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Autonomous Network System with Specialized and Integrated Multi-Sensor Technology for Dynamic Monitoring of Marine Pollution (SMARTPOL)

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Abstract

This project aims to provide a novel and compact pollution detection, monitoring, and analysis system architecture to monitor marine fields and detect different types of marine pollution that includes hardware and software components. The system will mainly consist of a Shore Control Centre (SCC) and unmanned surface vessels, both equipped with multi-sensor technology and artificial intelligence-based solutions. The SCC will play a key role as a central network hub of the system.

Keywords: Marine pollution, Sensor technology, Remote control

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1. Introduction

According to MARPOL 73/78, the principles have been established to prevent pollution of the marine environment. However, illegal discharges by ships above permitted limits in prohibited areas persist. Marine pollutants originating especially from anthropological activities threat the marine and coastal ecosystems.

Therefore, the 2002 EU Integrated Coastal Area Management Recommendation and the 2008 Marine Strategy Framework Directive were developed to protect all European coasts and marine waters. To address these problems and support EU regulations, the idea of SMARTPOL has emerged with the aim of producing technological solutions for marine pollution detection while establishing data services that can be integrated with existing EU services in synergy with the European Green Deal. From this viewpoint SMARTPOL aims to present a novel and compact pollution detection, monitoring, and analysis system architecture to monitor marine fields and detect different types of marine pollution, consisting of hardware and software components.

2. Project Objectives

Integration of different types of sensors [e.g., remote sensing, unmanned aerial vehicles (UAV), and unmanned surface vessels (USV) integrated Internet of Things (IoT)], development of a marine pollution detection algorithm using sensor data, and state-of-the-art intelligent system technologies, including artificial intelligence (AI)-based image processing, autonomous navigation, and smart communication systems, will be presented as R&I objectives of the project.

The project is in good agreement with the 2019 European Green Deal, which aims to exploit sustainable digital technologies such as AI, 5G, cloud and edge computing, and the IoT. From this viewpointour project aims to provide a novel and compact pollution detection, monitoring, and analysis system architecture to monitor marine fields and detect different types of marine pollution that includes hardware and software components. The system will mainly consist of a Shore Control Centre (SCC) and USVs, both equipped with multi-sensor technology and AI-based solutions. The SCC will play a key role as a central network hub of the system.

SMARTPOL will validate USVs by monitoring pollutants in specific areas of Türkiye, Malta, and South Africa through sensors identified for pollutants monitoring. USVs will perform local environmental monitoring and data analyzesUSVs will also be equipped with pollution detection sensors for data collection. The data will be collected from the sensors, and the results will be transmitted to the SCC. Smartpol network system will provide communication and reliable data transfer between SCC and USVs will be provided by the SMARTPOL network system. As stated in the European Commission Staff Working Document on Digital Solutions for Zero Pollution, the use of sensors, IoT solutions, and satellite systems integrated with AI technologies can help us make more evidence-based decisions and improve our ability to comprehend and address climatic and environmental issues.

In addition, a pollutant often released into the ocean by scrupulous entities is industrial wastes released by carrying them in small boats. The solution to this issue is an integration of images from European Space Agency's radar satellite Sentinel-1 and Automated Identification System (AIS) tracking of boats. Radar-based satellite images are proven methods to detect industrial waste spills in the ocean. By combining these with real-time monitoring of AIS data, an alarm system will be developed as part of the overall system. The command-and-control software platform that will facilitate the visualization of the pollution alerts, USV positions, and its path tracking will also integrate the data fusion processing (AI based) results and other expected and estimated pollution evolutions so that a proper intervention mechanism could be shared with other authorities/legal institutions. The command-and-control software platform will allow the complete review of pollution detection data series, pollution confirmation data from the USV and additional data sources (UAV, if available), and expected evolution and impact. The command-and-control software will be installed on the SCC, and in addition to the visualization of data results, it will coordinate the navigation of the USV during its seaside missions.

In sum, the integration of different types of sensors, the development of a marine pollution detection algorithm using sensor data, and the use of state-of-the-art intelligent system technologies, including AI, machine learning-based image processing, autonomous navigation, and remote sensing, are presented as scientific and technological objectives of the project. Our understanding of marine pollution monitoring can be enhanced and shaped into a form that is useful for decision makers and sustainable environmental protection with new analytical tools (e.g., AI), multisensor integration, and advanced communication technologies. Within the coverage area, the system will also can improve maritime safety and become a deterrent factor against marine pollution. Moreover, SMARTPOL aims to reuse current European data sources, such as Copernicus satellite products and Copernicus marine services. It is also aimed at providing generated open digital marine pollution monitoring data for reuse in the Copernicus system. Raising awareness of marine pollution and protecting the marine ecosystem are the socio-economic objectives of the project.

3. Consortium Composition

3.1. Yıldız Technical University

Yıldız Technical University (YTU) is one of the seven public universities situated in İstanbul and is the third oldest university in Türkiye. YTU has 11 faculties, 2 institutes, and 25 research centers. YTUs SMARTPOL team consists of academicians that are experts in the fields of Naval Architecture, Marine Engineering and Geomatics Engineering. The project coordinator, Prof. Dr. Nurten Vardar, is a member of the Naval Architecture and Marine Engineering Department. Some of the main research areas of the Geomatic Engineering Department are remote sensing, geographical information systems image processing, artificial intelligence, big data analytics, unmanned aerial/surface vehicles, LIDAR technologies, virtual reality, and multi-criteria decision support systems.

3.2. AquaBioTech

AquaBioTech (ABT) is an independent aquaculture, fisheries, biotechnology, environmental testing/research, engineering, consulting, development, and training company (SME) with its own dedicated biosecure and fully licensed research and marine survey facilities in Malta. These include research laboratories with GLP certification, 31 independent biosecure wet labs containing more than 500 marine and freshwater tanks using precision controllable recirculating aquaculture system technology, and two marine field-testing sites in different marine environments (Natura2000 mixed use site and industrial port). ABT has a strong background in commercial research for aquaculture and the marine environment and has been involved in several EU, regional, and national research projects. ABT MarineTM provides a range of services, including marine surveying and mapping/Geographic Information System.

3.3. The Malta College of Arts, Science and Technology

The Malta College of Arts, Science and Technology (MCAST), established in 2001, is the country's leading Vocational Education and Training Higher Education Institution. With six Institutes in Malta and the Gozo Campus, MCAST offers 180 full-time and over 300 part-time vocational courses ranging from certificates to Master's degrees. MCAST has profound experience participating in and leading various EU funded R&I projects under H2020. EIT Climate-KIC, Interreg Europe and Erasmus + align with the 2030 Agenda for Sustainable Development Goals & Targets and Mediterranean Strategy for Sustainable Development 2025, and the National R&I Strategy 2020 as the main priorities for the College.

3.4. Interactive Software S.R.L

Interactive Software S.R.L is a Romanian company active in the development and integration of voice communication and data transmission solutions, as well as the development of integrated control-command solutions, especially for defense forces and governmental agencies and institutions. In addition to the suites of Command & Control software with special designations, Interactive Software is also developing special electronic equipment with embedded software.

3.5. University of Cape Town

University of Cape Town (UCT) is South Africa's oldest university and a leading teaching and research institution in Africa. UCT is spread over four main campuses situated in Cape Town, South Africa. UCT has more than 80 specialist research units that provide supervision and support for postgraduate study and research. The Electrical Engineering (EE) department at UCT is part of the Engineering and Built Environment Faculty, which comprises seven departments. The EE department has 11 research groups and 25 academic staff members.

3.6. Sirena Marine

Sirena Marine (SM) is a prominent manufacturer in the yachting and automotive industries. The next step of SM's award-winning sailboats was entering the powerboat market. SM has ISO 9001, IATF 16949, IRIS, ISO 14001, EN 15085, and DIN 6701 certificates.

4. Pilot Studies

4.1. Türkiye Pilot Study

Turkish seas are affected by chronic pollution similar all other marine environments. Typical pollutants consist of household waste, land-based and ship-based pollutants, and oil tankers, which are also one of the most significant sources of this environmental problem. These pollutants can accumulate inside marine organisms and cause their deaths, but they can also harm society and human health through the ingestion of marine life as food, which would create a significant threat and harm biodiversity. The Marmara Sea has been refreshed by the currents of the Bosphorus and the Dardanelles Strait from the Aegean Sea and the Black Sea. Therefore, it is quite urgent and vital to monitor the pollutants flowing from the Aegean and Black Sea regions toward the Marmara Sea to prevent pollution of the Northern Aegean, Black Sea, Marmara Sea, Bosphorus, and Dardanelles. In this pilot study, the multi-scale approach of SMARTPOL will be used instantaneously to detect, monitor, and observe pollution in the Marmara Sea. A new integrated system will be presented to organizations and public institutions to prevent the death of marine life in the Marmara Region.

4.2. Malta Pilot Study

This pilot study will focus on verifying the functionality of the USV and verifying the data that the USV will collect autonomously with ground validation methods that use traditional data collection methods (collecting water samples using boats and analysing them in th e laboratory). The USV will cover coastal areas in tandem with the conventional boat approach, and both will collect the same set of data. These two datasets (USV vs. conventional) will be comparatively analyzed. Sea level data collection time will be coordinated in parallel with data collection from satellite imagery. Thus, correlations between both system parameters can be detected. In this project, sensor nodes will be used to monitor pollution and help biologists determine whether it plays a role in habitat destruction.

4.3. South Africa Pilot Study

A boat with a sensor assembly will be used in the South Africa pilot study. It is planned to extract data from both the Indian and Atlantic Oceans off the coast of South Africa. In addition to the above, both ground and satellite-based radar systems will be used to measure and detect pollutants. The data will be fed into an AI-based forecasting system to predict the flow and target of pollutants in the water.