Robotic intra-row weed hoeing in maize and sugar beet

Roboter-gesteuerte Unkrauthacke in der Reihe von Mais und Zuckerrüben

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Abstract

A prototype of robotic intra-row weed hoeing in maize and sugar beet is presented in this study. Weeds in the crop rows were identified using a bi-spectral image analysis system and shape analysis. Positions of weeds in the images were recorded. Selective weed control in the row was performed with a modified finger weeder driven by electrical motors. Speed of the finger weeder was increased at positions where only weeds were classified. The system was triggered by an encoder and controlled by a micro-controller.

Keywords: Digital image analysis, mechanical weed control, precision farming

Zusammenfassung

Ein Prototyp einer roboter-gesteuerten Hacke zur Unkrautbekämpfung in den Reihen von Mais und Zuckerrübe wird in dieser Studie vorgestellt. Unkräuter und Kulturpflanzen wurden mit einer bi-spektralen Kamera und Formenanalyse erkannt. Die Positionen der Unkräuter im Bild wurden bestimmt. Die selektive Unkrautbekämpfung in der Reihe geschah mit einer modifizierten Fingerhacke, die über Elektromotoren angetrieben werden. Die Fingerhacke wurde beschleunigt, wenn nur Unkräuter in der Reihe klassifiziert wurden. Das System wurde mit einem Inkrementalgeber getriggert und über einen Micro-Controller gesteuert.

Stichwörter: Digitale Bildverarbeitung, mechanische Unkrautkontrolle, Precision Farming

Introduction

Vision-based and GNSS-based row guidance systems for inter-row hoeing have been developed for maize, soybean, sugar beet and other crops with wide row spacing. Nørremark et al. (2008), Sun et al. (2010), Perez-Ruiz et al. (2012), Rasmussen et al. (2012) and Slaughter et al. (2012) have created crop seed/plant maps using RTK-GNSS technology that can later be used for intra-row mechanical weed control and spot spraying. Ruckelshausen et al. (2006) integrated a multi-sensor approach for weed identification in maize with a robotic system for selective weed control within maize rows. Selective intra-row weeding however has not yet been realized for many other arable crops. Weeds within crop rows and close to the crop are difficult to remove without damaging the crop. Intra-row weeding can be carried out in several different ways. We developed a prototype intra-row hoe for robotic weeding in maize and sugar beet.

Materials and Methods

A bi-spectral camera taking simultaneously a picture in the infrared and red spectrum and image analysis algorithms were developed to automatically identify weed species in maize and sugar beet based on shape features. Geometric shape features and fourier descriptors of the outer contour were computer for a training set of sugar beets and weed species commonly occurring in sugar beet. A step-wise classifier was developed for automatic weed/crop classification. Positions of crops and weeds were recorded in the classification results. Thresholds of one weed in each image were set to decide when the speed of the finger weeder was increased. Electric motors were rotating the finger weeder with a fluctuating speed. An encoder was mounted in the axis of a non-driven wheel running over the ground providing information concerning distance. After calibration, the distance between two images and between classified plants in the image and the finger weeder, were known to the system. A micro-controller gathered the information from the encoder, and the classification program, triggered the camera and the finger weeder. If weeds were close to crops or if no weeds were identified, the speed of the finger weeder was not increased (Fig. 1).

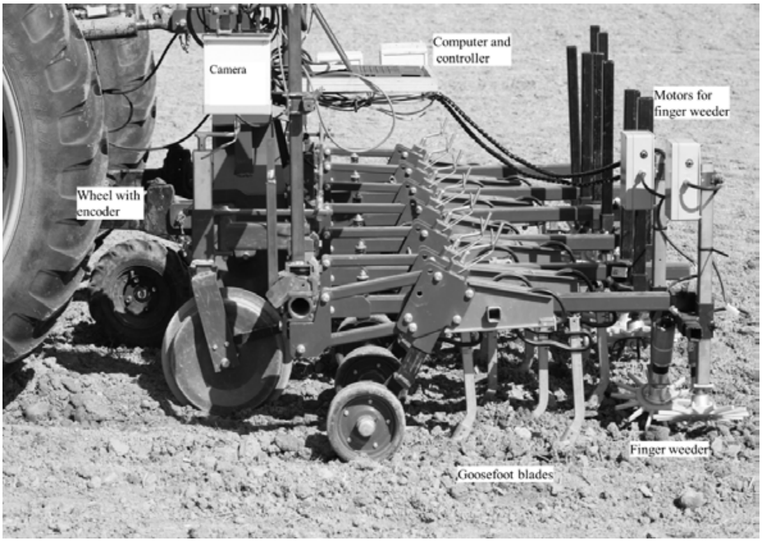

Fig. 1 Sensor-guided hoe with goosefoot blades operating between crop rows and an electronically controlled finger weeder in the intra-row area.

Abb. 1 *Sensor-gesteuerte Hacke mit Gänsefußscharen zwischen den Reihen und einer elektronisch geregelten Fingerhacke in der Reihe.*

Results and Discussion

At driving speed (2 km h^{-1}), the finger weeder worked selectively and did not damage the crops. At 8 km h^{-1}, the finger weeder removed all plants in the row.

So far, the prototype presented in this study has not been tested in field trials. Therefore, no results are presented in this manuscript. Field trials will be carried out in spring 2016 with different speeds, weed infestations and soil types in maize and sugar beet. We further plan to combine intra-row hoeing with camera-guided inter-row hoeing.

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