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Agricultural Robots in Targeted Spraying: A mini State-of-the-Art review

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Abstract

This article presents the most recent contributions to the field of agricultural robotics, with a focus on robot sprayers. The objective is to demonstrate the latest developments, specifically on robot sprayer systems for precision spraying (e.g. for weed control). The summary of the review shows that feasibility has been demonstrated in a number of projects with significant results especially in pesticide use reduction, with good spraying coverage for this complex agricultural task

Keywords: Agriculture; Robotics and automation; Precision spraying; Human-robot interaction

Introduction

One of the most frequent and important task in agriculture is the application of fungicides, herbicides and insecticides.It is frequent because diseases are a common occurrence on plants which affect the plant production, and it is important because it can have a significant impact on crop yield and quality. Fungicides, herbicides and insecticides are all pesticides used in plant protection. Current methods, either mechanical or manual, used for pesticide application, include human involvement. Figure 1 illustrates the excessive amount of pesticides released to the surrounding environment and the exposure of the farmers to these dangerous chemicals during the spraying process.

Figure 1: Current methods for pesticides application: Top (a) mechanized tractor sprayer, and bottom b) back pack human operated manual sprayer.

Robotic technology is an alternative method for spraying in agriculture, which provides multiple benefits, such as safety, sustainability and environmental impact. In terms of safety, it removes the farmer from the exposure to dangerous chemicals [1]. In addition, less pesticides means healthier food products for the consumer [2]. In terms of agriculture sustainability, robotic technology can provide a way to reduce inputs (e.g. by reducing the quantity of pesticides used) and make the most efficient usage of pesticide controls (e.g. by targeted spraying). Furthermore, targeted spraying can have a significant reduction on environmental impact [3,4], since with the current methods a major fraction of the pesticides sprayed, accumulate in the soil (i.e. soil degradation).

Robotic systems for agriculture fall under the "umbrella" of precision agriculture [5]. Many systems have been developed for various agricultural tasks such as monitoring, harvesting, spraying, weeding, cultivation, and planting [6-9]. A comprehensive review of automation and robots in agriculture [10] identifies the challenges of robotic systems in agriculture, and describes the different automation systems with application examples.

State of the Art Review

Gonzalez-de-Soto et al. [11] presented the features of a precise spraying robotized patch sprayer. The system consists of an autonomous mobile robot based on a modified commercial tractor (e.g. equipped with high-tech perception and actuation systems), a real-time machine vision system which can detect weeds, and a rapid-response spraying system. The experiments both laboratory and field tests revealed that the system can treat approximately 99.5% of the detected weeds while achieving a significant herbicide savings.

Malneršič et al. [12] evaluated a new technique for close-range air-assisted precision spot-spraying end effector. The spraying end effector was designed to enable connection to emerging agricultural robotic technology. Evaluation results showed that the spraying of the front side of the leaves was good, however the spraying on the back side of leaves surfaces should be further improved.

Oberti et al. [13], implemented a selective targeting robotic system of grapevines. The system was equipped with a manipulator which was configured to six degrees of freedom and a precision-spraying end-effector for multispectral imaging disease detection. The test results indicated a significant reduction of pesticide use from 65% to 85% (when compared to a conventional mass spraying of the canopy). The robot was able to treat from 85% to 100% of the disease area, and to limit the healthy area that was unintentionally sprayed from 5% to 20% of the total canopy area.

Adamides et al. [14], presented the human-robot interaction (HRI) design aspects and development process to transform a general purpose mobile robotic platform into a semi-autonomous agricultural robot sprayer. The main focus of this work was on user interface design and usability evaluation for mobile field robot teleoperation. The system effectiveness (58%) for spraying success was in similar range to low performance of harvesting robots average 66%, however it must be noted that the system was a small size robot aiming to show feasibility of the HRI system. Comparisons of existing benchmark data for User Experience [15] showed that the system was perceived as "excellent" in terms of attractiveness, perspoicuity, efficiency, dependability and stimulation, and "good" in terms of novelty.

Berenstein & Edan [16] presented a human-robot collaboration for site-specific spraying robotic sprayer. The article provides details on the robotic platform design, the human-robot collaboration framework, and on the tools used for the robotic sprayer to collaborate with a remote human operator for target detection and spraying. The field experiment proved the feasibility of human-robot collaboration for spraying specific targets. Moreover, this collaborative systems shows a 50% reduction of sprayed material, leading to both economic and environmental impacts.

Conclusion

This paper has presented a mini review of the state-of the art of agricultural robot targeted sprayers (also referred as site-specific or spot-spraying), for the period 2016 to 2017. The conclusion is that agricultural robot sprayers is a feasible solution that can help tackle health and environmental impacts by reducing the amount of spraying material used for pest control. As technology is developing, various limitations affecting system effectiveness and efficiency, will improve, making robotics a suitable solution for sustainable agricultural development.

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