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Detection of anchoring columns in low trellis

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Abstract. Low trellis of hop field was emerged in the Czech Republic in the mid-nineties of the 20th century. Growing hops in a low trellis has already been tested in 1991 by Hop Research Institute Ltd. in Žatec. However, at that time, the lack of adequate (the dwarf) varieties and special techniques prevent to their expansion. For full use low trellis is necessary mechanization, that is already currently being developed.

The main advantage of growing hops at low trellis is costs reduce. Some experts say cost reduction to 50%. Cost reduction is the result of simplifying the spring and harvest work (using a mobile harvester).

Currently, a prototype of a mechanical cutter is tested in field conditions. Activity of mechanical cutter is now controlled directly by the tractor driver. This control of mechanical cutter (or rather inter-axle carrier on which it is cutter mounted) puts on the tractor driver too high demands on precision. Failure to comply with the conditions set comes in contact the trimming disc with anchor pillar and the mutual damage.

The movement of inter-axle carrier would therefore be appropriate automatically. But at first, it is necessary to solve recognition (detection) anchoring columns of the low trellis.

During the cutting of hops needed to ensure the most accurate copy of the columns by the trimming disc, to be trimmed hop vines and hops growing in close proximity (distance hops from the anchoring column is about 150 mm).

The paper presents several types of sensors and describes their advantages and disadvantages. For laboratory test was developed model low trellis comprising also hop vine, at which were referred sensors tested. This article analyzes the measured results of individual sensors and it is shown, that not all sensors are suitable for this field application. In conclusion are recommendations for follow-up research.

Key words: hops, sensor, low trellis.

INTRODUCTION

A highly important aspect in the technology of hop growing on low trellis is the spring mechanical pruning, on the quality of which depends later yield (Ebersold, 2004; Srečes et al., 2013). An experimental model of mechanical pruner (Fig. 1) is being developed in the Department of Agricultural Machines, Faculty of Engineering CULS in Prague. This mechanical pruner is placed on the inter-axle carrier of tractor which owing to its rectilinear hydromotors secures the necessary motion for the carried mechanical pruner. The mechanical pruner's cutting disc moves directly in the axis of hop rows (under the supporting net) of low trellis. In the same axis, however, there are also placed supporting wooden poles which need to be avoided as closely as possible during the agrotechnical operation.

Despite all the advantages mechanical pruning may bring, currently mechanical pruners are not produced in series (Křivánek et al., 2008; Křivánek & Ježek, 2010; Krofta & Ježek, 2010; McAdam et al., 2013).

Figure 1. Experimental model of mechanical pruner placed on tractor.

MATERIALS AND METHODS

Detection of the right position for supporting poles of low trellis is the key step for automation of the whole operation of mechanical hop pruning. Tractor's operator pays full attention to driving through hop inter-rows. Manual control of the motion of inter-axle carrier with mechanical pruner would be too dangerous. At imprecision (delay) of supporting arm deflection, the cutting disc would come into contact with low trellis supporting pole, which would cause a damage to the machine or hop-field equipment. At the same time, there is an attempt to copy a supporting pole as precisely as possible with the cutting disc in a way so that even hop rootstocks growing in its immediate proximity were cut (distance of a rootstock from a supporting pole is app. 150 mm, though the recommended distance is 500 mm), (Štranc et al., 2007).

At imprecise driving in the hop inter-rows a tractor can damage the supporting net or uproot (eventually break) the supporting poles of the low trellis.

Steps in copying are depicted in Fig. 2. To achieve the right copying effect it is necessary to detect a precise position of supporting poles.

Direction of the mechanical pruner motion

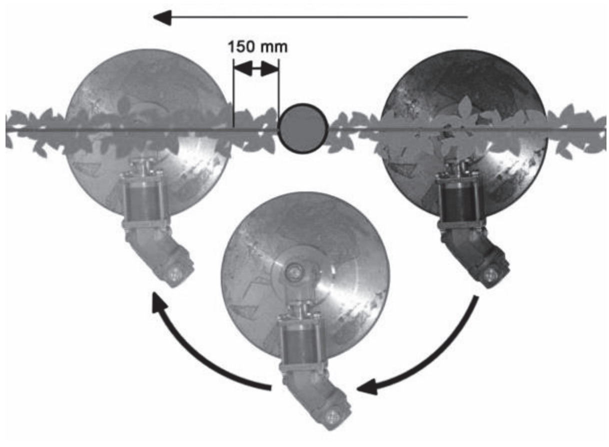

Figure 2. Copying of a supporting pole by a cutting disc.

Laboratory model of low trellis

For the purposes of sensors measurement a model of low trellis was created in the laboratory of the Department of Agricultural Machines.

The model is a faithful copy of a common low trellis construction for hop growing with one difference in the height which is only 1,300 mm. The model is formed of two supporting poles of 80 mm in diameter (Fig. 3 – left pole) and 100 mm in diameter (Fig. 3 – right pole), and of a white plastic supporting net covered with dry hop bines (amount of plant residues is the same as in field conditions). Between the supporting poles there are stretched two steel wire ropes of 6 mm in diameter which increase the firmness of the supporting plastic net. The lower stretching rope is situated 250 mm above the ground and the other is 1,200 mm above the ground. The axial distance of the supporting poles is 1,200 mm and are fixed to the floor by L-shaped anchors. The laboratory model and its placement in the laboratory is to be seen in Fig. 3.

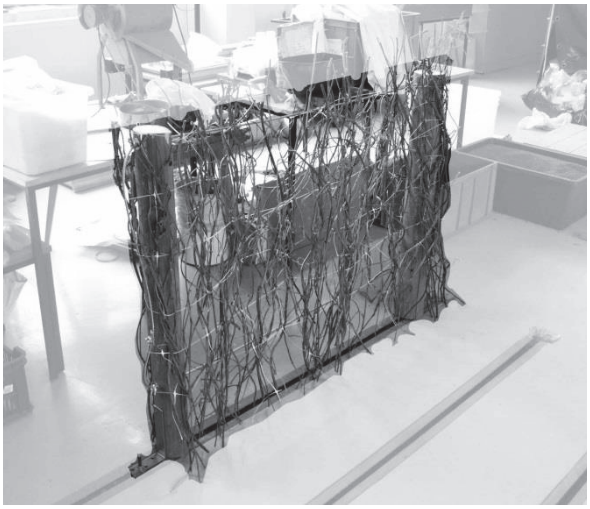

Figure 3. Laboratory model of low trellis.

The laboratory measurement was supposed to verify the suitability of using different sensor types. Our object was to find out whether a measured sensor is able to distinguish repeatedly a wooden supporting pole from the supporting plastic net with plant residues.

Measuring by means of Efector pmd 3d sensor

For the purpose of our measurement with the laboratory model we used Efector pmd 3d camera 03D201 infrared sensor (IR), which was during the whole measurement placed on its own photo tripod fitted with a special handle.

Efector pmd 3d (Fig. 4) is an IR sensor by Ifm Electronic intended to measure distance. It operates using the time-of-flight method: light passing through needs certain amount of time to get to the object (where it reflects) and comes back to the sensor. This stretch of time is directly proportional to its trajectory (PMD technology, 2013).

PMD is an abbreviation for Photo Mixer Device: both sensor and evaluation electronics are integrated into one silicon chip.

The resolution of this device is 64 x 50 pixels (px), which means the amount of image dots of the sensor. (According to the producer, the minimal resolution is 13 mm for a distance of 500 mm.)

Big advantage is innovative design with maximum performance in a compact, industrially compatible housing. Waterproof and dustproof is a very important property suitable into field conditions.

Figure 4. Efector pmd 3d camera 03D201 IR sensor.

RESULTS AND DISCUSSION

Survey image

First of all we measured so called survey images at a distance of 2,000 mm from the edge of the hop-field model, illustrating both supporting poles and the supporting net.

During the measurement we measured the distance of all the dots within a segment of the sensor's lens and according to RV we assigned them a shade of grey colour. RV mean relative value of the intensity and distance. Red colour in the figure (Fig. 5) marks the places which, due to their distance, were outside the measuring range of the sensor.

The lighter the colour gets, the closer to the sensor the measured object is. The supporting pole is well noticeable, despite the fact that some of the dry hop bines were up to 70 mm closer to the sensor.

After the data had been recorded, we carried out a visualization of the image, particularly of the 32nd line of image dots – counted from the top edge of the image (Fig. 5 – the horizontal line). When conducting the visualization, each RV is matched with a colour shade. Therefore the output voltage of a given line is able to be chosen and depicted independently in a graph. The visualized measured data of the 32nd line are to be found in Fig. 6.

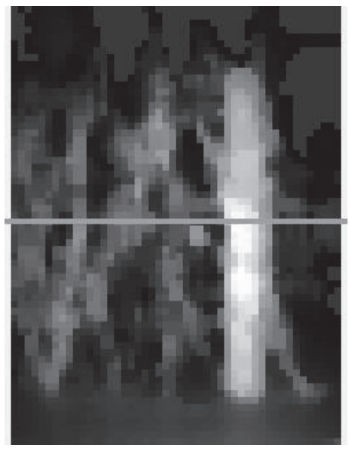

Figure 5. Survey image with marked position of visualized image data (intensity mode).

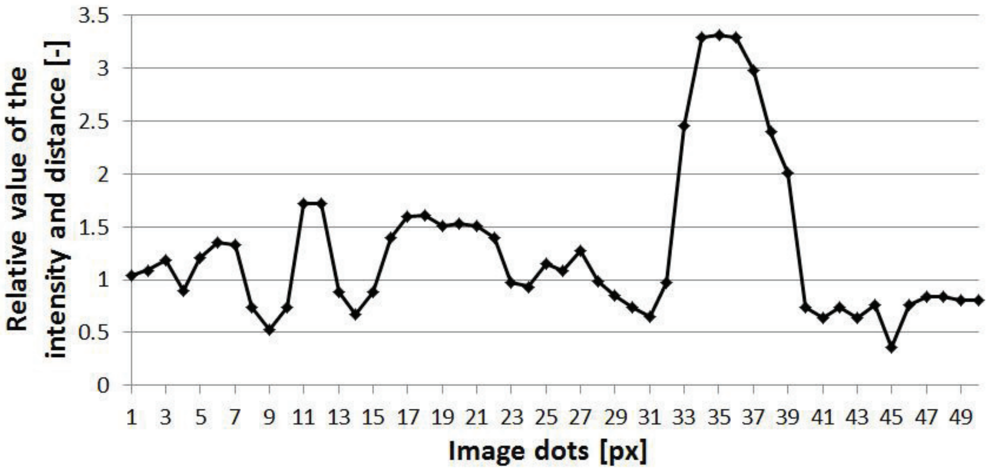

Figure 6. Measured RV of the right survey image.

In the graph there is a well visible deflection which almost reaches the value of 3.5. In exactly this place a pole is detected – in Fig. 5 it is marked with the lightest colour. To get a clearer idea it is possible to place the graph of the measured RV onto the survey image. The result of the overlap is depicted in Fig. 7. In it we may notice a clear dependency of the measured RV (yellow curve) on the colour shade. Analysed data are displayed in Table 1.

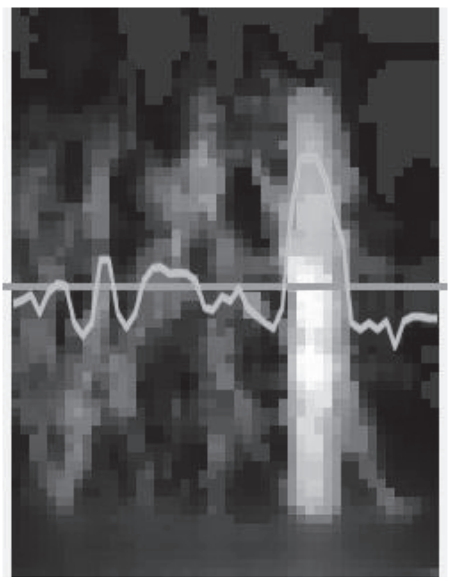

Figure 7. Graph of the measured RV overlapping the survey image.

Table 1. Analysis of measured data

Relative value of the intensity and distance	
Mean value	1.274705
Error of the mean value	0.10337
Median	1.009531
Modus	0.735344
Standard deviation	0.730938
Sampling variance	0.534271
Spikiness	2.092599

Measuring at a distance of 900 mm

Another image was taken at a distance of 900 mm from the edge of the low trellis model. The sensor was placed on a photo tripod, just as it was with the survey image.

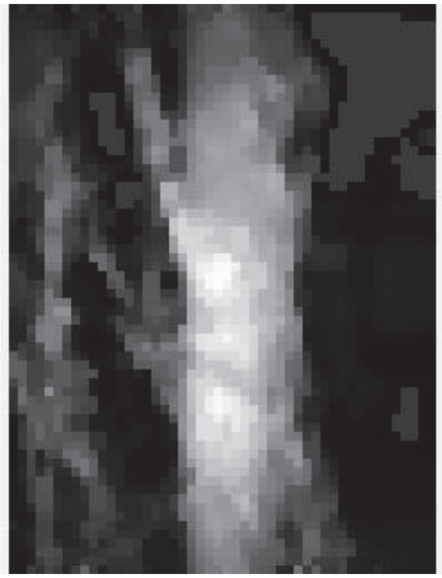

Table 2. Analysis of measured data

Relative value of the intensity and distance	
Mean value	3.874797
Error of the mean value	0.548159
Median	2.220263
Modus	2.961701
Standard deviation	3.876071
Sampling variance	15.02393
Spikiness	-0.18257
Skewness	1.12963
Minimum	0.276654
Maximum	12.60698
Sum	193.7399
Number	50
Confidence level	1.101567

Figure 8. Supporting pole, distance of 900 mm.

A graphic analysis of a supporting pole of 100 mm in diameter (Fig. 8) is depicted in the graph of Fig. 9. The course of graphic dependency makes noticeable the position of the supporting pole, which ranges between 20–35 px. The supporting plastic net with hop bines ranged about the RV of 4, namely between 1 and 20 image dots. Analysed data are displayed in Table 2.

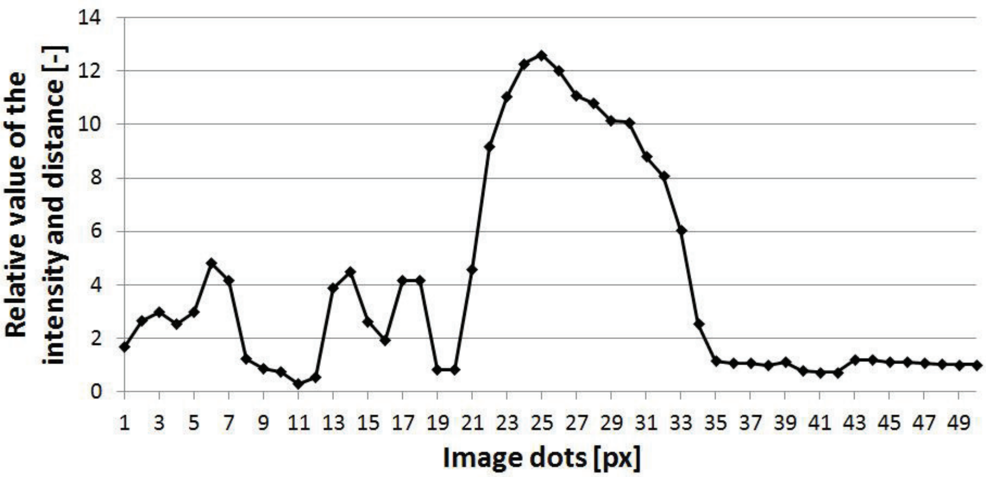

Figure 9. Graphic dependency of RV on image dots.

Measuring at a distance of 200 mm

Figure 10. Right supporting pole of 100 mm in diameter, with dry bines.

Table 3. Analysis of measured data

Relative value of the intensity and distance	
Mean value	45.32024
Error of the mean value	3.906432
Median	52.66297
Modus	4.420968
Standard deviation	27.62264
Sampling variance	763.0104
Spikiness	-1.16161
Skewness	-0.05245
Minimum	3.998318
Maximum	94.14951
Sum	2266.012
Number	50
Confidence level	7.850268

The graph in Fig. 11 illustrates the graphic dependency of the RV on image dots of a supporting pole of 100 mm in diameter with dry bines (Fig. 10). This image contains two parts which are vertically divided: in the left part there is the supporting net with hop bines, and in the right part there is the supporting pole of 100 mm in diameter. In the graph the pole is visible from 23rd to 50th line of image dots. Analysed data are displayed in Table 3.

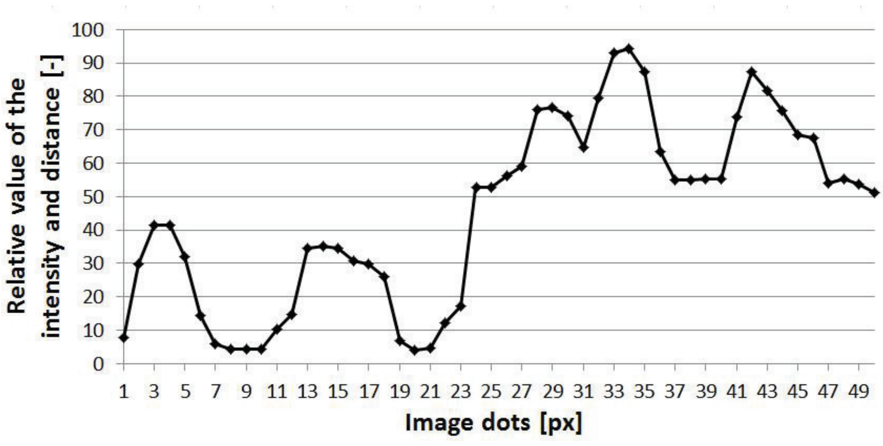

Figure 11. Dependency of RV on image dots.

CONCLUSION

The graphic analysis makes evident that to detect the position of supporting poles as more convenient proves to be the sensor distance of 900 mm from measured hop row. At such a distance the sensor detects old bines with the supporting plastic net as being one unit, therefore no IR beam passes through the measured object. Also the supporting poles, measured at this distance, are much better recognizable from the rest of the low trellis equipment. The position of poles at a measured distance of 900 mm is well visible as it is shown in Fig. 8 and its graphic illustration (Fig. 9).

Measuring at a distance of 2,000 mm is inconvenient, as the sensor would have to be placed on the other side of the tractor to the one where the cut is executed.

A measuring distance of 200 mm is inconvenient as well, because then the supporting poles in the image are distinguishable from the supporting net with hop bines only with difficulties.

Currently we have been carrying out a measurement using the laboratory model with another sensors, such as e.g. the infrared IR SHARP sensor (GP2Y0A21YK0F) or an ultrasonic sensor (UK1C-E1-0E). The last step will be to create an application which based on a detection of a supporting pole would produce a controlling impulse to deflect the inter-axle carrier.

Other measurements show that as the best distance measuring for technology growing hops at a low trellis is IR sensor SHARP GP2Y0A21YK0F.

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