RAISE

SPOKE 3

Environmental Caring and Protection Technologies, towards a Zero Emission Environment

Allegato B

DETAIL SHEETS OF SPOKE 3 PROJECTS AND PRODUCTS

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

PROJECT 1

Advances technological platforms for sea monitoring and forecasting

PARTICIPANTS: CNR (ISMAR, IAS, IBF, IMATI, INM) - IIT (BSR, MWS, SMARTMAT, nPMed, GEB) UNIGE (DIBRIS, DISTAV, DICCA, DITEN, DIFI, DCCI) – ETT – ENEA – INGV

LEADER: CNR-ISMAR

CO-LEADER: ETT

Objectives/Expected Result:

The current marine observing systems produce a huge amount of data and services relevant for the scientific community and more in general for the whole human society (e.g. food production, tourism, climate change mitigation, carbon dioxide absorption and oxygen production). Nevertheless, a step towards a more effective system of marine observations can be made by defining and developing a new paradigm based on the transition from single-point to diffuse monitoring. This can be achieved by defining and developing a new generation of marine observing systems that integrate the traditional wired single-point monitoring stations with new stand-alone and distributed observing points, innovative sensors capable of acquiring new environmental parameters, autonomous vehicles capable of adaptively extending the monitored areas.

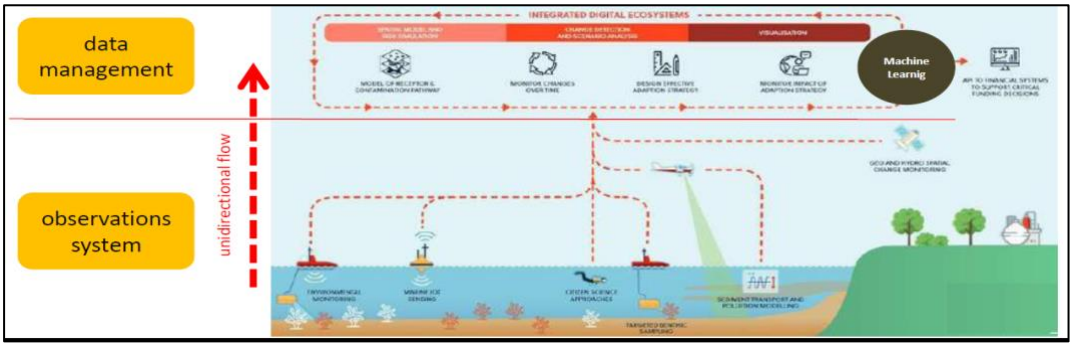

Fig. 2 Schematic representation of the current observing systems

This project proposes the development of a new integrated system that combines single-point and diffused monitoring through the development of hardware and software modules that integrate traditional in-situ measurements with adaptive monitoring managed by AI solutions. This integrated system will enable more efficient data collection even in extreme conditions, reduce energy costs, improve the forecasting system and allow the realization of innovative early warning approaches and effective decision support systems. The project combines AI-based technologies and models (RL2) with new robotic systems “ecorobots” and sensors (RL1) with “traditional” systems for coastal and offshore environmental and marine characterization and recovery. In fragile and significant areas like the marine protected areas or aquaculture farming, such integrated technological solutions represent innovative tools and solutions aimed to improve the knowledge on natural marine ecosystems and to protect them.

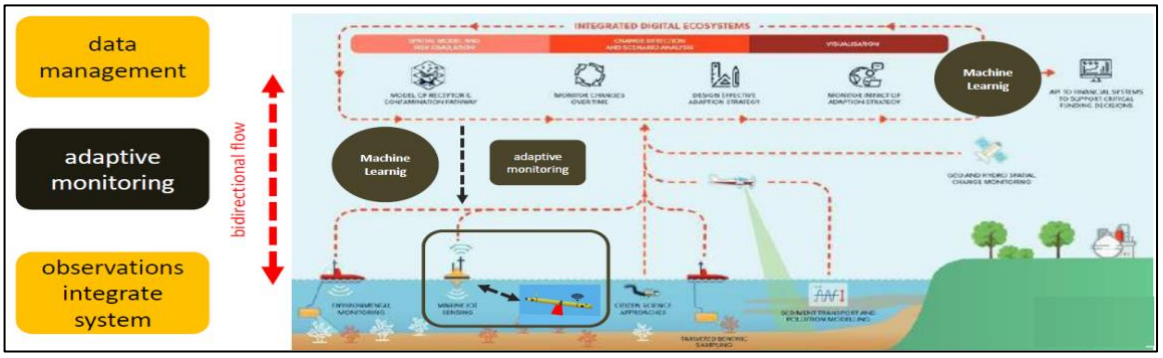

Fig. 3. Schematic representation of the new observing system paradigm

The project expected results consist of 12 products:

- 1.1 Smart Observatory for environmental monitoring
- 1.2 Passive environmental noise monitoring system
- 1.3 Fluorescent sensor for the detection of organic compounds in seawater
- 1.4 Octopus-inspired soft robotic arm
- 1.5 Early warning system for gelatinous zooplankton detection and classification in touristic coastal areas
- 1.6 Early warning system for nectonic biomass flows in coastal marine areas with strong mussel farming activity
- 1.7 Satellite Water Coastal Monitoring
- 1.8 Adaptive Sampling for Environmetnal Monitoring
- 1.9 Label-free polymer photonic sensors
- 1.10 Integrated system for sea waves, rainfall monitoring and marine data collection
- 1.11 SWAMP for Eco-interaction with Delicate Environments
- 1.12 Distributed space/time monitoring system based on AI-guided robots with innovative sensors and adaptive monitoring strategies

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PROJECT 2

Technologies for advances air monitoring and forecasting

PARTICIPANTS: UNIGE-DIBRIS, UNIGE-DICCA, UNIGE-DISTAV, ENEA, ETT, INFO SOLUTION

LEADER: UNIGE DIBRIS

CO-LEADER: ETT

Objectives/Expected Result:

The current state of the art in air-quality monitoring is by using static (or slowly moving) in-situ measurements. The main strength of the conventional strategy is the high accuracy of the measurement. Weaknesses are the results of the static nature of the monitoring system which does not allow any kind of flexibility. Our aim here is to produce a U-turn by a synergistic approach capitalizing the huge technological progress achieved in the last a few years in the field of autonomous drone swarms, autonomous mobile robots, and cheap and accurate air-quality sensors. Exploiting in concert these technologies, a paradigm shift will be possible by transforming the classical 2d-notion of environmental measure (1d in space and 1d in time) into a frontier 4d-based acquisition strategy (3d in space and 1d in time). State-of-the-art meteorological models and air quality models will work in concert to provide accurate weather/air-quality forecasts as proxies of potentially risky situations to be handled by the joint action of drones and robots. These latter will communicate with a node via suitable protocols the acquired environmental information to be handled remotely for successive actions, including the sending of warning messages A proof-of-concept will be delivered having the aim of monitoring an industrial area characterized by potentially serious environmental impacts. With minor modifications, e.g., to the type of used sensors, the proof-of-concept can be easily adapted to operate in different contexts non necessarily related to industrial plants.

The project expected results consist of 5 products:

- 2.1 An intelligent system for driving a mobile robot
- 2.2 UAV based platfoom for aerial monitoring
- 2.3 new air quality sensors and sensors play load
- 2.4 WebGIS air monitoring dashboard and mission control system
- 2.5 Advanced AI meteorological models for air quality assessment

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PROJECT 3

Technologies for advances environmental monitoring and seismic forecasting

PARTICIPANTS: UNIGE-DICA, UNIGE-DISTAV, INFO SOLUTION, IIT-DLS

LEADER: UNIGE DICCA

CO-LEADER: Info Solution

Objectives/Expected Result:

Development of an automatic procedure for the near real-time mapping of earthquake shaking and associated consequences at the urban scale. The procedure may benefit for further developments from AI and ML techniques (RL1), from images acquired by robots and drones (RL1) and from smart data management (RL4).

Development of a procedure for the automatic interpretation of images acquired after seismic events at the scale of individual artefacts or urban areas for the purpose of attributing synthetic damage levels. The procedure will benefit also of possible contributions from intelligent data management (RL4).

Development of tele-guided or autonomously guided mobile ground robots (available from RL1) aimed at the survey of damage in post-seismic conditions in indoor or outdoor environments, also obstructed by debris; depending on the operational scenarios, the data acquired by the robots may be integrated with those acquired in aerial mode by drones (CEntro DROni Unige).

The project expected results consist of 3 products:

- 3.1 Automatic real-time seismic shaking and consequences
- 3.2 Automatic on-site data acquisition and image processing
- 3.3 Design of a robot for damage surveying in post-earthquake conditions

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PROJECT 4

Technologies for advances environmental monitoring and hydrogeological instability

PARTICIPANTS: UNIGE DISTAV, UNIGE DICCA, CIMA, CNR IMATI

LEADER: UNIGE DISTAV

CO-LEADER: UNIGE DICCA

Objectives/Expected Result:
Project 4 essentially concerns the development of technologies for the ground and environment monitoring, with reference to natural hazards. Natural hazards are physical phenomena caused by atmospheric, water or geologic processes that threaten people, property or the environment. They can occur within a short or long period of time.
In the case of the RAISE Project, it is proposed to develop an intelligent monitoring system for geo-hydrological risk forecasting, including landslides, extreme rainfall, extreme winds and other weather and climate variables of interest. In detail, the products are aimed at monitoring meteorological, coastal and slope (landslide) hazards, also in the light of global change. The forecast products (4.1) will be produced at least at hourly temporal resolution and further processed through AI techniques aiming at further improving forecast skills for highly localized phenomena (heavy rainfall, hailstorms, severe wind etc) via hybridization or post-processing with machine learning and deep learning techniques. The processing of bathymetric data obtained by analysing images from satellites, planes or drones and the development of mathematical models that study the morphodynamic stability of coastal areas will allow the creation of a system for assessing the risk and vulnerability of these environments to climate change (4.2). With regard to ground stability, it is proposed SLHIM (SLope Health Integrated Monitoring), an intelligent, integrated system for monitoring slopes affected by landslides and assessing susceptibility to rainfall-induced landslides. It is implemented integrating a hydrological-geotechnical model, fed by sensor data, and a statistical analysis of rainfall thresholds. It includes a sensor prototype developed to continuously record the field variation of pore water capillary tensions caused by the interaction between the ground and the atmosphere to assess the slope stability. Data managed on platforms for early warning sharing (RL4).

The project expected results consist of 3 products:

- 4.1 An early warning system based on assimilation of heterogeneous observations to improve extreme event forecasts
- 4.2 Modelling tides effect, floods and sediment supply on rivers
- 4.3 SLHIM (SLope Health Integrated Monitoring) Integrated system for landslides monitoring and assess susceptibility of rainfall-induced landslides

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PROJECT 5

Advanced technologies and robotic solutions for precision agriculture and land management

PARTICIPANTS: IIT, UNIGE-DISTAV, UNIGE-DIBRIS, UNIGE-DITEN, INFO SOLUTION, CIMA

LEADER: IIT

CO-LEADER: Info Solution

Objectives/Expected Result:

The increasing world population increases the need for food, while natural resources and arable lands decrease, and the weather continuously and fastly changes in unpredictable conditions. Moreover, intensive agricultural activity wastes irrigation water, fertilizer, and other phytosanitary products, compromising environmental sustainability and farmers' profits. Innovative biological techniques, information and communication technologies, and novel robotic solutions can boost agricultural yields and profitability, as witnessed by many scientific investigations in recent years. In this context, the availability of terrestrial drones and especially of unnamed aerial vehicles (UAV) plays a key role in monitoring and surveilling cultivated lands with the possible final goal of taking action on the field. This project aims to develop technical solutions for two main domains: precision agriculture and land management. For precision agriculture applications, this project will focus on automating annual operations inside the vineyard, developing a soft gripper for gentle fruit grasping, and developing miniaturized devices for in-situ monitoring and drug delivery. In the land management part, the project will provide solutions to intervene in different terrestrial scenarios, e.g., releasing autonomous platforms to clean up beaches and small alleys or monitoring surface land parameters (such as humidity) and reforestation strategies in extended and difficult-to-reach areas.

A first integrated solution will provide a set of aerial and terrestrial platforms for their synergistic use in monitoring and intervention. There will be a total of 4 integrated platforms and 5 standalone products. One terrestrial robotic platform will be developed for the automation of winter pruning of grapevines, which is one of the most labor-intensive operations in the vineyard. Our solution will be based on the results of the VINUM project that developed a robotic pruning manipulator consisting of a robot arm, electric shears, depth camera, and neural network-based control for correct pruning. The arm is mounted onto a large quadruped robot that walks through the vineyard. In RAISE, we will increase the TRL of the existing technology by replacing the current cutting tool with an improved version, increasing the performance of the neural networks and manipulation controller, as well as improving the locomotion capabilities. As an alternative to the quadruped robot, a tracked vehicle will be adapted for vineyard operations with a specific algorithm for assisted teleguidance, and autonomous navigation in the vineyards will be developed. The terrestrial platform will be endowed with a soft gripper for fruit monitoring and sorting. Moreover, the urgent need for plant monitoring and health management is increasing interest in using innovative technologies to sense on-site parameters, screen whole plants, and deliver

molecules to plants, especially in plant organs for in situ applications. Few devices can directly attach themselves to plant leaves without damaging them due to their fragile and heterogeneous nature. We will provide in this project solutions for a “natural” and reliable attachment.

Another robotic platform will be deployed to automate litter collection on beaches and small alleys. While mechanized vehicles can efficiently clean the roads and squares, clean-up of beaches and small alleys are predominantly manual tasks performed by city workers and volunteers. Our solution will be based on an existing quadruped robot prototype modified to collect small litter efficiently. In RAISE, we will increase the TRL of the existing technology by improving the mechanical parts, as well as the neural networks and locomotion controller. Additionally, we will develop a novel system that can pick up and sort through the medium and larger-sized litter. A soft gripper inspired by an elephant trunk will be attached to a commercial robot manipulator mounted onto the quadruped robot. For large-area monitoring and reforestation, drones will be employed to disperse monitoring and remediation technological solutions. We will provide miniaturized biodegradable devices for their full integration with the ecosystem. These devices will be functionalized for their autonomous soil penetration, seedling, and/or physical parameters detection at the soil surface.

The project expected results consist of 9 products:

- 5.1 An integrated monitoring system for precision agriculture and land management
- 5.2 Robotized missions for distributing consortia of microorganisms to bioremediate and biostimulate lands and cultivated areas
- 5.3 Quadruped Robot for Litter Collection on Beaches and Small Alleys
- 5.4 Automation of Winter Pruning of Grapevines
- 5.5 Soft gripper for fruit monitoring and sorting
- 5.6 Miniaturized eco-friendly systems for on-leaf sensing and drug delivery
- 5.7 Seed-like devices for reforestation and sensing
- 5.8 Long reach robotic arm
- 5.9 Assisted tele guidance and autonomous localization and driving KIT for compatible mobile robots

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PROJECT 6

Advanced technologies for coastal erosion

PARTICIPANTS: UNIGE-DISTAV, UNIGE-DICCA, INGV, ETT

LEADER: UNIGE-DISTAV

CO-LEADER: INGV

Objectives/Expected Result:
Application of AI and ML (RL1) for the joint use of conventional and unconventional measurements for wave and meteo-marine propagation models with focus on data management and sharing platforms (RL4). Development of an automatic procedure with ML and AI techniques for the realization of a storm surges warning system. The method is based on the geomorphological features of the site and wave parameters. Development of a combined 1D laser scanner webcam system for continuous monitoring of the marine storm events. Once a critical run-up threshold is exceeded, the device will be able to activate the alert system. The final aim of these products is to create an integrated early warning system of storm surges and apply it in a pilot site of the metropolitan city of Genoa.

The project expected results consist of 3 products:

- 6.1 Storm surges early warning system by developing a *machine learning* model
- 6.2 Realization of a combined camera and 1D laser scanner system (linear) for an early warning system of storm surges
- 6.3 Hi-resolution digital terrain models for coastal status survey

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PROJECT 7

Technologically assisted ecotoxicological tools

PARTICIPANTS: CNR-IAS, ETT

LEADER: CNR-IAS

CO-LEADER: ETT

Objectives/Expected Result:

Environment management needs operative tools that, besides basic scientific knowledge, are able to supply in a short time reliable results on contamination levels. Several bioassays have been standardized, based on the analysis of biological responses observed on exposed model organisms. Main drawbacks of this ecotoxicological approach are often represented by prolonged observation times (especially for chronic toxicity tests), the substantial technician labour required, the subjectivity of scoring. Moreover, the majority of such tests are carried out in the laboratory at fixed conditions (in terms of temperature, salinity, pH, dissolved oxygen, etc.) and not directly in the field. The availability of innovative tools able to provide data through automated systems directly in the field would bring benefit for environmental monitoring, reducing test time, technician labour and avoiding results variability connected to operator judgment. This project aims to develop innovative, automatic and smart technological solutions (namely technologically assisted ecotoxicological tools) to be used directly in the field for environmental surveys, implementing biological testing during environmental monitoring actions. Three biological early warning systems will be developed (i.e. based on bacteria, and larval/adult aquatic invertebrate's responses) as products of the project to monitor the aquatic health status, able to provide a real-time signal when pollution or other stress may occur in the natural environment. Specifically, i) a biosensor able to monitor bacteria growth alteration, ii) an indicator of pollution stress and toxicity based on adult aquatic invertebrate's motion, iii) an automatic swimming behavior recorder for in-field environmental monitoring by using planktonic organisms. These tools will be deployed thanks to the ecotoxicological expertise of CNR-IAS and considering the participation on previous projects on these topics, besides the technological skills of ETT. The deployment of such products will be of interest in the field of environmental monitoring and pollution control. Automatization, reliability, experimental set up directly in the field and impartiality of results are the characteristics that make these tools innovative and competitive products, offering advantages for users involved in the environmental protection branch.

The project expected results consist of 3 products:

- 3.1 Smart biosensor based on biofilm growth alteration as a warning system for aquatic pollution
- 3.2 System able to record motion of invertebrates adult organisms as indicator of pollution stress and toxicity in the aquatic environment
- 3.3 Automatic swimming behavior recorder for laboratory/in-field alarm of water pollution detection by using planktonic organisms

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PROJECT 8

AI-powered Management Systems for Resilient Networks with Coordination and Integration of Distributed Energy Resources

PARTICIPANTS: algoWatt SpA, ANSALDO GREEN TECH, UNIGE-DITEN-IEES, UNIGE-DIBRIS, UNIGE-DICCA, CNR-IMATI, CNR-ITC, CNR-, ENEA-TERIN-STSN, ENEA-TERIN-SEN

LEADER: UNIGE

CO-LEADER: algoWatt

Objectives/Expected Result:

The liberalization of the electricity market and the subsidy policies for renewable Distributed Energy Resources (DER) promote a growing national energy independence. Nevertheless, assistance for proper technical management of active electrical networks is required, addressing issues that span from integration of renewable sources and storage systems, management of energy communities, network resilience and quality of service, involving different operators, end users and stakeholders. The project aims at delivering a comprehensive set of complementary AI-powered tools to support the optimized management of resilient electric/energy networks, taking into consideration the proper integration and coordination of Distributed Energy Resources (DER) and other assets (storage systems, electric vehicles, etc.), according to different yet synergic paradigms (spanning from smart grids up to Virtual Power Plants and Energy Communities).

The MV / LV distribution network observability, carried out both directly (through smart metering) and indirectly (by state estimation, pseudo-measures, load and production forecast), lays the groundwork for the development of services and value-added functionalities both for the technical/operational infrastructure management and for the modulation of the market dynamics. The project aims at providing innovative operational AI-based tools to provide value-added services for proper optimization of heterogeneous energy assets to:

Distribution System Operator (DSO): development of algorithms for the optimization of distribution-network operational management - regarding the large-scale introduction of non-programmable renewable sources (especially, PV) - by using controllable storage systems alongside to the control of reactive-component compensation systems; super-conductive based technologies are excluded from the project.

Transmission System Operator (TSO): development of functionalities for aggregating and formalizing technical/operational information about the distribution network structure and state; the DSO can provide such information for the optimization of dispatching policies (load profile and local production). Balancing Service Providers (BSP): development of functionalities for modeling and managing heterogeneous electric loads and distributed generation – particularly effective for the use of smart-meter data - with reference to the development of autonomous communities and virtual power plants, including of residential, industrial, and service-sector users, as well as storage units.

Energy Community Designers (ECD): preliminary assessment (to analyze utilities and consumption, territorial distribution, type (industrial, commercial, residential, public use), use of energy, possible presence of generation plants from renewable sources); user engagement (dissemination plan will be defined in order to allow the involvement and participation of all interested users); definition of governance tools (Support for the identification of the organizational and management model of the energy community including: Drafts of the Statute, deed of incorporation, internal regulation, economic management models and economic plan for the CERs); plant design (Identification of sites for the installation of energy production plants from renewable sources (photovoltaic), technical/economic feasibility study, preliminary, definitive, executive and as-built design); financial economic plans (Development of the economic-financial plan of the operation with evidence of the initial investments, revenues and costs, determining the payback time and guaranteeing, at the same time, adequate recognition to all participating members).
Energy Community Managers (ECM): administrative practices and relations with Authority (Preparation, drafting and management of administrative and authorization procedures for the construction of the plant and management of relations with the GSE for the fulfillment of the technical rules for access to the shared electricity valorisation and incentive service); turnkey EPC of the renewable plant (Implementation of the executive project of the system, purchase of all materials (panels, structures, storage, etc.), civil, mechanical and electrical assembly of the systems and connection to the network); management of self-consumption and energy produced. Microgrid Management: In order to manage microgrid structures energy management systems are needed to provide the optimal scheduling of production plants, storage systems, electric vehicles and other components with the goal of minimizing operational costs. Integration and Management of Storage Systems: In order to maximize renewable sources penetration and to better exploit their contributions adequate storage systems are needed to compensate their random production and scarce predictability.
Battery Energy Storage System (BESS) are integrated into smart building energy management control systems and into analogous management systems for aggregation of buildings like energy districts.

The project expected results consist of 5 products:

- 8.1 Distributed Energy Management System (DMS): Tools for electrical distribution networks
- 8.2 Tools for optimal planning and management for Smart Cities and Energy Communities
- 8.3 A tool for the optimization and control of coupled networks for the integration of the electrical grid, polygeneration and EVs
- 8.4 AI-based solution for performance optimization of lithium storage systems in Zero Energy Buildings
- 8.5 Design and testing of solutions for quality of services and protection from cyberattacks in industrial-type networks with ML-based approaches

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PROJECT 9

Simulation, performance prediction an validation of energy-storage systems for renewable sources, exploiting AI, robotics and innovative materials

PARTICIPANTS: CNR-SPIN, CNR-ICMATE, Ansaldo Green Tech (AGT), UNIGE-DIME, UNIGE-DICCA

LEADER: CNR-SPIN; AGT

CO-LEADER: UNIGE-DIME

Objectives/Expected Result:

- Development of innovative energy storage management technologies, materials and systems (robotics, simulation and digital twin), with possibility of validation within JOINTLAB (defined in figure).
- Operation data management and plant supervision (AI, performance prediction, residual life evaluation). Electrochemical storage prototypes and the electrolyzer for the JOINTLAB will be built and installed by AGT. The JOINTLAB will provide an opportunity to evaluate various storage systems and not only electrochemical solution, namely: hydrogen storage in high-pressure and/or liquid tanks, magnetic storage (SMES- Superconducting Magnetic Energy Storage), and geothermal solutions related to geothermal heat pump applications

The project expected results consist of 4 products:

- 4.1 Environmental monitoring robot of the Vanadium Redox Flow Battery (VRFB) tank installation area
- 4.2 VRFB battery electrochemical modelling tool
- 4.3 Superconductive sensor for measuring the level of liquid hydrogen stored in tanks
- 4.4 Design tool for geothermal storage

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PROJECT 10

Eco-sustainable Platform of Smart Systems for Efficient Energy Harvesting and Storage (ENHANCE)

PARTICIPANTS: CNR, CNR-INM, CNR-ICMATE, CNR-SCITEC, CNR-SPIN, UNIGE-DIFI, UNIGE-DICCA, UNIGE-DITEN

LEADER: CNR

CO-LEADER: UNIGE-DIFI

Objectives/Expected Result:

Environmental monitoring in remote and harsh areas calls for autonomous vehicles, which for definition do not require on-board personnel. This new paradigm allows the development of small-scale technology (in terms of both size and weight) and opens the possibility of increasing the renewable energy availability on autonomous vehicles. An environmentally mindful platform secures the versatility of the device, which can then be deployed in pristine areas, such as Polar environments and marine protected areas, as well as in polluted and dangerous locations, e.g. oil spill sites. The reduced dimensions and weight of monitoring vehicles lowers the amount of energy required for scheduled missions. Furthermore, the on-board green quota should be increased in order to cover the whole energy requirements and drastically decrease pollution and Green House Gases (GHG) emissions, minimizing the carbon footprint of emerging technologies.The autonomous vehicle may transport and deploy smart drifting sensors for monitoring purposes. A smart processing unit would be available on the autonomous vehicle for data exchange with the smart sensors. The schema sensor nodes + central unit can be conveniently adopted in different situations: for example, in the marine environment (deploying the sensor nodes in small buoys and the central unit on a boat) for environmental monitoring purposes; or in a forest to prevent the development of fire; or to monitor the integrity of a civil infrastructure. The present project also aims at developing smart piezoelectric polymer-ceramics and thermoelectric polymer-Van der Waals dichalcogenides composite materials to be integrated in flexible PEH (piezoelectric harvester) and TE (thermoelectric) devices for producing sustainable electric energy by efficiently exploiting plentiful mechanical and thermal energy sources accessible all around us, such as natural (marine) environment/human/machinery vibration, bending, and pressure for PEH and solar energy and waste heat sources for TE.

The project expected results consist of 3 products:

- 10.1 Platform of autonomously powered small-sized sensors
- 10.2 Multi-source power supply system: from the software model to a small-scale prototype
- 10.3 Smart functional polymer-based composite films for sustainable energy harvesters

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PROJECT 11

Development of innovative Technologically Assisted Citizen Science Systems (TACS)

PARTICIPANTS: CNR - IIT - UNIGE – ETT – ENEA – INGV

LEADER: CNR

CO-LEADER: ETT

Objectives/Expected Result:

Citizen science is a growing field that involves the active participation of non-professional scientists in scientific research projects. It represents a powerful tool for scientists to gather large amounts of data and observations, which would be difficult or impossible to obtain otherwise. At the same time, it provides the public with the opportunity to engage with scientific research and contribute to a greater understanding of the world around us.The importance of citizen science extends beyond just scientific discovery, however. It also has important social implications, as it can promote scientific literacy and help to build trust between the scientific community and the public. Additionally, citizen science projects can have a positive impact on local communities, as they can help to address issues of environmental and social concern and provide opportunities for people to come together and work towards a common goal. Furthermore, citizen science is not just limited to a few specific fields of study but can be applied to a wide range of scientific disciplines. This includes areas such as ecology, astronomy, genetics, and more. As such, it has the potential to unlock new discoveries and insights across a diverse range of fields. Overall, citizen science represents an exciting opportunity for both scientists and the public alike, as it enables collaboration and engagement on a scale that was previously unimaginable. By working together, we can unlock new discoveries, promote scientific literacy, and make a positive impact on our communities and the world at large. Citizen science projects can collect a wide variety of environmental data, including physical, chemical, and biological parameters. Some of the most commonly collected parameters include water temperature, pH, salinity, dissolved oxygen, and nutrient concentrations. These parameters can provide valuable information about the health of aquatic ecosystems and help identify potential environmental issues. In addition, citizen science projects may also collect data on species diversity and abundance, habitat characteristics, and weather conditions, among other factors. By involving members of the public in the data collection process, citizen science projects can greatly expand the amount of environmental data that is available, leading to better scientific understanding and informed decision-making. In this context, project 11 aims to promote and organize citizen science activities technologically assisted applied to environmental monitoring in order to collect valuable scientific data while maximising population engagement on environmental caring and protection. A selection of sensors and tools with potential compatibility in terms of target, size, use easiness and price, will be selected as a development basis of specific devices (TACS) dedicated to Citizen Science, keeping as priority endpoint the sufficient precision and accuracy to ensure the scientific reliability of the data.

Task 1 of the project will be to establish most relevant environmental variables that may be of scientific interest in the field of environmental caring and monitoring in relation of UN nations Sustainable Development Goals (https://sdgs.un.org/goals). In particular concentrating efforts on climate change mitigation, environmental protection, biodiversity conservancy and population engagement.

Fig 31

Task 2 of the project will be to identify suitable tools and sensors already applied or applicable to citizen science campaigns for environmental critical parameters. Tools and sensors will be selected keeping in mind fundamental principles:

- Easy to use/user oriented
- Environmental oriented
- Low cost
- Scientifically solid data collection

For this porous existing infrastructures and tools, alongside with products realized in the RAISE ecosystem, will be considered in order to capitalize research efforts:

- Citizen Science Catalog is USA governmental website dedicated to cataloging citizen science projects and resources. The page includes a comprehensive list of tools and sensors that can be used in environmental monitoring, such as air quality monitors, water quality test kits, and weather stations. Each tool or sensor is accompanied by a brief description, including its purpose and potential applications, as well as links to relevant resources and projects where it has been used.
- https://www.citizenscience.gov/catalog/#!/areas-of-practice/environmental-monitoring-and-forestry/environmental-monitoring/tools-and-sensors

Here is a list of tools and sensors that can be used for citizen science in environmental parameters:

- Air Quality Egg - measures air quality
- ArduSat - measures temperature, humidity, atmospheric pressure, and carbon dioxide levels
- BeeSmart - measures the weight, temperature, and humidity of beehives
- Citizen Weather Observer Program (CWOP) - measures weather conditions such as temperature, wind speed, and precipitation
- eButterfly - records butterfly sightings and species data
- Foldscope - a portable microscope used for identifying and observing microscopic organisms and particles
- GLOBE Observer - measures cloud cover, mosquito habitats, and land cover
- iNaturalist - records sightings of flora and fauna
- Leafsnap - identifies tree species through photographing leaves
- Lichen AQ - measures air pollution using lichen as an indicator species

- Marine Debris Tracker - records debris found on beaches and coastlines
- Safecast - measures radiation levels
- SoilWeb - identifies soil types and properties
- Sound Around You - measures noise pollution levels
- Water Reporter - records water quality data in lakes, rivers, and streams

These are just a few examples of the many tools and sensors available for citizen science in environmental parameters.

Task 3 This phase will concentrate in putting to profit or in the field information gathered in the previous tasks in order to define stakeholders and plan/promote Citizen Science campaign. Existing organisations and institutions will be considered for possible partnership and collaboration in this project task in order to maximize efforts of dissemination, organization and planning, alongside with visibility and media resonance.