A mobile crowdsensing app for improved maritime security and awareness

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***Abstract*—The marine and maritime domain is well represented in the Sustainable Development Goals (SDG) envisaged by the United Nations, which aim at conserving and using the oceans, seas and their resources for sustainable development. At the same time, there is a need for improved safety in navigation, especially in coastal areas. Up to date, there exist operational services based on advanced technologies, including remote sensing and in situ monitoring networks which provide aid to the navigation and control over the environment for its preservation. Yet, the possibilities offered by crowdsensing have not yet been fully explored. This paper addresses this issue by presenting an app based on a crowdsensing approach for improved safety and awareness at sea. The app can be integrated into more comprehensive systems and frameworks for environmental monitoring as envisaged in our future work.**

***Index Terms*—Crowd-sensing, Volunteered Geographic Information (VGI), Citizen Science, Oil spill, Pollution, Maritime security and safety**

I. Introduction

Since the dawn of civilisation, the sea has always represented a source of wealth but also a dangerous environment and a gateway for threats. There are, therefore, two deeply connected needs: from one side, it is crucial to be able to protect the sea and make sustainable use of its resources, form the other it is necessary to be able to navigate through the environment safely and enhance the security against possible illegal and malicious actions and traffics, including piracy, trespassing, smuggling of immigrants and poaching. The first step in these directions is represented by environmental monitoring systems encompassing both marine and maritime aspects. Several approaches have been proposed, showing that solutions based on the integration and cross-correlation of multimodal data and disparate resources are the most promising [1]. Sensorized buoys, Autonomous Underwater Vehicles (AUVs), water-column samplers, ships of opportunity have been considered as in situ monitoring resources while airborne and space-borne imaging and sensing offer great opportunities for remotely assessing different aspects, including vessel traffic and water quality at different scales, ranging from global coverage data to the detailed assessment of small areas.

In situ resources can be linked together in order to create a distributed and pervasive network with the aim of creating an integrated infrastructure capable of characterising the open sea and the coastal environment in the marine boundary layer [2]. The network can be able to analyse different analytes (e.g. sulphates and nitrates) in the water, to measure the temperature profile of the water column, to estimate the parameters that define the state of the sea (significant wave height, direction, period and wavelength of the dominant waves), the field of surface currents and to detect the presence of contaminants such as hydrocarbons and heavy metals [3]. Buoys can also be equipped with submerged hydrophones capable of identifying activities related to poaching or signaling the presence of vessels in protected marine areas, or to generate early-warnings for offshore seismic waves of significant intensity. The pervasive network on site can be completed by additional sensors such as ground or vessel-borne radar, including passive radar technologies taking advantage of opportunistic sources [4]. Indeed, with reference to coastal marine areas where it is not possible to install active radar sensors due either to radio-frequency pollution constraints or to the coast profile, passive sensors have demonstrated to have good capabilities for localisation, tracking and re-identification of vessels.

Among such disparate sources, a valuable contribution might be represented by Volunteered Geographical Information (VGI), that since the seminal work [5] has proven to provide helpful information in case of events like hurricanes, earthquakes and pandemics. A VGI approach to the monitoring of oil spills has been proposed in [6] in the framework of a more general and full-fledged Marine Information Sys-

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tem (MIS), featuring proactive decision support services [7]. However, the possibilities of using VGI and, more generally, crowdsensing information have not be fully exploited to treat more general events related to safety and security.

In this paper, we present in Section II a demonstration of our proposed crowdsensing app that allows for the collection of extensive data for a wide range of observations. As mentioned in Section III, the collected data represent a wealth to be analysed to improve our knowledge of the sea. Finally, Section IV concludes the paper with directions for future work.

II. App prototype

Aiming at promoting its wide usage, the application has been developed exploiting the software framework React Native [8]. Thanks to this, the application has been easily exported and built for both Android and iOS systems. It has been designed as simple as possible in order to promote its usage among volunteers, that could be discouraged by an excessive complexity. Thus, the application offers only a few essential functionalities with a basic and straightforward interface.

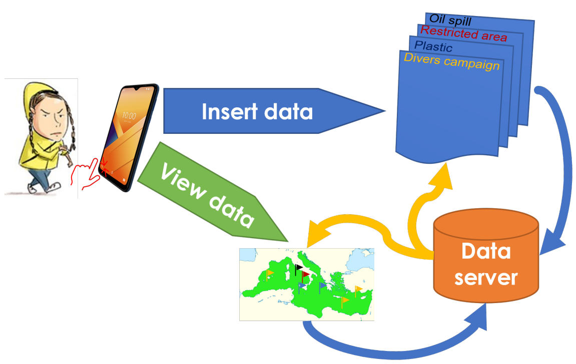

Fig. 1. Working diagram of the app.

As shown in Fig. 1 the application relies on a data server to store and retrieve the submitted reports. The data server is composed by a set of REST APIs, in charge of satisfying application requests, plus a PostGIS [9] database. PostGIS database allows providing complex queries that take into account spatial position and distances, such as retrieving reports in the nearby of the volunteer position.

III. Data collection and usage

The application can be used to report the presence of anomalous situations discovered by any volunteer at sea or coastal areas (e.g. presence of plastics or oil spill), or to share particular and useful observations retrieved during divers campaigns. When the application is loaded, users can choose, from the opening screen to submit a new report to the data server, as shown in Fig. 2, or to refer to previously stored reports near the actual location.

Once the typology of the report is chosen, a second screen of the app is loaded. In this screen, volunteers can specify a set of details relative to the report; for instance, as shown in

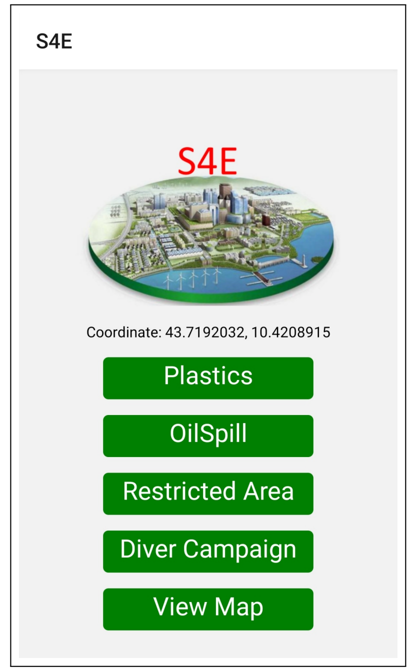

Fig. 2. Opening screen of the app.

Fig. 3 for a plastic report, the user can specify the distance where the plastics are found and add a description about the plastic quantity, spreading and extension. By pressing the ”Add” button, the data inserted by the volunteers, are used to compose a dedicated JSON that will be submitted to the data server through a REST request. On the server side, a service is in charge to collect the submitted JSONs, parse them and store the retrieved data into the PostGIS database. After that, an acknowledgement of the succeeded operation is sent to the application.

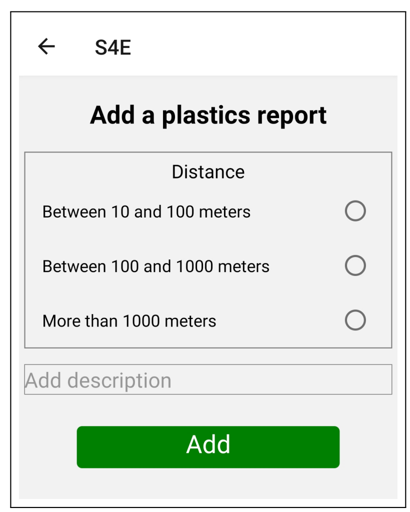

Fig. 3. Example of screen for adding a plastic’s report in the app.

Users can also view all the nearby reports from the opening screen by pressing the ”View Map” button. Through the REST APIs, the application retrieves from the Data server all the previously submitted reports located near the user, and displays them on the map, where different types of reports are shown with different colours, as shown in Fig. 4. By selecting a report, users can access further information, such as its typology, the time of submission, exact GPS position, and eventual other details (e.g. distance of the plastic sightings, photo taken at the site).

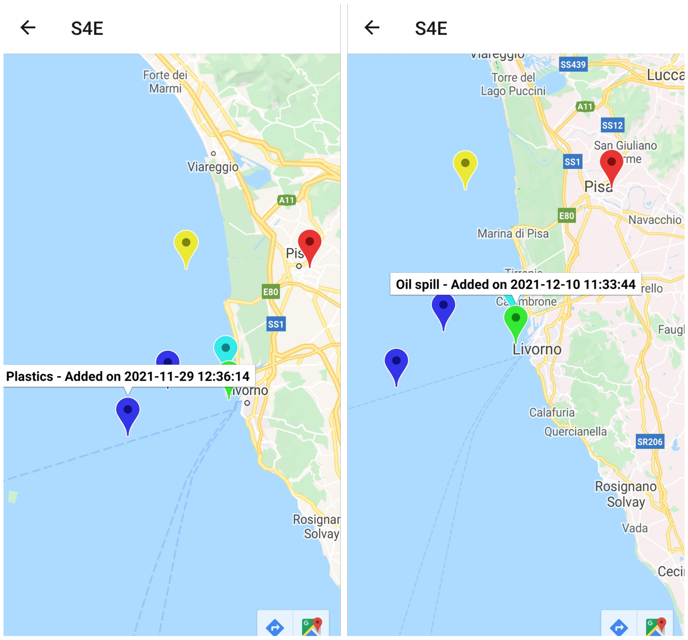

Fig. 4. Example of map view with reports depicted as marker with different colours (in the example blue for plastic report, green for oil spill report)

IV. Conclusions and further work

As described in Section II, the application is developed exploiting the software framework React Native that allows to easily publish and share it on both iOS and Android devices. This promotes the app diffusion and contributes to its wider usage. Moreover, the simplicity of the interface and the practicality of the available functionalities encourage volunteers to use it.

Despite at its current status the adoption of a spatial-enabled database (PostGIS) is used only to retrieve reports near to the user position, PostGIS will guarantee to develop more complex queries that relate to spatial information, e.g. considering the distance between several reports of the same type, discovering riskier areas or detecting dangerous clusters of events. A dedicated Web browser interface will be developed by integrating a GeoServer [10] in charge of generating a set of Web Map Services (WMSs) relative to the stored reports. In a such Geographic Information System (GIS) system, it will be possible to display the stored information and perform complex interactions to obtain statistical information about the submitted reports.

Extensive use of this app is planned in various collection campaigns, spanning from recreational sailors within the scope of the Italian National Project S4E, to citizen scientists in the frame of H2020 Project NAUTILOS, which will provide new and different data, particularly concerning the area in front of Leghorn, in the north Tyrrhenian Sea.

A prompt and performing system for the early detection of anomalies is of paramount relevance to pursue marine habitat safeguard, preservation, and to reduce threats related to the presence of pollutants or harmful chemicals.

Potential developments concern the exploitation of the proposed system as a bridge between multiple punctual observations and a consistent informative picture describing a given scenario at increasing spatial scales. Eventually benefiting from the data abundance ensured by the adopted pervasive sensing paradigm, novel services will address the integration of tasks dedicated to signal manipulation within the chain of the crowdsensing process.

To this aim, the app will be enriched by adding functionalities to manage images related to citizen science activities using artificial intelligence. Algorithms for automatic segmentation, classification and identification of biological fauna and flora species, as well as techniques to perform quantitative measurements of dissolved substances, represent the objective of future research.

Submitted reports and their elaboration will be converted into an ERDDAP (a well established open-source data platform [11]) accepted format to promote data diffusion. The overall system will be kept alive after the timeframe of the projects involved to provide a valuable tool for reporting anomalous events or of particular interest that may occur at sea or coastal areas.

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