Navigation of an autonomous all-terrain mobile manipulator in semi-structured vineyard environment

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1. Introduction

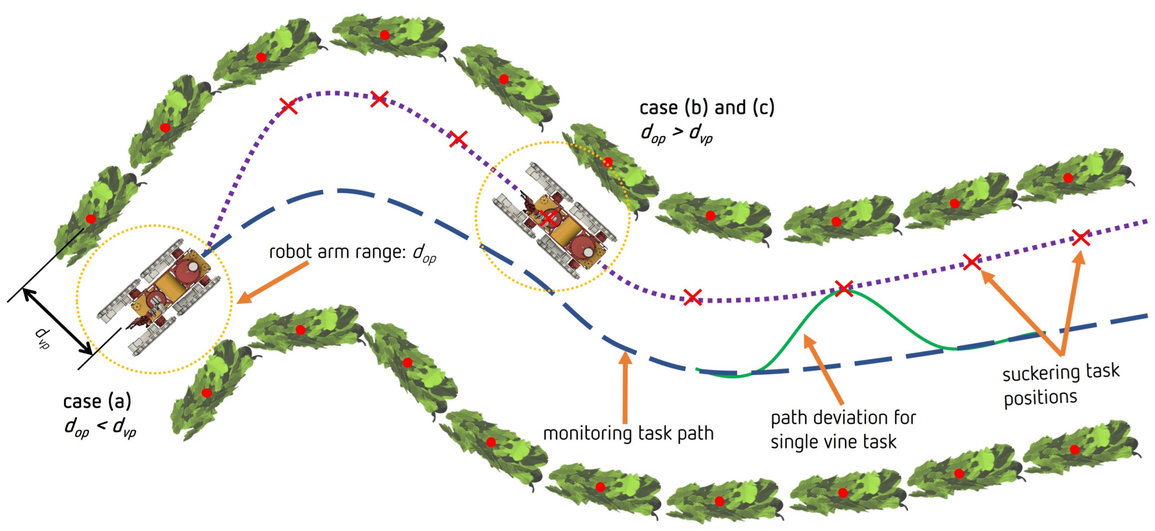
- Winegrowing is a labor-intensive agricultural discipline, especially for vineyards on steep karst terrain

Steep vineyard (left), manual suckering (middle) and spraying (right)

- It would be very beneficial to replace humans with robots able to perform required tasks autonomously, in all terrains

2. Problem Description

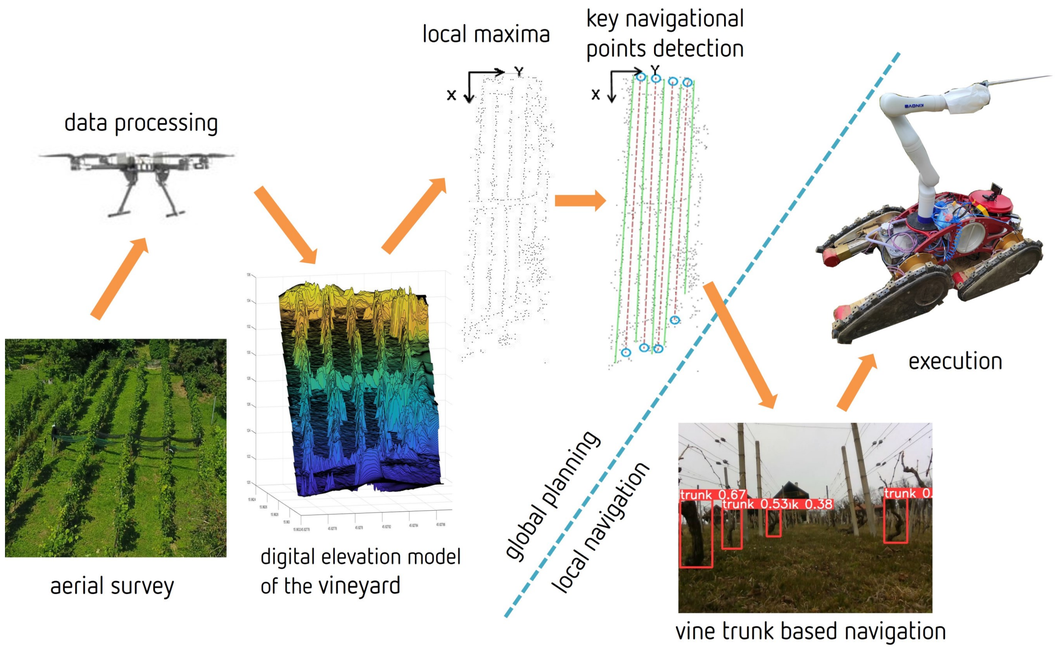
- How to design autonomous all-terrain mobile manipulator with accurate navigation, positioning, and predictive energy consumption, within semi-structured vineyard environment



Navigation during three different phases of winegrowing: central-line navigation (dashed blue), suckering (solid green), and spraying (dotted violet)

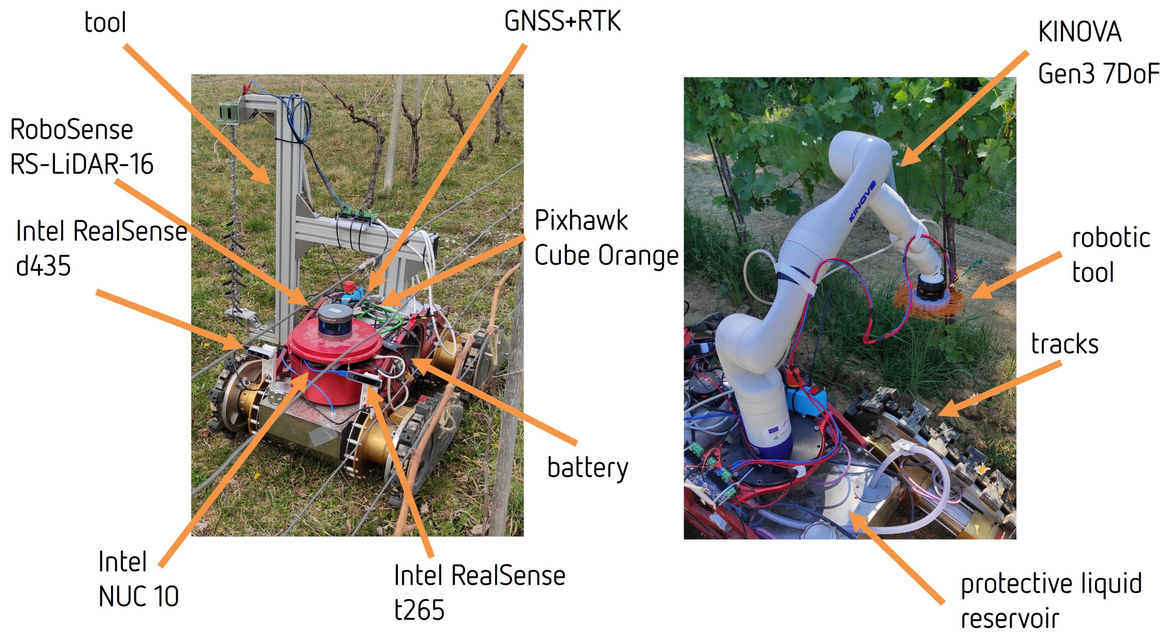
3. Methodology

- Visual recognition and localization of vine trunks using neural networks fed by LIDAR and RGBd camera
- Energy consumption estimation based on Google Earth data
- In-situ verification in different vineyards with varying slopes



Overview of complete navigation and positioning procedure of all-terrain mobile manipulator in steep-slope vineyard

4. Results

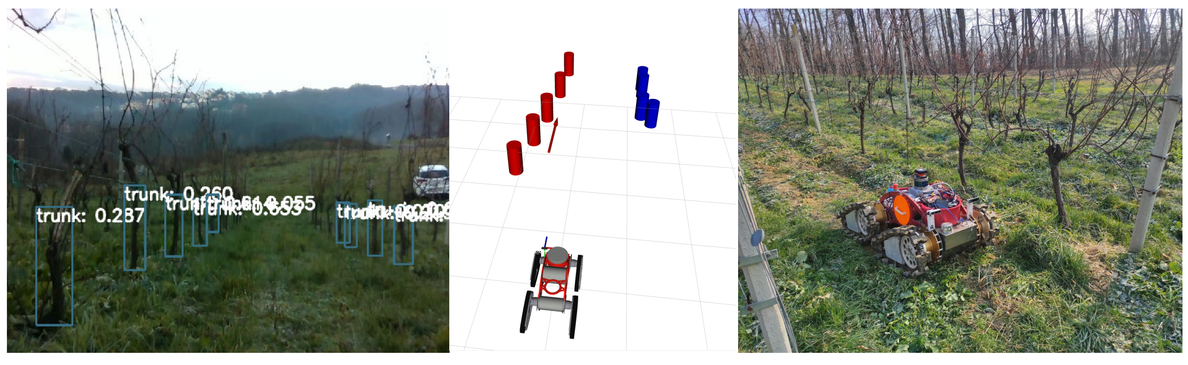


Developed all-terrain mobile manipulator (ATMM-VIV) driven by four independently controlled flippers/tracks in two possible configurations. Robotic tool with one degree of freedom (left) and robotic tool based on 7 DoF robot arm with brush (right)

- Developed solutions were tested in three representative vineyards:

Vineyard	Jazbina	Zelina	Lumbarda
Soil type	dirt	grass	meliorated karst
Slope	9 %	52 %	28 %

Testing sites: Jazbina (left), Zelina (center), and Lumbarda (right)



Experimental results of localization, navigation and positioning in Jazbina vineyard:
vine trunk detection (left), localized vine trunks visualized in Rviz (middle), task execution – positioning of the robot (right)

5. Conclusion

- Navigation, positioning, energy consumption estimation and task execution of developed manipulator were validated and tested in several representative vineyards
- An all-terrain mobile manipulator for autonomous precise selective spraying and suckering was developed
- Methodology for autonomous navigation and task execution in steep vineyards was proposed

Acknowledgments

Heterogeneous autonomous robotic system in viticulture and mariculture (HEKTOR), financed by the European Union, through the European Regional Development Fun-The Competitiveness and Cohesion Operational Programme (KK.01.1.1.04.0036).

HEKTOR
hektor.fer.hr

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