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Fully Autonomous Vertical Farm to Increase Crop Production

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Abstract : New technologies in agriculture are opening new challenges and new opportunities. Among these, certainly, robotics, vision, and artificial intelligence are the ones that will make a significant leap, compared to traditional agricultural techniques, possible. In particular, the indoor farming sector will be the one that will benefit the most from these solutions. Vertical farming is a new field of research where mechanical engineering can bring knowledge and know-how to transform a highly labor-based business into a fully autonomous system. The aim of the research is to develop a multi-purpose, modular, and perfectly integrated platform for crop production in indoor vertical farming. Activities will be based both on hardware development such as automatic tools to perform different activities on soil and plants, as well as research to introduce an extensive use of monitoring techniques based on machine learning algorithms. This paper presents the preliminary results of a research project of a vertical farm living lab designed to (i) develop and test vertical farming cultivation practices, (ii) introduce a very high degree of mechanization and automation that makes all processes replicable, fully measurable, standardized and automated, (iii) develop a coordinated control and management environment for autonomous multiplatform or tele-operated robots in environments with the aim of carrying out complex tasks in the presence of environmental and cultivation constraints, (iv) integrate AI-based algorithms as decision support system to improve quality production. The coordinated management of multiplatform systems still presents innumerable challenges that require a strongly multidisciplinary approach right from the design, development, and implementation phases. The methodology is based on (i) the development of models capable of describing the dynamics of the various platforms and their interactions, (ii) the integrated design of mechatronic systems able to respond to the needs of the context and to exploit the strength characteristics highlighted by the models, (iii) implementation and experimental tests performed to test the real effectiveness of the systems created, evaluate any weaknesses so as to proceed with a targeted development. To these aims, a fully automated laboratory for growing plants in vertical farming has been developed and tested. The living lab makes extensive use of sensors to determine the overall state of the structure, crops, and systems used. The possibility of having specific measurements for each element involved in the cultivation process makes it possible to evaluate the effects of each variable of interest and allows for the creation of a robust model of the system as a whole. The automation of the laboratory is completed with the use of robots to carry out all the necessary operations, from sowing to handling to harvesting. These systems work synergistically thanks to the knowledge of detailed models developed based on the information collected, which allows for deepening the knowledge of these types of crops and guarantees the possibility of tracing every action performed on each single plant. To this end, artificial intelligence algorithms have been developed to allow synergistic operation of all systems.

Keywords : automation, vertical farming, robot, artificial intelligence, vision, control
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