Agrobot: autonomous robots to support economic growth and environmental sustainability of Umbria's agriculture

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***Abstract*— The AGROBOT project is aimed at the realisation and experimental validation of an autonomous robot with the purpose of supporting innovative agricolture approaches suitable for territories characterised by small, family owned agricultural firms, with not too large fields located in hilly areas. The project will demonstrate the suitability of precision farming solutions for the designed target stakeholders, with the goal of supporting the economic growth and the introduction of approaches aimed at improving environmental sustainability. From the technological point of view, the project will be based on state of the art methods as for perception, control and navigation. Also, advanced, photo realistic simulation environments will be used, to take full advantage of those solutions and to reduce the burden of in-field experimental tests.**

***Index Terms*—Autonomous robotics, precision farming, visual slam, robot navigation.**

I. Introduction

The AGROBOT project aims to develop and demonstrate in real application contexts the technologies necessary to automate some crop scouting and monitoring operations (mainly related to olive grove and vineyard), which can allow a concrete advantage in agronomic management and crop protection. The explicit objective of the project is to use state of the art technologies in the field of mobile robotics and image processing in order to reduce the time and costs of regularly monitoring the physiological and phytosanitary crop state. The project outcome will be a prototype vehicle able to drive autonomously, with minimum supervision, following a path planned according to the cultivation needs, and that can be easily reconfigured by the farmer, equipped with proper sensing equipment to carry out on-line agriculturally meaningful monitoring.

The introduction of autonomous mobile robotics applications in agriculture is considered as one of the levers for improving the associated economic, environmental and energy sustainability elements [1].

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With respect to the Umbria Region strategic objectives pursued with the PSR funding initiative, the project has the goals of

- improve the economic efficiency indicators of agricultural firms, with an improvement in the benefit/cost ratio of some significant agricultural activities;
- improve environmental sustainability and reduce negative impacts, with targeted foliar and soil treatment actions (e.g. plant protection products, fertilisers and water) and calibrated to the specific needs of the plants.

The use of robot in precision farming is receiving a large attention in the literature; see, among many others, [2], [3], [4], [5], [6], [7], [8], [9], [10].

II. The research team

The project consortium comprises the Engineering Department, University of Perugia; the Agricultural, Food and Environmental Sciences Department, University of Perugia; the Institute of Life Sciences, Sant'Anna School of Advanced Studies; Cratia srl; Assoprol Umbria soc. coop. Agr; the "Ciuffelli Einaudi" Technical Agricultural Institute; and Infomobility srl.

Cratia srl is a company specialised in training, consultancy and management for the agricultural and agro-industrial sector, owned by Confagricoltura Umbria, with a strong expertise in cooperation and innovation projects. Cratia role within the Agrobot project, in addition to coordination and administration, is to support and take part into field experimental and demonstration tests.

Assoprol Umbria soc. coop. Agr., a major organization of oil and olive producers of Umbria, has the aims to work toward the improvement and the enhancement of the production of extra-virgin olive oil, including through cooperation and innovation projects. Within the Agrobot project Assoprol, beside administrative and management tasks, will support the consortium both with end-user involvement and result dissemination. The "Ciuffelli Einaudi" Technical Agricultural Institute will cooperate to the field experimental and demonstration tests.

Infomobility srl, a company quite active in the automotive, infomobility and machine control areas, will develop the main control station and some of the sensing equipment.

The role of the research institutions will be both to support the design of the prototype and its planning, navigation and localization algorithms, and to propose, discuss and evaluate monitoring methodologies suitable for the olive grove and vineyard environments of interest.

III. Project goals and robot architecture

The AGROBOT is a prototype of an autonomous vehicle for precision farming applications. Based on an high-level task description provided by the farmer through a possible remote ground control station, the robot will deploy a proper path within the target vineyard, or the olive grove. The associated robot perception, navigation and control architecture will make the system able to react and adapt to unforeseen events, such as dynamic obstacles (people or animals moving in the field), roughness of the terrain, poor visibility conditions or variable weather, GNSS denied locations, and at the same time acquiring a variety of information on the vegetative and phytosanitary status by passing through the row.

To this end, both the whole stack of algorithms able to locate the vehicle in a georeferenced map, to build a proper occupancy map, to perceive possible obstacles and objects (from trees, shrubs, people and animals, to steep terrain or puddles of water), and the hardware, based on a mechanical system, equipped only with the electric propulsion section, must be developed.

These general objectives will be pursued with the following specific demonstration objectives.

1) Development of a navigation stack based on GNSS, Lidar, vision and inertial sensors capable of:
   - locate the vehicle in a known map using some combination of the available sensors;
   - improve or build from scratch the map in which the robot has to navigate, by using suitable SLAM approaches;
   - detect and avoid some of the most common obstacles, such as people, farm animals, other vehicles and bulky objects;
   - navigate and control the vehicle along the planned trajectory.
2) Realisation of a ground control station to remotely manage vehicle operations and monitor all operating parameters.
3) Development of use cases related to typical and relevant situations, in order to demonstrate their correct behaviour and to measure the effects of such functionalities.
4) Development of use cases for automatic image-based detection for insect pests monitoring protocols including their damage in olive orchard. The attention will be focused on key pest, Bactrocera oleae (Rossi) or Olive Fruit Fly.

IV. The simulation segment

To support the development of the whole software stack, a simulation environment has been already developed, based on i) the unreal simulation engine, ii) a novel ROS-unreal integration framework developed at the ISARLab group, Engineering Department at University of Perugia, and iii) the whole ROS ecosystem.

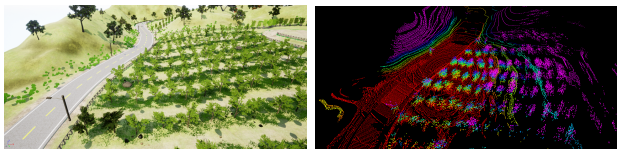

Fig. 1: The simulation environment.

Such a simulation based approach will allow to facilitate the development of the key software segments, and to reduce the burden of preliminary in-field experimental tests. In addition, this will also allow to deploy machine learning approaches based on synthetic data set, which is a state of the art paradigm in the field [11].

The simulation environment will also return realistic sensory data, both for the camera and the lidar case. Figure 1 depicts an example of agricultural environment, aerial view (top) and the associated lidar scan (bottom).

References

[1] S. F. U. (STOA), "Precision agriculture and the future of farming in europe scientific foresight study," in *European Parliamentary Research Service. PE 581.892. 2016*. [Online]. Available: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS_STU(2016)581892_EN.pdf

[2] P. Gonzalez-de Santos, A. Ribeiro, and C. Fernandez-Quitanilla, "The rhea project: using a robot fleet for a highly effective crop protection," in *Proceedings of the International Conference of Agricultural Engineering (CIGR-Ageng12), Valencia, Spain*, 2012.

[3] E. E. Cepolina, M. Przybyłko, G. B. Polentes, and M. Zoppi, "Design issues and in field tests of the new sustainable tractor locostra," *Robotics*, vol. 3, no. 1, pp. 83–105, 2014.

[4] M. Pérez-Ruiz, P. Gonzalez-de Santos, A. Ribeiro, C. Fernández-Quintanilla, A. Peruzzi, M. Vieri, S. Tomic, and J. Agüera, "Highlights and preliminary results for autonomous crop protection," *Computers and Electronics in Agriculture*, vol. 110, pp. 150–161, 2015.

[5] P. Gonzalez-de Santos, A. Ribeiro, C. Fernandez-Quintanilla, F. Lopez-Granados, M. Brandstoetter, S. Tomic, S. Pedrazzi, A. Peruzzi, G. Pajares, G. Kaplanis, *et al.*, "Fleets of robots for environmentally-safe pest control in agriculture," *Precision Agriculture*, vol. 18, no. 4, pp. 574–614, 2017.

[6] F. A. A. Cheein and R. Carelli, "Agricultural robotics: Unmanned robotic service units in agricultural tasks," *IEEE industrial electronics magazine*, vol. 7, no. 3, pp. 48–58, 2013.

[7] M. Gonzalez-de Soto, L. Emmi, M. Perez-Ruiz, J. Aguera, and P. Gonzalez-de Santos, "Autonomous systems for precise spraying–evaluation of a robotised patch sprayer," *biosystems engineering*, vol. 146, pp. 165–182, 2016.

[8] R. F. Carpio, C. Potena, J. Maiolini, G. Ulivi, N. B. Rosselló, E. Garone, and A. Gasparri, "A navigation architecture for ackermann vehicles in precision farming," *IEEE Robotics and Automation Letters*, vol. 5, no. 2, pp. 1103–1110, 2020.

[9] L. Cantelli, F. Bonaccorso, D. Longo, C. D. Melita, G. Schillaci, and G. Muscato, "A small versatile electrical robot for autonomous spraying in agriculture," *AgriEngineering*, vol. 1, no. 3, pp. 391–402, 2019.

[10] T. Hiramatsu, S. Morita, M. Pencelli, M. Niccolini, M. Ragaglia, and A. Argiolas, "Path-tracking controller for tracked mobile robot on rough terrain," *International Journal of Electrical and Computer Engineering*, vol. 13, no. 2, pp. 59–64, 2019.

[11] J. Tobin, R. Fong, A. Ray, J. Schneider, W. Zaremba, and P. Abbeel, "Domain randomization for transferring deep neural networks from simulation to the real world," in *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE, 2017, pp. 23–30.