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Development and Initial Evaluation of a Multi-Purpose Spraying Robot Prototype

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***Abstract*— We present a versatile mobile robotic sprayer system, primarily aimed for pesticide application in greenhouses and for disinfection of indoor spaces. The prototype is built around a skid-steered wheeled platform driven by a pair of DC motors, and is equipped with an electronically controlled sprayer unit that is mounted on a pan/tilt robot arm for directing the spray. The robot can be operated either manually or in AGV mode, utilizing a magnetic guide sensor to track a predefined path, along with a depth camera and ultrasonic sensors for obstacle detection. The robot's control architecture employs a central Single Board Computer running ROS, with peripheral functions allocated to three 8-bit microcontrollers. Closed loop flow regulation schemes have been developed to provide precision variable application rate of the sprayed agents, combined with motion control strategies of the pan/tilt unit to implement rectangular coverage spraying. The robot's capabilities are demonstrated through a series of tests, involving laboratory experiments as well as application scenarios trials.**

***Index Terms*— Spraying robot, Agricultural robotics, Greenhouse robot, Disinfection robot.**

I. INTRODUCTION

A number of spraying robots for use in the agri-food chain have been developed, primarily aimed towards pesticide application and weed control in various types of crops [1]–[6], but also for livestock disinfection [7]. The main motivation relates to leveraging technologies such as autonomous navigation, advanced image processing, machine learning, and precision spraying to ensure appropriate, safe, traceable, and cost-effective use of pesticides, while drastically reducing health concerns for the personnel. This could contribute towards reduced labour costs, improved product yield and quality, environmental sustainability, as well as higher profitability, in the context of precision agriculture [8].

The 2020 outbreak of the COVID-19 pandemic sparked further research efforts and development of commercial spraying robots for the application of disinfection agents to automate sanitisation treatment of public areas as well as health care, transportation, and logistics facilities [9]–[11].

In this context, we present here a versatile robotic spraying platform, developed primarily for pesticide application in greenhouses, which, through a series of simple modifications, can also be adapted for disinfection tasks in indoor settings. The prototype is built around a skid-steered wheeled platform equipped with an electronically controlled sprayer unit that incorporates a pan/tilt robot arm for directing the spray and closed loop flow control schemes to provide precision variable application rate of the pesticide/disinfection agents. The robot, whose software has been developed under the Robot Operating System (ROS), supports either manual teleoperation or automated movement over a predefined guide path (AGV mode) by means of a magnetic tape. The latter option provides a robust, cost-effective and sufficiently flexible solution for the intended application scenarios. Additional sensors, including ultrasonic rangers and a depth camera, are employed for obstacle detection and collision avoidance, towards increased operational robustness.

The robot's mechanical and electronics design is described in Section II, while details regarding it's control systems are provided in Section III. Experimental studies to assess the performance of the robot, both in a laboratory setting and in realistic application scenarios, are provided in Section IV.

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II. ROBOT DESIGN

A. Mobile platform

The spraying robot prototype, shown in Fig. 1, is built around an in-house developed four-wheel differential drive platform, measuring $75\,\mathrm{cm}$ in length, $72\,\mathrm{cm}$ in width and $57\,\mathrm{cm}$ in height. The platform's overall weight is $52\,\mathrm{kg}$ and it has a payload capacity of $45\,\mathrm{kg}$. The upper part of the body has been fabricated out of $1.25\,\mathrm{mm}$-thick stainless steel panels for structural rigidity and corrosion resistance, while the top cover is made from aluminium.

Each left/right wheel pair is driven by a $200\,\mathrm{W}$ brushed DC gearmotor (*Faulhaber* 3863-036C) combined with a belt transmission. The motors are equipped with $500\,\mathrm{cpr}$ incremental encoders that provide feedback for closed-loop speed control, implemented on a ROS-enabled 2 x $20\,\mathrm{A}$ motor drive unit (*Roboteq* SDC2130).

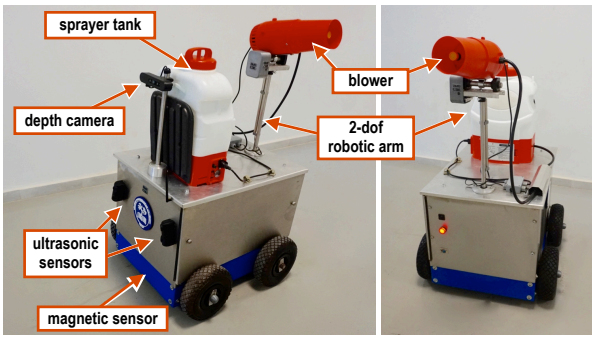

Fig. 1: Overview of the spraying robot prototype.