PHD COURSE IN LIFE AND ENVIRONMENTAL SCIENCES

Report Form for PhD student annual evaluation (XXXVII and XXXVIII cycles)

Name of PhD student: Giuseppe Lelow

Title of PhD research: Emergency Management and Information Technologies: challenges and potentials

Name of PhD supervisor: Prof. Fausto Marincioni
Research lab name: Disaster Risk Reduction Laboratory

Cycle:
[ ] XXXVII
[X] XXXVIII

PhD Curriculum::
[ ] Marine biology and ecology
[ ] Biomolecular Sciences
[X] Civil and environmental protection

DISVA instrumentation labs/infrastructure eventually involved in the project:
[ ] Actea Mobile Laboratory
[ ] Advanced Instrumentation lab
[ ] Aquarium
[ ] MassSpec lab
[ ] MaSBiC
[ ] Simulation/informatics lab
[ ] Other. Please, indicate: .....

ABSTRACT (1000 characters, including spaces):

The widespread diffusion of portable devices enable data collection and knowledge sharing through communication networks formed by citizens. In mass emergency scenarios, individuals publishing a large number of real-time multimedia messages, become de facto human sensors. Emergency Services may use social media data as an additional layer of information to enhance decision-making and response capacity. However, Social Media and Crowdsourcing (SMCS) exhibit some critical issues, such as trustworthiness, information overload and privacy policies, which limit their use towards stakeholders. The overall objective of this project is to gain insight into the challenges and potentials of crowd-sourced data by exploring a new form: emergency calls to the first-level Public Safety Answering Points (PSAPs) of the European Emergency Number 112. The preliminary results demonstrate that the knowledge generated by the PSAPs has the potential to overcome social media data barriers.

Part 1. Scientific case of the PhD Research (2 to 3 pages, including figures)

- BACKGROUND

Information and Communication Technologies (ICT) has driven digitization across various sectors. The widespread diffusion of portable devices, equipped with sensors and communication capabilities, has led to the concept of Cyber-Physical Convergence (Avvenuti et al., 2020). Social Media plays a central role in this context, serving as the primary source of information and communication services, with approximately 4.8 billion users worldwide (Datareportal, 2023). Its usage ranges from keeping in touch with friends and family to reading news and searching for content, especially during rapidly developing events that impose stringent time requirements. Crises and disasters fall into such events, and it often happens that many people act as human sensors, posting information-rich messages on social media in real-time (Avvenuti et al., 2016). Crowdsourcing, a collaborative approach to information gathering and sharing, leverages this wealth of data to generate knowledge about emergency events (Ernst et al., 2017). Researchers are increasingly interested in developing emergency detection systems that use diverse information sources, including social media (Grimaz et al., 2022). Managing crowd-sourced data such user-generated content requires rapid, reliable and relevant information extraction, which is crucial for emergency response.

- SCIENTIFIC AIMS

The study aims to expand research on Social Media and Crowdsourcing (SMCS) in emergencies by identifying related challenges and exploring the potential of emergency calls to the Single European Emergency Number 112. The goal is to demonstrate the superior value of the information layer generated by the first-level Public Safety Answering Points (PSAPs) as hazard and risk monitoring system.

- WORKPLAN AND RESEARCH ACTIVITIES

WP 1. Objective.

Identifying use patterns, role patterns and perception patterns of SMCS-based (Social Media and Crowdsourcing) emergency communication.

Methods.

Literature review on social media and crowdsourcing approaches in emergencies.

Expected/Obtained Results.

A fundamental description of Social Media and Crowdsourcing-based communication can be made through the Crisis Communication Matrix (Reuter & Kaufhold, 2018). Four distinct directions for using social media in such situations have been identified (Figure 1). The domains depend on the differentiation between authorities (A) and citizens (C) as senders and receivers of information. The term “authorities” ranges from institutions to emergency services, representing those who are not laypeople in the field of emergency management. The communication direction is defined from a sender to a receiver, dividing crisis communication into four channels: A2C, A2A, C2C, and C2A. Authorities to Citizens (A2C): The main purpose is institutional communication, which involves sharing informative content and alerts with a top-down approach. Alongside traditional communication, some emergency services are beginning to harness expressive approach (Denef & Bayerl, 2013), which allows for a

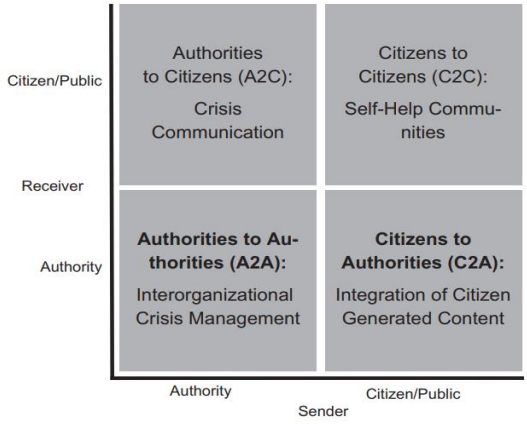

Figure 1: Crisis Communication Matrix (Reuter et al., 2018)

close relationship with the public, increasing the engagement. However, it demands significant resources, maintenance, and adherence to legal restrictions, ensuring data privacy and the accuracy of information. Authorities to Authorities (A2A): Inter-organizational communication often doesn't use social media extensively due to concerns related to data security and privacy. However, it could enhance inter-organizational awareness and informal processes. This domain may have limited relevance in SMCS-communication since the channels adopted are well-defined and interoperable.
Citizens to Citizens (C2C): The result of this type of communication lies in the self-coordination and self-help activities of real or virtual communities to which the citizen belongs. In this context, “emergent groups” (Quarantelli et al., 1983)refer to a community of private citizens who work collectively in a physical realm to achieve common goals related to real or potential disasters but whose organization has not yet been institutionalized. Digital volunteers are the virtual domain's manifestation of emergent groups(Starbird & Palen, 2011). They engage in crowdsourcing activities, such as collecting data from social media users to gather information about missing persons, available shelters, and urgent needs. However they can form and extinguish within a few hours or days, acting without guaranteeing effective and conclusive response. Citizens to Authorities (C2A): C2A communication involves collecting information and data from the population, which authorities then analyze. This communication can be indirect or direct. Indirect C2A or opportunistic sensing involves observing, collecting, and evaluating publicly available social media posts relevant to the Disaster Management Organization but not directly addressed to them. Direct C2A or participatory sensing occurs when authorities actively request citizens to provide information and data for specific purposes, such as early warning systems (Kapadia et al., 2009; Xu et al., 2016). Much of the research effort in the field of social sensing falls within this domain.

WP 2. Objective.

Identifying barriers and solutions of social media data management in emergency situations; Studying the emergency call handling processes of the Single European Emergency Number 112; Demonstrating that 112 emergency calls represent a new form of crowd-sourced data.

Methods.

Literature review on Social Media for Emergency Management (SMEM) and related case study-based analysis of social media data management systems; Analysis of the national and international legislation on emergency communication; Analysis of 112 emergency call handling service chain and procedures.

Expected/Obtained Results.

Social sensing entails the process of analyzing user-generated content on various online social media platforms, such as Twitter, Facebook, and others. This content – produced by individuals often referred to as "human sensors" – includes text, images, coordinates, and tags. The primary objective of social sensing is to detect events, assess responses, and gauge sentiments within online social discourse (Fan et al., 2020). The methods of crowdsourcing are employed to generate collective intelligence from individual citizens in order to assist authorities in decision-making processes and strategic-tactical activities. However, managing real-time social media data in emergency situations requires an in-depth analysis of the associated organizational and technical challenges. The first ones are defined as issues caused by the set of interactions among citizens, between individuals and authorities, and among organizations: digital divide; data security and privacy; liability concerns; lack of guidelines, policies and expertise; financial support to build platforms and the staff to manage them (Harrison & Johnson, 2019; Luna & Pennock, 2015).When it comes to utilizing data retrieval methods to aid in situational awareness during disasters, emergency managers encounter two significant technical challenges: ensuring the reliability of the information they receive and the sheer volume of the data stream, which exceeds human processing capacity. The "Human as a Sensor" (HaaS) paradigm (Avvenuti et al., 2016) is implemented in prototypes combining two systems: the Artificial sensors-based Detection System and the Social Detection System. The latter relies on social media data and identifies emergency messages based on characteristics like user affinity with the event topic, the user's location as a direct witness, and message credibility. The aim is to filter and classify user-generated content, extracting pertinent crisis details

concerning the who, what, where, and when. To achieve this, artificial intelligence algorithms such as Natural Language Processing are used to understand and interpret human language in a valuable way from input data. Spatial analysis methods such as geoparsing allow for assigning geographical coordinates to unorganized text content that mentions toponyms (Middleton et al., 2018). This process results in structured content and makes it more amenable to further processing. Finally, approaches to collecting crowd-sourced data that combine opportunistic (basic extraction from social media) and participatory sensing (targeted collection based on specific system requests) succeed in optimizing processing times in the former case and mitigating reliability issues in the latter (Kapadia et al., 2009; Xu et al., 2016). These state-of-the-art systems exhibit similarities with the emergency call handling procedures of the Single European Emergency number 112 (Figure 2).

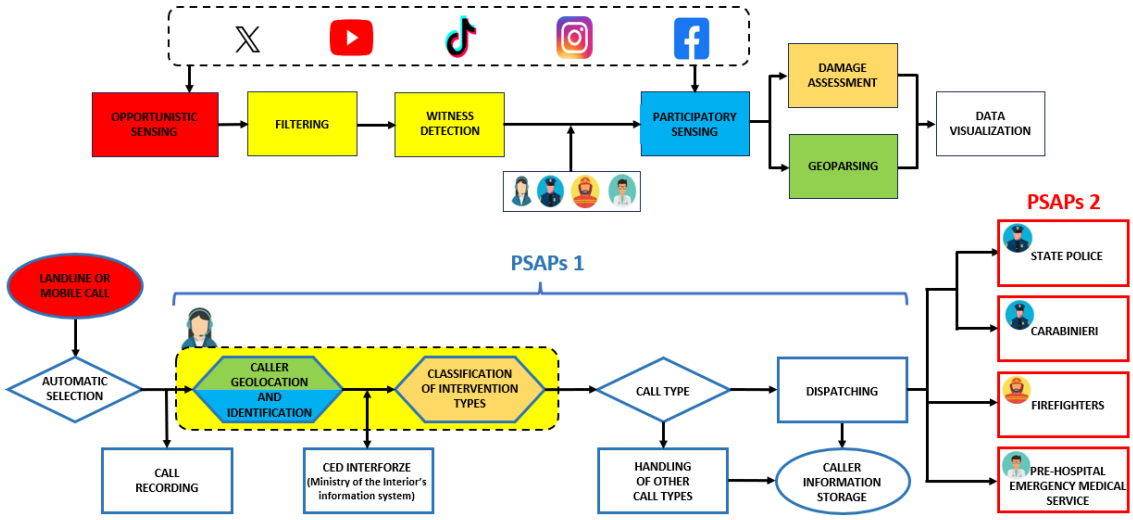

Figure 2: Comparison between an example of a social media data management system and the flowchart for the Italian model of 112 emergency call handling. (Adapted from Avvenuti et al., 2020 – European Emergency Number Association, 2022)

Dialing 112, the call is automatically routed to the territorially competent response center. 112 operates alongside national emergency numbers in many European countries but is increasingly recognized as the primary emergency number for the EU. Italian call handling model is organized in 2 stages: first-level Public Safety Answering Points (PSAPs) are managed by lay operators, who are responsible for receiving calls and collecting data (caller identification and geolocation, classification of the type of intervention and needs). The call is thus filtered and passed on to the second-level specialized PSAPs (law enforcement, firefighters, pre-hospital emergency medical service) that will carry out response interventions (EENA - European Emergency Number Association, 2022). As shown in the two flowcharts, processes performing analogous functions are highlighted in the same colors: opportunistic sensing translates into the large number of calls that spontaneously arrive during a major emergency. The filtering function, witness detection, localization, and impact assessment are concentrated in the telephone interview conducted by the operator in the PSAP 1. From this observation, arises the proposal of a new HaaS paradigm through the extension of research on Social Detection Systems. The standardized and interoperable procedures of first-level PSAPs enhance the quality and management of crowd-sourced data. 112 calls can provide a solution to the inherent challenges of social media data. The knowledge generated ensures greater source credibility, structured and reliable content through the information gathered in emergency call's contact cards. Additionally, accuracy and rapid localization are assured through state-of-the-art technologies like Advanced Mobile Location (AML) (EENA - European Emergency Number Association, 2022). Future research directions aim to test the potential of the 112 service in terms of citizen-sensing through spatial and temporal analyses of emergency calls. A comparative analysis with social media data on the same case study will serve to demonstrate the superior value of this new form of crowdsourcing.

- REFERENCES

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Part 2. PhD student information on the overall year activity (courses/seminars/schools, mobility periods, participation to conferences)

List of attended courses/seminars/schools

List of attended courses:

1. Design of Research: European projects – Prof. Nicola Paone (12-16-19-23-26/01/2023) (2 CFU)

2. Technology Transfer and Innovation – Prof. Donato Iacobucci (1-8-22-29/03/2023; 12/04/2023) (2 CFU)

3. Methods of Disaster Research – Prof. Fausto Marincioni (22-29/03/2023, 03/05/2023) (1 CFU)

4. Getting started with R: Environmental computing – Prof. Giuseppe d'Errico (22-24-29/05/2023) (1 CFU)

5. Regression analysis using Microsoft Excel – Prof.ssa Francesca Beolchini (23-25-26/05/2023) (1 CFU)

6. Climate-related risks and extreme events – Prof. Pierpaolo Falco (12-15-19/06/2023) (1 CFU)

7. Environmental Sustainability: the Life Cycle Assessment, LCA – Prof.ssa Alessia Amato (27-29-30/06/2023 (1 CFU)

8. Human, Environment and Geology (28/06/2023) – Prof.ssa Alessandra Negri (1 CFU)

List of individual internship:

1. Participation in the European Civil Protection Exercise 'EU Modex 2023' (Arcevia (AN), 6-7-8-9/06/2023) - Supervisor: Prof.ssa Susanna Balducci (48 hours - 6 CFU)

Modex (Module Exercise) is a real-scale exercise of the European Civil Protection Mechanism aimed at testing self-sufficiency, interoperability, procedures, and coordination of civil protection modules. The exercise simulates an emergency scenario consisting of a combination of seismic and pandemic impacts (earthquake with a magnitude of 6.8 with its epicenter located in Gubbio, along with a significant number of patients exhibiting symptoms related to meningoencephalitis).

List of attended seminars/webinars:

Lecturer at seminars (2 CFU each):

A. Dai cambiamenti ambientali alla Riduzione Rischio Disastri (as a part of the PNRR Course: "Orientamento sulla Protezione Civile ed Ambientale rivolto all'Istituto Mercantini di Ripatransone" – Course Coordinator: Prof.ssa Silvia Bianchelli - 21/02/2023)
B. Giornata per la custodia del Creato - Che scorrano la giustizia e la pace - A un anno dalla alluvione dei fiumi Misa e Nevola - Lancio della riflessione sulla mappatura e presa in carico delle persone vulnerabili (01/10/2023)

Participation to seminars/webinars (0,5 CFU each):

1. La pericolosità sismica della Regione Marche - Prof. Emanuele Tondi (DiSVA seminar 29/11/2022)

2. Laurearsi nelle tematiche del Rischio ambientale e della Protezione civile: quale figura professionale e quali opportunità di lavoro (DiSVA seminar 30/11/2022)

3. Monitoring and forecasting marine heat waves - Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC (webinar 16/12/2022)

4. Toxicological effects of cigarette butts for marine organisms - A Shot of Science (seminar 20/12/2022)

5. I Talk di Highlander: Fuoco. Come le tecnologie digitali aiutano ad affrontare il cambiamento climatico - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 19/01/2023)

6. Delegated Regulation of the European Electronic Communications Code: What you need to know" - EENA European Emergency Number Association (webinar 30/01/2023)

7. Maritime Spatial Planning in a changing climate - Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC (webinar 09/02/2023)

8. Agroecological practices for climate change mitigation - Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC (webinar 14/02/2023)

9. Toward model-consistent initialization of decadal climate predictions - Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC (webinar 21/02/2023)

10. Il clima e il rischio climatico nelle Marche - Regione Marche - Dipartimento Infrastrutture Territorio e Protezione Civile (seminar 21/02/2023)

11. Monitoraggio nel Mare Adriatico: valutare i cambiamenti ambientali per ispirare azioni di adattamento - Centro Euro Mediterraneo sui Cambiamenti Climatici (webinar 09/03/2023)

12. Rischio idraulico e cambiamento climatico - Dipartimento di Ingegneria Civile, Edile e Architettura UNIVPM (seminar 17/03/2023)

13. Cambiamenti climatici 2023: Rapporto di sintesi dell'IPCC - AR6 - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 20/03/2023)

14. The glacial (?) sapropel S6 (172 ka; MIS6): a multiproxy approach to solve a Mediterranean "cold case" - A Shot of Science (21/03/2023)

15. Giustizia ambientale in Italia: quadri di vita e opportunità di cambiamento per le comunità residenti nei siti di interesse nazionale per le bonifiche - Società Geografica Italiana (webinar 04/04/2023)

16. How to talk about climate change in a way that makes a difference - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 12/04/2023)

17. Environmental intelligence - Centro Euro-Mediterraneo sui Cambiamenti Climatici (19/04/2023)

18. Journalism and science: narratives of climate change | Foresight Dialogues - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 10/05/2023)

19. Art and science towards climate action - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 25/05/2023)

20. AML Report Card: 2023 Update - EENA European Emergency Number Association (webinar 01/06/2023)

21. The EU Artificial Intelligence Rulebook and What it Could Mean for Public Safety - EENA European Emergency Number Association (webinar 10/07/2023)

22. An integrated approach for coastal habitat mapping based on autonomous survey and remote operated technologies - Centro Euro-Mediterraneo sui Cambiamenti Climatici (webinar 11/07/2023)

23. Exploring the Potential of Graphene Field-Effect Transistors in Biosensing for Health and Environment - A Shot of Science (11/07/2023)

24. CMCC Data Delivery System: Overview, Recent Advances and Future Perspectives (webinar 18/07/2023)

25. Social Media and Public Safety: New Challenges and Opportunities - EENA European Emergency Number Association (webinar 04/09/2023)

List of periods spent abroad

None

List of conferences/workshops attended and of contributions eventually presented

1-a. Participation to II Workshop CNR IRPI (Istituto di Ricerca per la Protezione Idrogeologica) – La mitigazione dei rischi geo-idrologici in un contesto di cambiamento globale: quali risposte dalla comunità scientifica. (Aula Marconi CNR, Rome, 03-04-05/07/2023, in presence) (1 CFU)

1-b. Presentation Lelow G. – Marincioni F. "Crowdsourcing for Next Generation Emergency Management" – Session 6: Risk communication and risk perception: comparing methods, techniques and experiences. and (Aula Marconi CNR, Rome, 05/07/2023, in presence) (4 CFU)

2- XII Congresso Nazionale SISMEC (Società Italiana di Statistica Medica ed Epidemiologia Clinica) Ambiente, Clima, Popolazioni: Fonti, Dati, Metodi per la tutela della salute individuale e collettiva" (20-23 settembre 2023) (1 CFU)

Part 3. PhD student information on publications

If not yet published, please indicate the publication status (submitted, accepted, in preparation...)

List of publications on international journals

J1. [*Lelow*, G., Marincioni, F. "1-1-2 Public Safety Answering Points as technological hubs for next-generation crowdsourcing", IJDRR - International Journal of Disaster Risk Reduction (2023)] Status: in preparation

List of publications on conference proceedings

None

List of other publications (books, book chapters, patents)

None

[13/10/2023]

Student signature

Supervisor signature