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A Computer Vision System for Evaluation of Field Robot Operations

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Abstract

The usage of field robots is increasing as more commercial products become available on the market. Among other measures, they can be used for seeding and mechanical weed control, using the geolocation of each individual seedling. The weed control process is performed without visual recognition of the plants. The precision of such weed control robots depends on the quality of the localisation, plant emergence, and soil properties. In order to evaluate the field robot operation accuracy, we developed a cost-effective, long-term autonomously working computer vision evaluation system based on two RGB cameras for pre- and post-weed control image capture. Our system was successfully tested to collect image data of the hoeing precision of a FarmDroid FD20 field robot.

1. Introduction

Recently, robotics and automation is playing an important role in smart farming technologies. Available field robots can be used for a variety of operations, e.g. for mechanical weed control using duck foot share and active hoes [1], a tube stamp [4] or a side-shifting frame [5]. Some of the field robots use computer vision to identify different plant species, such as [4], while others rely on a global navigation satellite system (GNSS) for high precision localisation [5]. Those systems store the location of each individual seedling and operate the area around the expected crops. The precision of such a system depends on the accuracy of the sowing, the regularity of the emergence of the crops, and the precision of the localisation [2]. The objective of this work is to develop a computer vision system to evaluate the weed control precision of a field robot.

Figure 1. Field robot FarmDroid FD20 with mounted computer vision evaluation system (CVES) on the field.

2. Material and Methods

2.1. Computer vision evaluation system

Our computer vision evaluation system (CVES) consists of a front and back camera, see Figure 1. It was used to collect RGB images before and after the weed control took place. We refer to those images as the pre-weed control (Figure 2, top left) and post-weed control (Figure 2, bottom left) images, respectively. The system consists of two single-board computers (Raspberry Pi - Model 3B+) with an integrated RGB camera (Raspberry Pi camera v2) with a resolution of 2596×1944 px. To mount the cameras top-down at a height of 1 m, we built an aluminum carrier, that could be adjusted to the robot construction. A GNSS module (Emlid Reach M+) with an antenna above the back camera was used for RTK GNSS localization. Consumer-grade power banks were used to supply the CVES, resulting in operation times of about 8 hours.

2.2. Field robot

The used field robot FarmDroid FD20 [1] has seeding modules, duck foot share for inter-row and active hoes for

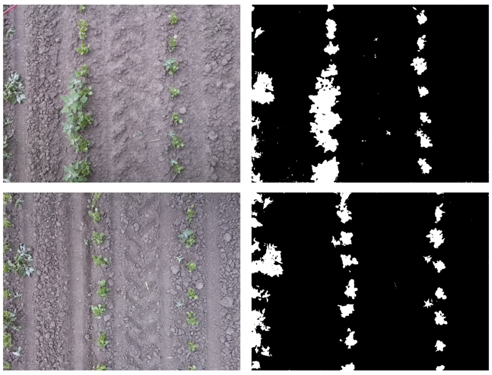

Figure 2. Representative RGB images (left) and vegetation segmentation (right) of the front camera (pre-weed control image, top) and the back camera (post-weed control image, bottom) at the same location during weed control of the anise plot at 2022/05/24.

intra-row hoeing. It is equipped with two GNSS antennas and receives real-time kinematic (RTK) correction signals. The field robot is powered by batteries that are loaded with solar panels and achieves to work for up to 24 hours, fully autonomously. The operating speed is limited to a maximum of $0.26\,ms^{-1}$. The weeding is based solely on the localization and the stored seeding points of the crops.

2.3. Field trial

Data was collected at a plot in Fuchsenbigl, Lower Austria, Austria in 2022. The field robot was used for seeding a 3.2 ha plot of anise (*Pimpinella anisum*). After seeding, our CVES was mounted. The first weed control was triggered manually based on the emergence of weeds and on a regular basis in the following weeks. Before the first weed control a test run of the CVES was performed. At selected weed control dates, we activated our CVES by connecting it with the power supply and validated the status. If the setup phase was successful, the system worked autonomously and the weed control process of the field robot continued.

3. Results

3.1. Evaluation based on total plant cover

Exemplary data analysis has shown that a decrease in the total plant cover can be observed between the pre- and post-weed control image of the same site. Here the plant cover dropped from 9.0 % (pre-weed control, Figure 2 top right) to 6.4 % (post-weed control, Figure 2 bottom right). We used decision tree classifiers based on color index maps for the vegetation segmentation [3] and analyzed all images of pre- and post-weed control in a given operating area, leading to a total of 9,113 images from two measurement dates. Results are given in Table 1.

Images	Date	Camera	m PC	sd PC
2,027	2022/05/06	Pre	0.58%	0.22%
1,808	2022/05/06	Post	0.44%	0.19%
2,649	2022/05/24	Pre	4.19%	2.36%
2,629	2022/05/24	Post	4.10%	2.27%

Table 1. Comparison of pre- and post-weed control total plant cover (PC) for two measurement dates, mean (m) and standard deviation (sd) are given in %.

4. Conclusion

We successfully developed a cost-effective, long-term autonomously working system to capture geolocated RGB images with the field robot FarmDroid FD20. A plant cover based evaluation of the whole area has limited power, see Table 1. Therefore, more advanced methods, such as a three-class semantic segmentation method are currently being developed. They should be used to distinguish between crops, weeds, and killed weeds but need more labeling effort. Our CVES is very flexible to use and can be adapted for usage with other field robots or robotic platforms.

Acknowledgments

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References

[1] Farmdroid FD20 field robot. `https://farmdroid.dk/en/product/`. Accessed: 2022-07-25.

[2] Hans W Griepentrog, Michael Nørremark, Henning Nielsen, and BS Blackmore. Seed mapping of sugar beet. *Precision Agriculture*, 6(2):157–165, 2005.

[3] Florian Kitzler, Helmut Wagentristl, Reinhard W. Neugschwandtner, Andreas Gronauer, and Viktoria Motsch. Influence of selected modeling parameters on plant segmentation quality using decision tree classifiers. *Agriculture*, 12(9), 2022.

[4] Frederik Langsenkamp, Fabian Sellmann, Maik Kohlbrecher, Arnd Kielhorn, Wolfram Strothmann, Andreas Michaels, Arno Ruckelshausen, and Dieter Trautz. Tube stamp for mechanical intra-row individual plant weed control. *Proceedings of the 18th World Congress of CIGR, Beijing, China*, pages 16–19, 2014.

[5] Michael Nørremark, Hans W Griepentrog, Jon Nielsen, and H Tangen Søgaard. The development and assessment of the accuracy of an autonomous gps-based system for intra-row mechanical weed control in row crops. *Biosystems engineering*, 101(4):396–410, 2008.