Natural Intelligence for Robotic Monitoring of EU Forest Habitats: first steps of an exciting challenge

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According to the Directive 92/43/EEC of the European Council (Habitats Directive), EU countries are required to periodically assess habitat monitoring campaigns to evaluate the effectiveness of conservation measures and the achievement of conservation targets, which is crucial for the preservation of biodiversity. In forest habitats, characterizing floristic composition, structure, and presence of typical species is complex and requires a high level of botanical expertise plus the ability to move for hours in wild unstructured environments. Nowadays, this task can be carried out only by highly trained human operators. The H2020 Project "Natural Intelligence for Robotic Monitoring of Habitats - NI " ("Research and Innovation boosting promising robotics applications") aims to develop quadruped robots able to move autonomously in the unstructured environment of several habitat types (dunes, grasslands, forests, screes). Our study case focused on beech forests (9110/9210 Annex I Habitats). We brought the robot to selected 9210 habitat stands in the Special Area of Conservation La Verna-Monte Penna (Arezzo, Italy) to conduct several tests. The robot successfully overcame multiple challenges, including autonomously moving on highly uneven, slipping, and irregular terrains, and managing unexpected contacts and impacts with deadwood and vegetation on the ground. The second round of tests aimed at proving the ability of NI robot to gather floristic and structural data, the two main challenges of environmental monitoring in these forests according to the Manual for Italian habitat monitoring [1]. In selected test areas, a plot-based vegetation (species cover) and structural (tree diameter at breast height and tree height) monitoring was carried out by trained botanists on 200 m^2 circular surfaces. At the completion of human monitoring, the robot scanned the same plot to create a 3D map using its Velodyne VLP-16 Puck LITE LiDAR. From this, it was possible to segment single trees and to measure their diameter. The robot ability to move in the study area during the laser scanning was another technological achievement for habitat monitoring. The sole comparable technology to such structural data acquisition is mobile

laser scanning (MLS), which requires to be carried by human operators. The acquisition system was also directed upward to measure tree height. The robot was also equipped with RGB-D Intel Real Sense D435 camera on each side. The four cameras had a field of view of 77° x 69.4° x 42.5° and recorded full-HD photos and videos for a later identification of some key indicator species, useful to assess the habitat conservation status. Nevertheless, in the context of image recognition, autonomous mission planning and tree segmentation, the algorithm will require further improvements. Notwithstanding these actual limitations, we moved the first steps toward a fully functional robotic assistance in vegetation monitoring. From the botanical point of view, the exciting ongoing challenge is to develop a human-robotic monitoring framework, that, although obviously not replacing the human botanical skills, might represent a precise quantitative support for those repetitive and time-consuming activities in habitat monitoring, offering a valuable benefit for biodiversity conservation.

1) Angelini P., Casella L., Grignetti A. & Genovesi P. (Eds.), 2016. Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/ CEE) in Italia: habitat. ISPRA, Serie Manuali e Linee