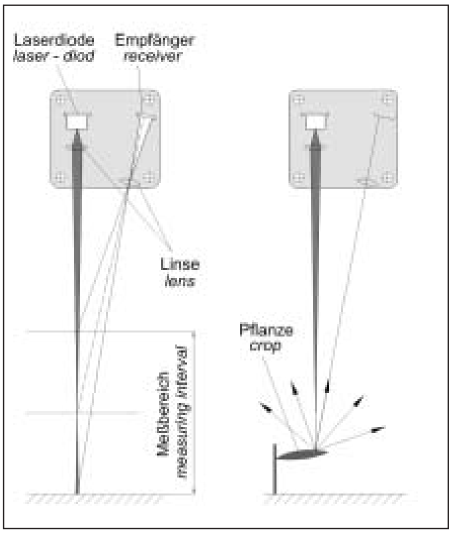

Fig. 1: Measurement principle of laser-triangulation for recording morphological crop

Investigations with the Waycon LAS-Z-800-A showed that this sensor does not work under regular outdoor daylight conditions. Beginning darkness was necessary for receiving sufficient reflection signals. Analysing the frequency distribution of the reflection distances a continuous reduced frequency below 0.50†m in correspondence with the crop morphology was observed. It was not plausible that the lowest distance class (0... < 0.1 m) had a frequency of 18.4% and the next higher class (0,1...< 0.2 m) only 3.9%. Because the designed measuring distance was not exceeded, this frequency increase can be only explained by failure measurements, since values are near zero.

The triangulation sensor LASE ODS 1400 HT was designed for the measuring of distances to very hot (glowing) and shining surfaces in rolling mills. The measuring frequency of the sensor is 1000 Hz. It has one output canal for the original measuring signal (reflection distance) and a second output canal for identified failure measurements. The sensor was tested on grassland in the beginning of November 2003 under sunshine conditions around noon.

The first test run resulted in a ratio of 10.7% failure measurements. About one hour later, a second test run did show a similar result (*Fig. 2*).

The sensor MEL M7 L 400 has two analogue output canals. One output canal gives the signal for the reflection distance and the other one a signal according to the intensity of the reflected light, with a voltage level from 0 to 10 V. The optimum is 7 V, below 1 V the intensity is too low for preventing inaccurate values and noise. 93.2% of the values were below the 1 V light intensity, therefore out of the acceptable range. In addition, the measured reflection distances indicate a high ratio of failure measurements. The calculated frequency distribution showed that 23.6% of all values were above and 3,4% below the designed measuring distance. Taking into account the specific test conditions, for both shares failure measurements can be assumed.

In contrast to the above presented laser sensors, the Eltrotec LDS 400 is based on the light delay time measuring principle. This sensor was tested on grassland at July 2004. Based on the specific sensor installation and the grass morphology it was possible to restrict the range of valid measuring values and to estimate the ratio of failure measurements. Under the test conditions, this ratio was more than 85†%. Since all potential plant reflection distances were inside of the nominal measuring distance, the high percentage of failure measurements is caused by an insufficient reflection intensity. Compared to triangulation lasers, this sensor has a rather great beam diameter of about 0.01 m. Because of the filigree and irregular shaped plant surfaces, there were very unfavourable reflection conditions resulting in failure measurements.

Conclusions

The tested laser distance sensors showed considerable differences according their suitability for measuring morphologic crop parameters. Essential problems were caused by sunshine, irregular shaped crop surfaces, and the designed range of measuring distances.

Based on the existing results it can be concluded that the investigated laser sensors do not yet satisfy the basic criteria for a sufficient measuring of morphologic crop parameters under practical agricultural conditions.

Based on its lower ratio of failure measurements, the sensor ODS 1400 HT by LASE may have a sufficient characteristic after adequate technical improvements. Further comprehensive tests are required to investigate the relationship between crop biomass density, crop height, and the measuring results of other crop sensors.

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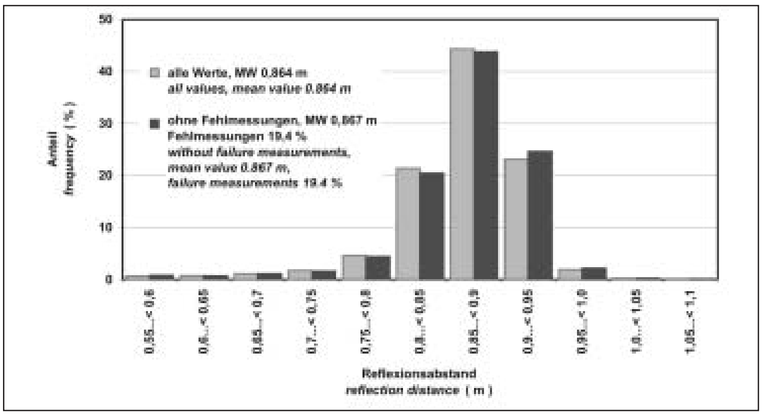

Fig. 2: Frequency distribution of measured data of the sensor LASE ODS 1400 HT