NATURAL INTELLIGENCE FOR ROBOTIC MONITORING OF ANNEX I HABITATS: FIRST STEPS IN AN UNEXPLORED WORLD

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INTRODUCTION

The Council Directive 92/43/EEC of 21 May 1992, has identified the Natura 2000 network, with its habitats and species (H&S) of European importance, as one of the main objectives of attention for effective protection of natural and semi-natural biodiversity. This process implies a huge effort for the EU States, which are in charge of implementing periodic monitoring of the state of conservation of H&S, and intervening with appropriate management measures, where necessary. Environmental monitoring is a complex task that requires a high level of experience, knowledge, and skills. Today, **human operators are the only option to perform the activity of H&S monitoring**, with the increasing support of supervised and semi-supervised tools (e.g. satellite or drone imagery). A possible artificial alternative is robotics, which made tremendous advancements in recent years.

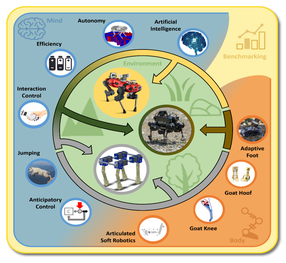
AIM

The H2020 Project "Natural Intelligence for Robotic Monitoring of Habitats - NI" (call H2020-ICT-2020-2, ICT-47-2020 "Research and Innovation boosting promising robotics applications") started in January 2021, with the aim to develop quadruped robots able to successfully and autonomously move in different habitat types and perform monitoring tasks. The monitoring protocols follow the field guidelines for Annex I Habitats reported in the Manual for Habitats Monitoring in Italy, developed by ISPRA and SISV (2016).

METHOD

NI robots will be empowered by "natural intelligence", leveraging on the fusion of artificial cognition and articulated soft-robotics. In the developed experimental design, a set of specific parameters for each case study have been selected, concerning the physical environment, vegetation structure, and key species occurrence, in order to "teach" the robot's intelligence to acknowledge, recognize, and quantify some key indicators useful to assess the habitat's conservation status.

A Nature-Centered Approach to Robotic Environmental Monitoring



CASE STUDIES

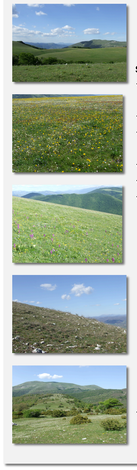
Dunes, grasslands, forests, and Alpine screes, corresponding, respectively, to 2110, 2120, 6210, 8110, 8120, 9110, and 9210 Annex I Habitats, were selected as case studies in different areas of Italy, in the Regions: Lombardy, Tuscany, Sardinia, and Umbria.

dunes

main pressures & threats
- Mechanical disturbaces
- Invasive species

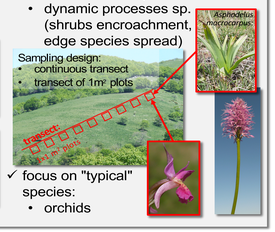
selected indicators:
- ✓ elevation and inclination of the dune, soil stability, sand deposition, tracks of mechanical disturbances
- ✓ total vegetation cover
- ✓ "typical" species identification and estimation of cover (%)
- ✓ bare soil (%)
- ✓ pollinators and other insects
- ✓ invasive species
- ✓ focus on typical species:
  - plant/tuft size,
  - population structure (seedlings, saplings, adults, dead tufts cover),
  - number of ears or flowers,
  - sand build-up

grasslands



main pressures & threats
- Abandonment of traditional activities
- Overgrazing

selected indicators:
- ✓ abiotic features: slope, aspect, stoniness, rockiness
- ✓ total vegetation cover
- ✓ "typical" species identification and estimation of cover (%)
- ✓ bare soil (%)
- ✓ pollinators and other insects
- ✓ "early warning species"
  - disturbing, nitrophilous sp.
  - alien invasive sp.
  - dynamic processes sp. (shrubs encroachment, edge species spread)



- ✓ focus on "typical" species:
  - orchids

forests

main pressures & threats
- Inappropriate silvicultural practices
- Overgrazing, damages by wild ungulates
- Soil erosion

selected indicators:
- ✓ abiotic features: slope, aspect, stoniness, rockiness
- ✓ cover (%) of tree, shrub, and herbaceous layers
- ✓ focal (nemorals and geophytes) plant species identification and estimation of cover (%)
- ✓ height and diameter of the tree species
- ✓ dead wood diameter, length/height, number)
  - standing
  - laying
- ✓ renewal
  - young trees (height >30 cm and < 5 m)

Plot type:
circular plots with a radius of 8 m (about 200 m²)

Alpine screes

main pressures & threats
- Outdoor sports, recreational activities
- Abiotic natural processes
- Climate change

selected indicators:
- ✓ abiotic features: grain size, surface stability
- ✓ surface temperature and moisture
- ✓ debris thickness
- ✓ total plant cover (%)
- ✓ vegetation patch dimension and distance
- ✓ species identification: «green» vs. «grey»
- ✓ morpho-functional macrocategories (specific life forms: «cushion» plants)
- ✓ cover values for each species
- ✓ leaf dimension, plant height, phenological status.

Sampling design:
- one sampling each 2-5 ha
- minimum sampling area 16-20 m²

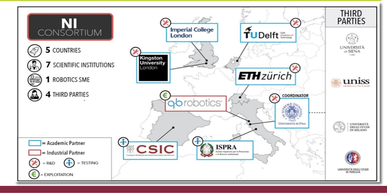
CHALLENGES

At present, most ground robots are not robust and efficient enough to survive in the real world, and cannot autonomously percept, interpret, and interact with highly uneven, slipping, and irregular grounds, not to mention the ability to manage unexpected contacts and impacts. The challenge of the Project "NI" is to develop tools that, although obviously not replacing the human botanical skills, might represent robust support for those repetitive and time-consuming activities in habitat monitoring, offering a valuable benefit for biodiversity conservation.

EXPECTED IMPACTS

- ❖ Improving precision, objectivity, trustability in measuring habitats' biotic and abiotic parameters.
- ❖ Reducing the time spent in field works.
- ❖ Providing larger data sets.
- ❖ Strengthening EU excellence in Robotics Science & Technology.
- ❖ Lowering the barriers in the deployment of robotics-based solutions.
- ❖ Widening the use of robotics in promising application areas.

WORKING TEAM



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