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Photo-analytical project for controlling implements in maize

On ecological as well as economical grounds, mechanical weeding is once again increasingly applied. However, automatic steering of the cultivator is needed. Described in this paper is a system that delivers data for the steering system with the required accuracy. Photos of the maize crop are taken by video camera and these are digitalised and processed. Through the system's pre-processing the deviations of the actual position of the cultivating implement from the ideal position can be determined.

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Keywords

Image processing, automatic guidance, hoe

In organic as well as conventional cropping there remains demand for weed control systems that work without chemicals. On the one hand there is always the risk of environmental damage with the chemicals, on the other, herbicide application becomes more expensive thanks to resistance development in weeds or there's always the risk of restrictive legislation affecting permission to use plant protection substances.

Mechanical weeding is currently restricted to just a few special crops because the required precise steering is associated with a high labour input or while by less precise control of the implement severely limits its practicality. Where the steering precision problem of weeding implements in row crops can be solved by technology a renaissance for mechanical weed control could be possible. For a long time there have been attempts to automatically identify the row position via mechanical sensors [5]. Progress has been made with high-capacity sensors and processing systems [4]. A breakthrough for precise steering appeared to have been achieved via GPS technology [6].

Another very promising possibility is based on video sensors, the photographs from which being used to identify crop rows [1, 2, 3].

In this paper a relatively simply algorithm is presented with the help of which pictures video sensors are processed. The result is a steering parameter representing the lateral position of a weeding implement with regard to a crop row. Because of the great importance of the crop, maize was chosen for the development of this system.

Calibrating the video sensors

The video sensor, a commercially-available video camera, is so positioned that three maize rows can be seen through the lens consecutively so that gaps in any one row can be bridged through information from the other rows. To begin the work with the photo-processing system the operator must feed-in some parameters allowing the system to adjust to differences in crop height, weed populations and light conditions. A picture of the crop serves as basis on which the effects of the individual adjustment steps can be visualised. Where required, every input can be repeated.

As soon as the operator completes the calibration, the main program begins with the determination of the steering parameters.

Functions of the algorithm

1. Picture exposure

Because the video sensor delivers photo sequences whilst single photos are actually required for processing, a static photo is created as a first processing step. This picture is subsequently digitalised and thus changed into a form processable by computer. Preliminary tests have shown that colour pictures of the maize crop from the above technique offer no measurable advantage compared with grey scale pictures so that the simpler grey scale images can be worked with – which gives a shorter processing time. Even during this step an optical distortion takes place. This has the effect of making the crop rows in the image for further processing appear as parallel lines. Through overlapping of the distorted photos with a measuring

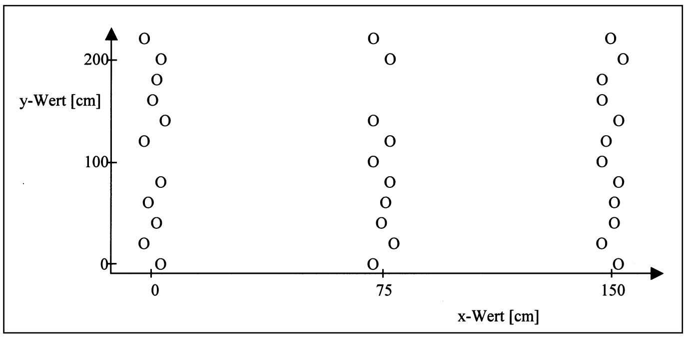

Fig.1: Schematic representation of a pre-processed picture

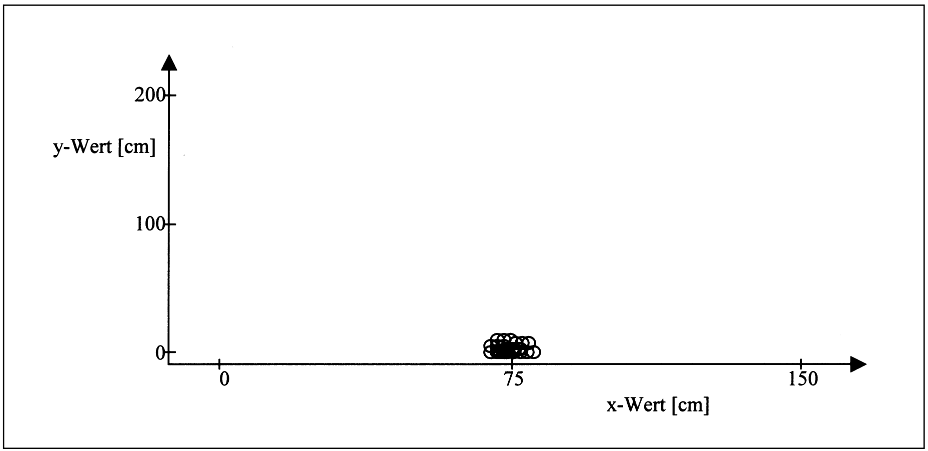

Fig. 2: Schematic representation of calculating the mean of the central row using the means of the three neighbouring rows

grid, the actual position of a photo point on the field can be deduced from its position in the picture.

2. Extracting plant picture points
In that plants are usually lighter than the picture background, as a next step all picture points (pixels) lighter than a specific threshold level, which has been determined by the calibration, are marked. As a rule there appears in the area of the crop rows larger related areas with marked picture points, whereas smaller areas are marked in the rows between.

3. Enlarging areas
"Small" areas are then blended out while it can be assumed that these represent weed plants, whereas larger areas as a rule stem from large numbers of plants in the areas of the crop rows. The respective border length is used as a scale in determining the size of an area. The size of the areas so defined is then compared with a value which was also established during calibration. All areas smaller than this threshold value are then blended out *(fig. 1)*.

4. Establishing area parameters
From the remaining areas the coordinates of the centres and area sizes are determined. The y-dimension is blended out and therefore only the position lateral to the direction of travel is further processed from the area centres.

5. Determining the row position in the picture
The distance between rows being known (here: 75 cm), it is possible to copy both outer rows logically onto the middle row so that in the centre region a strong assembly of areas or area centres can be identified. From the x-coordinates weighted with the area size a total average value can be calculated which represents the position of the middle crop row in the picture (*fig. 2*).

6. Calculating steering parameters
A parameter which represents the required lateral movement of the weeding implement is reached by comparing the determined and the ideal average value *(fig. 3)*.

Practical testing still to come

The algorithm was developed and tested offline because a problem caused by the vibrating of the video camera during the operation could not be eliminated in the time available. Therefore the pictures used were taken from a static tractor.

On average, the algorithm was 1.65 cm out compared with the real row positions (standard error 1.65 cm). This indicates that a practical application for a weeding implement with this kind of steering control is possible.

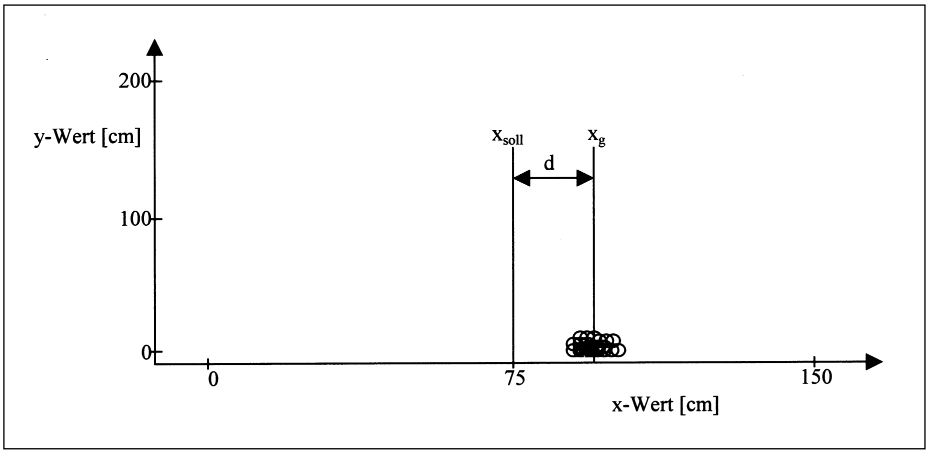

Fig. 3: Schematic representation of the deviation of the ideal and calculated row position; x_{soll}: set value (calculated position of row in the picture exactly following the track); x_g: actual value (true position of row in the picture; weighted mean of the x-values of centres of all foreground areas); d = $x_{soll} - x_g$ Deviation of the hoeing from optimum track, correction signal for the steering system

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