DESIGN OF AN AUTOMATIC MACHINE FOR VARIABLE RATE APPLICATION OF FLAME WEEDING ON MAIZE

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An automatic operative machine for variable rate application (VRA) of flame weeding on maize was designed and built at the University of Pisa within the European Project "Robot fleets for Highly Effective Agriculture and forestry management" (RHEA). The machine was designed to conduct non-selective mechanical weed control between the crop rows and site-specific VRA of flaming in the intra row space. Flame weeding is applied by a pair of burners liquefied petroleum gas (LPG) fed, which work cross to the row, and is activated automatically only in presence of weeds. The machine was coupled with an autonomous tractor equipped with an optical sensor for real-time row crop and weed detection. Specific hardware and software provide information about the weed cover percentage detected and send these data to the operative machine. The LPG dose that has to be applied is chosen in real-time between two doses identified in the calibration phase to be effective on weed cover percentages lower or higher than 25%. In the case of 0% weed cover, burners are switched off. The burners ignition system was designed to be almost instantaneous in order to minimize all delays, which elapse between weed detection and the presence of the flame in the area that have to be treated. The almost instantaneous burners ignition system allows also to avoid the use of a pilot flame, which would be switched on for all the effective working time of the machine. The operative machine is equipped with and automatic steering system, which according to directional movement of two metallic wheels, allows maintaining the same trajectory of the autonomous tractor, and avoiding the accidental damage of the crop. A study aimed to find the optimal LPG doses for an effective weed control and which not lead to yield losses, as a consequence of damages occurred to maize plants treated at different development stages, was conducted in 2012 and 2013 at the experimental farm of the University of Pisa. Maize and weeds response to the application of five LPG doses was evaluated in terms of yield, weed density after the application and weed dry biomass at harvest. The optimal LPG doses estimated were useful for the automatic operative machine calibration. The site-specific VRA of flaming and the use of an almost instantaneous burners ignition system allow to reduce the LPG consumption compared to a continuous application and the presence of the pilot flame during turning, leading to a reduction of costs for the thermal weed management of heat-tolerant crops. The operative machine represent a new technology for precision agriculture, which if integrated with a proper perception system, independent from the autonomous tractor for the receiving of information needed for the automatic regulation of the LPG dose, could work coupled with a common tractor.

TUNING A TERRAIN FOLLOWING REMOTELY PILOTED AIRCRAFT SYSTEM FOR CROP MONITORING IN PRECISION AGRICULTURE

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Remotely Piloted Aircraft Systems (RPAS), generally known as *drones*, are very promising in environmental monitoring and they has a very high technological level to apply them in reconnaissance mission with an high level of automation in order to reduce the workload of the operators. In the next 10 years, over 75% of existing RPAS will be used for crop monitoring in precision farming, where prompt management reactions to plant disease, lack of plants nutrients and environmental changes are the focal point to farm efficiency and productivity.

In order to optimize the RPAS monitoring activities in terms of time (process automation) and in term of costs (economic sustainability), planning the reconnaissance operations is crucial: every single procedure to accomplish the survey mission must be examined and evaluated. Furthermore, we have to consider the Italian Regulation on RPAS that introduces restrictions on RPAS operations.

Different kind of sensors can be used for crop monitoring and each sensor has a specific mission profile. Active sensors require a very low flight (within 2 meters above the ground) and a commercial RPAS cannot achieve this performance. Passive sensors require a very high overlap (over 70%) of the images.

In this work we present the results of the analysis of monitoring performances of RPAS, in terms of workrate (ha per day) and a cost estimation (€ per ha). In this analysis, we considered two different kind of commercial sensors. We show the calibration test performed to achieve the very low level flight, the validation of the performances, the repeatability of the flight path and the validation of sensors measurements.