CITIZENS AS ADDITIONAL MOBILE SENSORS IN CASE OF NATURAL DISASTERS: A NEW EMERGENCY DECISION SUPPORT SYSTEM FOR ITALY AND CROATIA

LES CITOYENS COMME CAPTEURS MOBILES SUPPLÉMENTAIRES EN CAS DE CATASTROPHE NATURELLE : UN NOUVEAU SYSTÈME D'AIDE AUX DÉCISIONS D'URGENCE POUR L'ITALIE ET LA CROATIE

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Abstract: A novel Emergency Decision Support System (EDSS) platform has been developed within the Interreg E-CITIJENS project nd will be presented in this work. Similarly to other DSSs, the platform's purpose is not to "impose" a choice but to provide further support to technicians and decision-makers in analysing emergency situations related to natural disasters to ensure and efficient and effective response. In particular, the risk typologies addressed are floods, forest fires and earthquakes. Besides the entry of data from sensor networks and institutional sources, contributions from the citizen are envisaged in the EDSS platform through posts published on the main social media.

Keywords: crowdsourcing, social media, emergency management, Decision Support Systems

Résumé: Une nouvelle plateforme EDSS (Emergency Decision Support System) a été développée dans le cadre du projet Interreg E-CITIJENS et sera présentée dans ce travail. Comme les autres DSS, la vocation de la plateforme n'est pas « d'imposer » un choix mais d'apporter un soutien supplémentaire aux techniciens et décideurs dans l'analyse des situations d'urgence liées aux catastrophes naturelles pour assurer une réponse efficiente et efficace. En particulier, les types de risques auxquels ils sont confrontés sont les inondations, les feux de forêt et les tremblements de terre. En plus de l'insertion de données provenant de réseaux de capteurs et de sources institutionnelles, des contributions des citoyens sont fournies dans la plateforme EDSS à travers des messages publiés sur les principaux médias sociaux.

Mots clés: sciences participatives, médias sociaux, gestion des urgences, systèmes d'aide à la décision

Introduction

The Croatian and Italian Adriatic regions are subjected to almost all types of natural hazards, including earthquakes, fires, landslides, mudslides, floods and extreme weather conditions, and they have been affected by various natural and man-made disasters in recent years (CEMS, 2022). In this sense, joint risk management and the prevention of damage caused by natural and man-made disasters, mainly based on the improvement of monitoring and emergency management measures, represent a necessity and an opportunity to increase the safety and overall environmental quality in the Adriatic basin.

Identifying the event scenario quickly in case of emergencies and, consequently, providing an intervention of human resources and means proportionate to the need is the main challenge to address nowadays. The line between success and failure is very fine and the development of innovative Decision Support Systems able to include alternative data sources using new IT solutions can make a difference (Hellmund et al., 2019). Social media platforms are widely recognised as a valuable source of data during crises, but their potential is still not fully exploited, mainly because of their complex nature (Zhang et al., 2019).

The Interreg E-CITIJENS project aims at promoting and enhancing, through cross-border cooperation between Italy and Croatia, the sharing and use of non-sensitive data and information, communications and geospatial and space-based technologies and related services to support national measures for successful disaster risk management and communication in compliance with the Sendai Framework for Disaster Risk Reduction (UNDRR). The project aimed at developing a trans-frontier and innovative Emergency Decision Support System (EDSS) platform with the prospect of integrating the information provided by citizens through social media into the traditional emergency management process.

The methodology developed for selecting emergency-relevant posts by social media users and integrating additional traditional sensors into this system will be presented in the following sections, along with the description of the EDSS's potential use for emergency response.

1. Methodology

The Emergency Decision Support System EDSS developed within the Interreg project E-CITIJENS, a semantically enriched web-enabled platform has been designed to be a decision support multi-channel tool in emergency contexts to define an event scenario in the shortest possible time and to coordinate emergency interventions. Taking a cue from the Sendai Framework for Disaster Risk Reduction (UNDRR), where the international community has given total value to social networks, social connectors are also to be included. Therefore, the goal in the EDSS development has been to define a system able to exploit institutional sources (reliable monitoring network) and social networks to acquire the information necessary to identify critical situations regarding three target risk typologies: floods, forest fires and earthquakes. To pursue this target, inputs to the platform have also been integrated with mobile or permanent amateur connectors (sensors installed by private citizens). First, these external data sources must be restricted to the area of interest through geographic positioning, in order to eliminate non-required information that can cause a sort of "external noise" and compromise the result of the analyses. The result will be a platform able to provide to the Civil Protection experts, in the shortest possible time and in an area of competence pre-defined by the user, the event scenario. The platform will be fully operational at the end of the E-CITIJENS project (after June 2022).After extensive research work and internal surveys within the Project partnership, the essential platform characteristics to be developed in order to obtain the desired result have been identified. These are listed and briefly described below.

1) External searchable interfaces; 2) Analysis and classification core component, 3) Data persistence; 4) Display component.

The external searchable interfaces are specifically search engines and data assimilators. The platform must be able to activate APIrest connectors or directly search for information and "capture" solutions on web pages of interest (e.g. webcams, data in tables). Therefore, it is understood that the platform will have to assimilate data coming from heterogeneous sources and reproduce them in its own database. Based on methodologies identified by the design team, the platform also needs to be able to analyse the assimilated data and classify them in an analysis and classification core component. The analysed data will constitute the database history (data persistence), which will be essential for a correct evaluation of the obtained results. Furthermore, to ensure an improvement in data analysis over time, the analysis could be performed through an Artificial Intelligence (AI) component. Finally, to limit the evaluation and implementation time of an event scenario, the operational parts of the platform that provide direct interaction with the user must have a graphic interface with display components to filter and analyse the results.

After this preliminary analysis, the principal platform's modules to be deployed have been identified as they define the desired EDSS architecture (Figure 1). A brief description of the primary functions of each module is provided below.

- The first "Integration Layer" (on the left in Figure 1) collects data from institutional sources, social media sources and non-institutional amateur sensors. It is the connection with the social world, able to scan the various platforms such as Facebook, Twitter, and Instagram, identifying pre-inserted guiding terms in geo-localised posts.
- The "Analysis and Aggregation" module contains data evaluation algorithms based on the semantic classification developed during the Project.
- The second "Integration Layer" (on the right in Figure 1) compare data with the institutional sources and sends the aggregated data to the "Decision-Maker" module to automatically classify the event.
- The "Decision-maker module will be an Artificial Intelligence component to improve the semantic analysis over time and to help an automatic decision for the ongoing event.

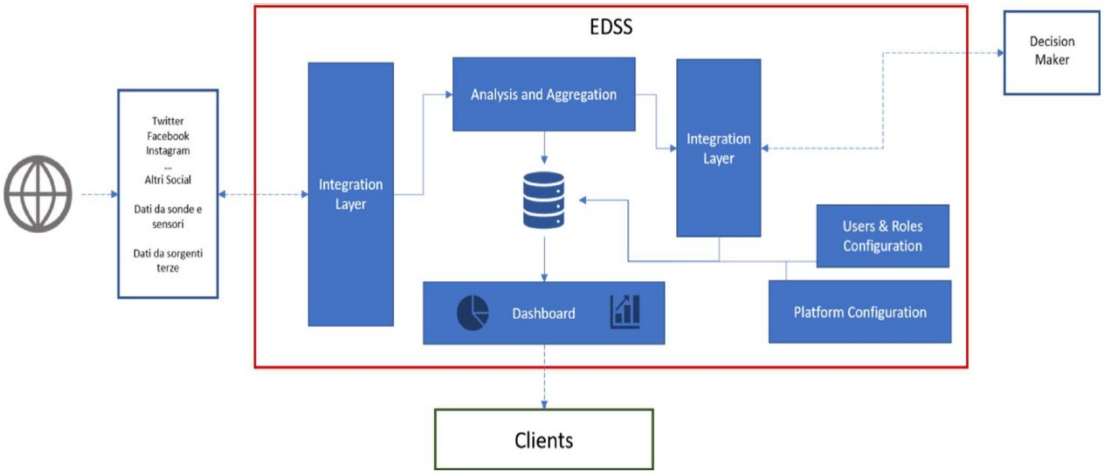

figure 1. Emergency Decision Support System architecture.

Figure 2 provides further details on the EDSS infrastructure. Specifically, it addresses two data flows within the first integration layer and the analysis and aggregation module and how they are presented to the users in the dashboard.

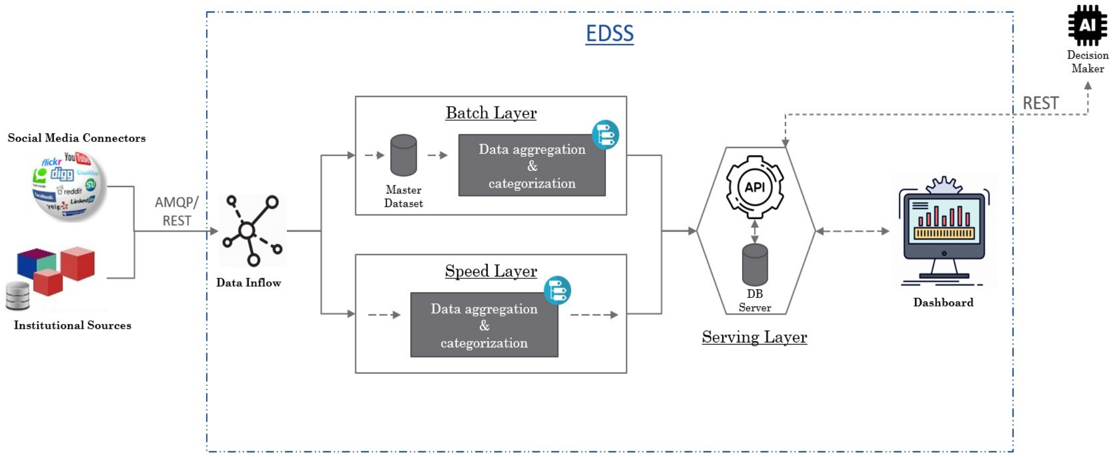

figure 2. Scheme of the final EDSS infrastructure.

It can be seen that the data flow "captured" on social media and institutional web resources is split into two equal flows: one is analysed in an engine with speed layer components and one on batch layer components. Specifically, the speed layer analyses the data without interacting with them, operating a geographic and semantic evaluation (data located within the geographic box of the tenant). On the other hand, the batch layer analyses the same data but processes thematic aggregations and categorisations according to the target risk typologies. Subsequently, thanks to the comparison of data stored in the DB server and through API Rest connectors towards the Decision Maker, external to the platform, the result of the analysis and classification of the " criticality of the captured" data is proposed on the user dashboard.

Concerning the platform's practical use, it is to stress that the EDDS developed will be easily accessible by the Civil Protection users as it has a user dashboard (as depicted in Figure 3) and a user and role configuration module.

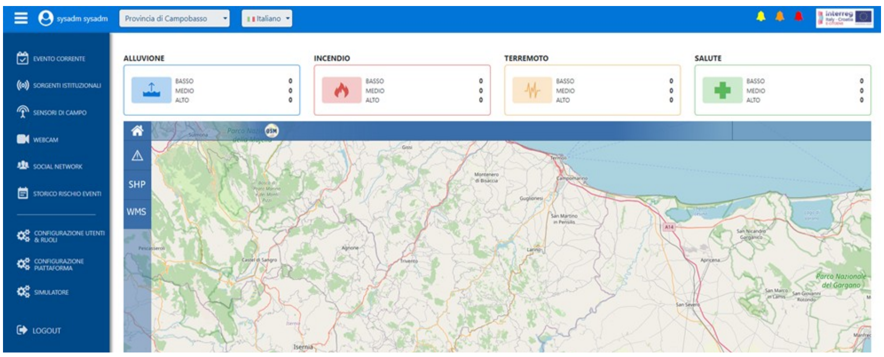

figure 3. The EDSS platform dashboard.

Each user (tenant) operates exclusively in his/her box of competence, but in case of need for support or discussion with other operators, a collaborative interoperable chat between tenants (i.e. the project partners of the Adriatic basin) is activated. In other words, this chat is a virtual copy of the functional principles of the network of decentralised functional centres.

2. Use case

Additionally, the platform will represent an essential source of data for those phenomena not otherwise monitored both due to instrumental limits (e.g. hailstorms) and lack of sensors (e.g. exceptional low-altitude snowfalls). , With this innovative tool, we expect to start obtaining and improving the information on events where, for example, information is lost due to a lack of sensors or events not correctly evaluated due to spatial exemption.

With geo-localised posts and possibly the publication of a photograph of the moment, the social network users will act as "mobile sensors" describing much more than a sensor placed incorrectly or even not present. Furthermore, the platform is conceived to connect with amateur meteorological data networks that, even if they are not fully complying with the Standards for monitoring stations (WMO, 2018), can supply knowledge on intense and localised meteorological events (e.g. downburst and summer storms) in areas not covered by institutional networks. Clearly, data acquisition is only possible when the amateur network exposes web services such as APIRest or grants acquisition through "capture" mechanisms on web pages for publishing data. In order to illustrate the potential use of the EDSS, three examples of events that could have been recorded by amateur networks or "mobile sensors" if the platform had been active is now presented.

The first example is the significant snowfall of February 2012 (Figures 4ab); this case is representative of extreme events related to climate change (Cardillo et al. 2013 - Fazzini et al., 2013). Institutional sensors did not record this event as it occurred at sea level (snow gauges are usually installed at mountain or sub-mountain altitudes) and involved the entire Adriatic coast from Friuli Venezia Giulia to Puglia. On the other hand, the social world documented this event extensively with posts, videos and photos, providing helpful information to define the event that could have been processed by the EDSS. An example is the photo presented in Figure 5. It was published on Facebook by a user and represents the snowfall of 17.2.2012 in Termoli (Campobasso).

a) b)

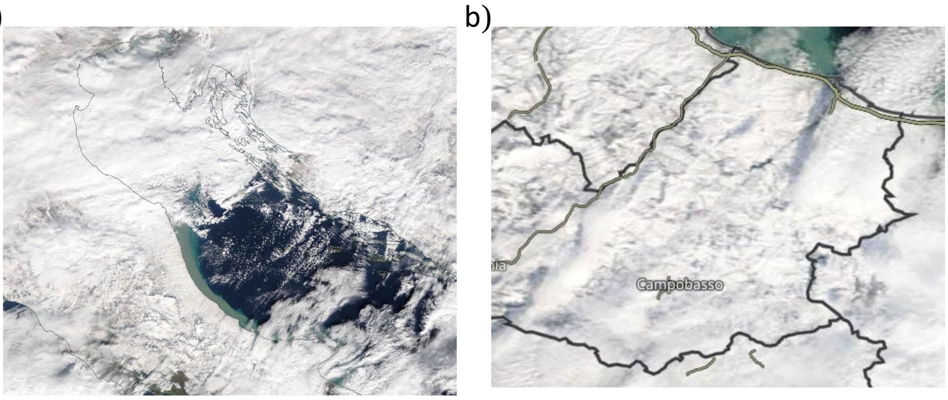

figure 4. Example of an Adriatic coast (a) and a low-altitude snow event in the Molise region not recorded by institutional networks (b) (image NASA Worldview application, Molise Region, 11.2.2012).

figure 5. Example of a low-altitude snow event not recorded by institutional networks (Costa Adriatica, litorale Termoli Nord, 17.12.2012) – Lat 41°59'45.75"N – Long 14°59'42.42"E.

The hailstorm of 19.7.2019 that occurred in Venafro (Lat 41°29'0''N – 14°3'0''E - Isernia) represents another interesting case to analyse, especially considering the absence of specific sensors for this typology of meteorological events. Also in this situation, processing the data provided by mobile sensors through social networks (examples of retrievable information are presented in Figure 6) with the EDSS, it would have been possible to reconstruct approximately the areal extension and the intensity of this highly geolocalised phenomenon, and eventually to estimate the damage (e.g. from the dimensions of the hail grains), allowing the immediate activation of any means and resources for rescue.

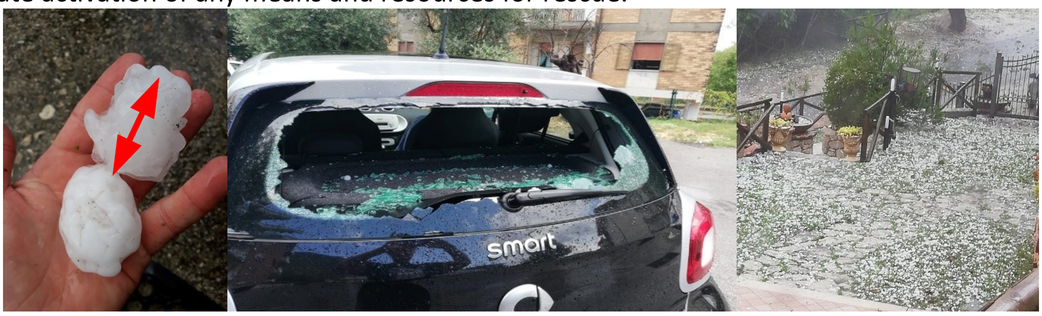

figure 6. Example of information that can be retrieved if geolocated (Venafro, 18.7.2019).

The last example concerns the exceptional snowfall of 5 and 6 March 2015 that affected the Adriatic coast and the Apennine hinterland. If the platform had been active, it could have had a double function: aiding the creation of the event scenario as previously described and, secondarily, providing support to the demonstration of a wrong meteorological record (in the specific case, the certification of a record snowfall recorded in the town of Capracotta situated in the northern part of Molise Region). Social network users documented a snowfall intensity of 256 cm/24 h; however, in many publications, it has been shown that this data does not conform to reality (Cardillo et al., 2015). With a proactive use of the platform, information similar to the images in Figure 7 would have been captured showing the exceptional snow accumulation due to the wind (Fig.7a) and the evidence of completely uncovered areas, testifying the false communication of an exceptional but not record-breaking snowfall.

figure 7. a) Photo of a snow accumulation due to the wind in the town of Capracotta. Photo of a snow accumulation due to wind in Capracotta (b) and Vastogirardi (c), with evidence of wind erosion on roofs and ground.

Conclusion

The main novelty of the EDSS platform presented in this paper is that, besides the entry of data from sensor networks and institutional sources, contributions from the citizen are envisaged through posts published on the primary social media. These geo-referenced posts could include photos, videos or texts and can actively contribute to a better description of the event scenario in which citizens act as mobile sensors.

Moreover, this platform is able to provide to Civil Protection valuable information on local severe weather conditions that cannot be detected with traditional systems. It is well known that these conditions could create an emergency situation by themselves or worsen the emergency situation caused by other risk typologies (e.g. earthquake) and make the necessary intervention operations more complex (e.g. based on specific weather conditions, the use of different resources could be required). Thus, concerning meteorological aspects, this platform allows citizens to create an unstructured monitoring network through privately owned meteorological sensors, potentially recording phenomena that would otherwise be lost, such as hailstorms or snowfalls at low altitudes.

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