



UNIVERSITÀ POLITECNICA DELLE MARCHE

DIPARTIMENTO DI SCIENZE DELLA VITA E DELL'AMBIENTE

Corso di laurea
Scienze Ambientali e Protezione Civile

L'uso dei Big Data nei disastri

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Sessione Autunnale
Anno accademico
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1. Introduzione

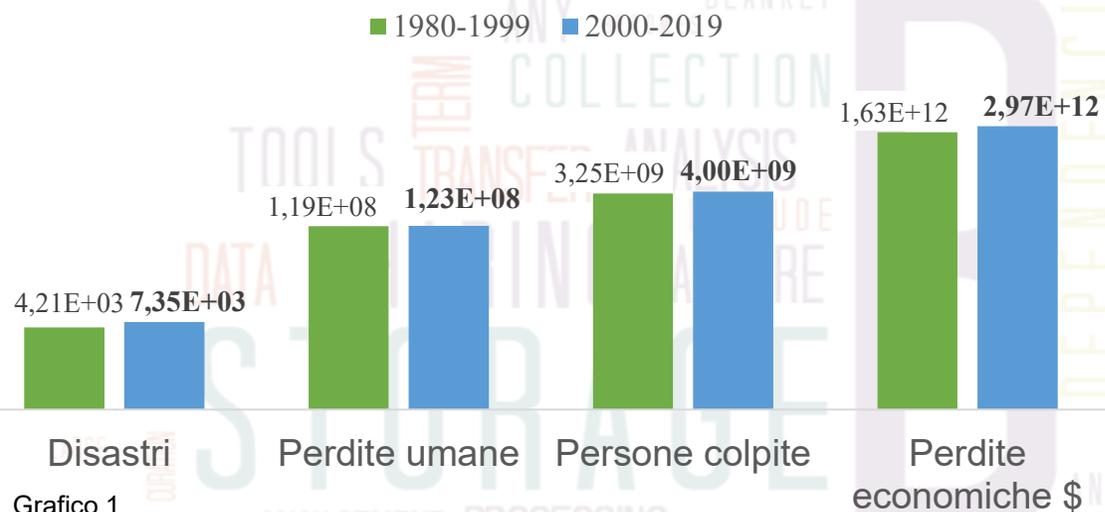


Grafico 1
Da UNDRR, & CRED. (s.d.). *Human Cost of disasters: an overview of the last 20 years 2000-2019*

Strategie basate su risorse di tipo tecnologico → essenziali per la *resilienza* di comunità e raggiungere un futuro *sostenibile*.



Created by Eucalyp



Big Data



Cambiamento climatico → Crescente aumento di catastrofi naturali



2020: anno più caldo mai registrato

(Greene & Peter, 2021)

Imprevedibilità

Risorse limitate

Povertà

Vulnerabilità

Esposizione

Bassa *resilienza*



Perdite elevate

(Bello & Aina, 2014)

Definiti nel campo dei disastri come l'integrazione di diverse fonti di dati e le capacità di analizzarli e usarli in tempo reale a beneficio delle comunità affette da calamità.

- Valutare l'efficacia di misure di riduzione dei rischi e di adattamento;
- Caratterizzare pericoli, esposizione e vulnerabilità;
- Studiare le dinamiche ambientali legate ad un disastro. (Zuccaro, Leone, & Martucci, 2020)

Tramite una revisione della letteratura scientifica, questa tesi si prepone di:

- esaminare le **fonti Big Data** (*satelliti, GIS, LiDAR, UAV, WSW & IoT, Crowdsourcing e social media, GPS e CDR*);
- analizzare i **campi** e le **fas**i in cui tali dati possono trovare impiego;
- analizzare il contributo dei Big Data nella gestione dei disastri;
- analizzare i principali **punti critici** del loro coinvolgimento;
- proporre potenziali **strategie** per un utilizzo ottimale.

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Procedia
 Social and Behavioral Sciences

The 3rd International Geography Symposium - GEOMED2013

Satellite remote sensing as a tool in disaster management and sustainable development: towards a synergistic approach

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Abstract

Disasters have become an issue of growing concern throughout the world, whether it is natural hazards or through human factors. The frequency, as well as magnitude, of disasters threatening large population living in diverse environments is increasing in recent years across the world. This paper addresses the issue of disaster management, sustainable development, and social

Enabling Mobility in Heterogeneous Wireless Sensor Networks Cooperating with UAVs for Mission-Critical Management

Ayyeal Tüysü Erman, Lodewijk van Hoeseil, Jian Wu, and Paul Havinga, *University of Twente*

Abstract—Wireless sensor networks (WSNs) have the promise of revolutionizing the capture, processing, and communication of mission critical data for the use of first operational forces. Their low-cost, low-power, and size make it feasible to embed them into environment-monitoring tags in critical care regions. First responders utilize gear, and data collector sinks attached to unmanned aerial vehicles (UAVs). The ability to actively change the location of sensors can be used to mitigate some of the traditional problems associated with static sensor networks. On the other hand, sensor node mobility brings with it its own challenges. These include challenges associated with in-network aggregation of sensor data, routing, and activity monitoring of responders. Moreover, all different mobility patterns (e.g., sink mobility, sensor mobility, etc.) have their special properties, so that each mobile device class needs its own approach. In this article, we present a platform which benefits from both static and mobile sensors and addresses these challenges. The system integrates WSNs, UAVs, and actuators into a disaster response setting and provides facilities for event detection, autonomous network repair by UAVs, and quick response by integrated operational forces.

I. INTRODUCTION

The ability and performance of intelligent systems providing wireless sensing-computing-actuating are of growing interest. Wireless sensor networks (WSNs) are used to increase the efficiency of many applications, such as target detection and disaster management. Wireless sensor networks with static nodes have been developed and also experimentally applied for detection and monitoring activities [1].

The main objective of the sensing-actuating system is to detect events (e.g. fire) by means of sensors and wirelessly communicate this event and assist other nodes to deliver the event. A typical scenario would consist of a field covering several square kilometers with hundreds of sensor nodes. These nodes would run a mission task and deliver their data to specific sink nodes. Sinks collect (sense) data and act as insertion point of new mission tasks. However, static WSNs have some limitations. The use of mobile sensor nodes could provide significant improvements. They can provide the ability to closely monitor the objects that we want to guard in WSN and to look at the events at a smaller granularity than static nodes.

II. APPLICATION SCENARIO

The protection in case of natural or human-made disasters is today main concern of our society. Recent terrorist attacks pointed out the limitations of existing technologies to protect

Crowdsourcing roles, methods and tools for data-intensive disaster management

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Abstract Mobile technologies, web-based platforms, and social media have transformed the landscape of disaster management by enabling a new generation of digital networks to produce, process, and analyse georeferenced data in real time. This unprecedented convergence of geospatial technologies and crowdsourcing methods is opening up multiple forms to participate in disaster management tasks. Based on empirical research, this paper first proposes a conceptualisation of crowdsourcing roles and then analyses methods and tools based on a combi-

I Introduction

Mobile technologies and social media have transformed the landscape of emergency and disaster management by enabling disaster-stricken citizens to produce digital, real time, local information on critical events. Hurricane Sandy in 2012, Typhoons Haiyan or Hagupit in 2013-2014, or the Nepal earthquake in 2015 offer examples of user-generated data by the millions (Poblet et al. 2014; Imran et al. 2015). The 2015-2016 refugee crises in Europe, with hundreds of thou-

Big Data in Natural Disaster Management: A Review

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Abstract Undoubtedly, the age of big data has opened new options for natural disaster management, primarily because of the vast possibilities it provides in visualizing, analyzing, and predicting natural disasters. From this perspective, big data has radically changed the ways through which human societies adopt natural disaster management strategies to reduce human suffering and economic losses. In a world that is now heavily dependent on information technology, the prime objective of computer experts and policy makers is to make the best of big data by sourcing information from varied formats and storing it in ways that it can be effectively used during different stages of natural disaster management. This paper aimed at making a systematic review of the literature in analyzing the role of big data in natural disaster management and highlighting the present status of the technology in providing meaningful and effective solutions in natural disaster management. The paper has presented the findings of several researchers on varied scientific and technological perspectives that have a bearing on the efficacy of big data in facilitating natural disaster management. In this context, this paper reviews the major big data sources, the associated achievements in different disaster management phases, and emerging technological topics associated with leveraging this new ecosystem of Big Data to monitor and detect natural hazards, mitigate their effects, assist in relief efforts, and contribute to the recovery and reconstruction processes.

Keywords: big data; disaster management; review

I. Introduction

Natural disasters can be defined as a combination of natural hazards and vulnerabilities that endanger vulnerable communities that are incapable of withstanding the adversities arising from them [1]. Human beings invariably face threats of natural as well as human-made disasters, which often lead to massive damages, human suffering, and negative economic impacts. The main characteristics of natural disasters are unpredictability, availability of limited resources in impacted areas, and dynamic changes in the environment [2]. Unpredictability implies that severe impacts on people and property during natural disasters cannot be predicted with acceptable accuracy [3]. The issue of limited resources emerges because unpredictability makes it difficult to allocate adequate resources in advance. Dynamic changes in the environment result because it is difficult to make predictions about the movement of people and the damages that may occur because of the natural disaster. It is difficult to predict such changes based on data that pertains to normal periods [4]. Introducing disaster management policies and applying appropriate levels of information technology and equipment offer immense potential in enhancing the capabilities of disaster management policies. In addition, the evolving trends have opened massive technological resources for reducing disaster risks [5].

Big data is defined as the technological paradigm that allows researchers to conduct an efficient analysis of vast quantities of data that is made available through the current practices [6,7]. It is the collection of scientific and engineering methods and tools that help in making the best of massive

2020 Tied for Warmest Year on Record, NASA Analysis Shows

NASA Finds 2020 Tied for Hottest Year on Record

2016 2020

TeMA Journal of Land Use, Mobility and Environment

Urban sprawl processes characterize the landscape of the areas surrounding cities. These landscapes show different features according to the geographical area that cities belong to, though some common factors can be identified: land consumption, indifference to the peculiarities of the context, homogeneity of activities and building typologies, mobility needs exasperantly designed private cars.

TeMA is the journal of the Land use, Mobility and Environment Laboratory of the Department of Urban and Regional Planning of the University Federico II of Naples. The Journal offers papers with a unified approach to planning and mobility. TeMA Journal has also received the Europe Seal of Open Access Journals released by Scholarly Publishing and Academic Resources Coalition (SPARC) Europe and the Directory of Open Access Journals (DOAJ).

THE RESILIENT CITY

Human cost of disasters

An overview of the last 20 years

CORDIS Risultati della ricerca dell'UE

Improving Resilience to Emergencies through Advanced Cyber Technologies

Servizi di gestione delle emergenze in crowdsourcing

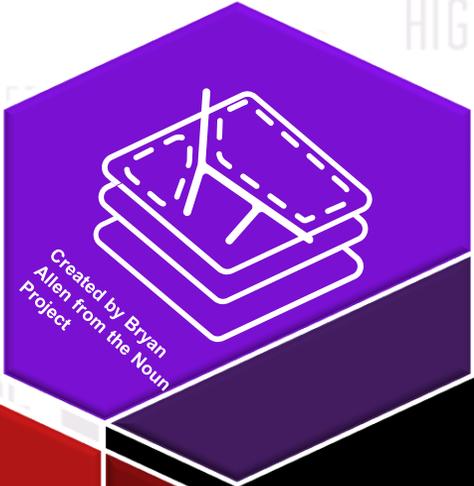
Poiché i cambiamenti climatici aumentano il numero di eventi meteorologici estremi, il progetto iREACT (Improving Resilience to Emergencies through Advanced Cyber Technologies), finanziato dall'UE, sta sviluppando uno strumento innovativo che integra una serie di dati provenienti da più fonti, comprendenti le informazioni fornite dai cittadini attraverso i social media e il crowdsourcing.

Questo progetto è apparso in...

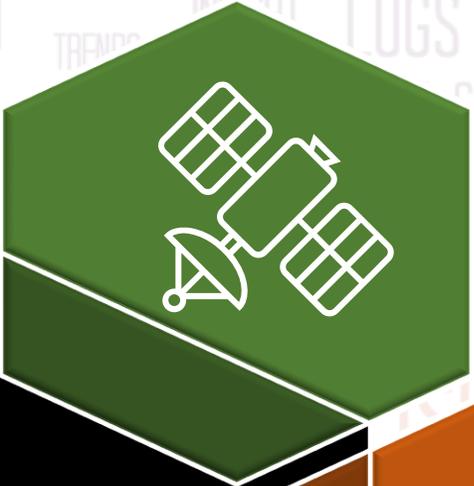
RVISTA RESEARCH4EU
 Alifanaro | 5 su 10 000: terapie innovative contro le malattie rare

2. Fonti

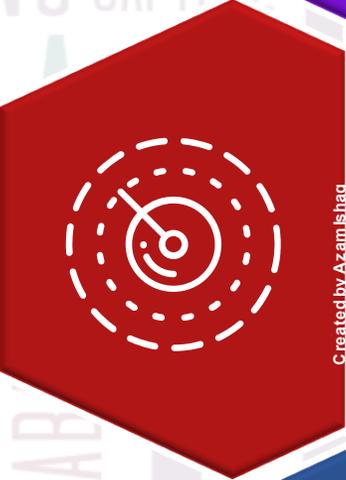
Big Data



GIS



Satelliti



LiDAR: Light Detection and Raging



UAV: Unnamed air Vehicles



GPS
CDR: Call Data Records



Wireless Sensor Web & Internet of Things
Crowdsourcing
Social Media

Satelliti

- + Immagini 2D, 3D, alta risoluzione
- + Informazioni pre/post disastro
- + Valutazione danni, estensione delle aree colpite
- + Monitoraggio/allerta cicloni, siccità e alluvioni
- + Satelliti vari in base alla scala spaziale del pericolo
- + Valutazione terreni, corpi d'acqua
- Accessibilità all'alta risoluzione e copertura nuvolosa



(Yu, Yang, & Li, 2018)

GIS

- o Valutazione vulnerabilità
- o Consultazione ed interrogazione mappe, dati ambientali e sociali
- o Supporto attività di pianificazione, previsione e prevenzione

UAV: Unmanned air Vehicles

- + Risoluzione spaziale
- + Sensori IR, UV, radiazione, meteo
- + Informazioni in tempo reale
- + Risorse, rilevamento incendi, analisi integrità strutturale
- Durata batteria, copertura limitata
- Restrizioni legislative, privacy



(Correia, da Costa Rubim, Dias, França, & Borges, 2020)

(Yu, Yang, & Li, 2018)

LiDAR: Light Detection and Raging

- + Raccolta dati ad alta definizione: Modelli Digitali del terreno, Modelli Digitali di superficie, Modelli Digitali di elevazione
- + Analisi di rischio idrologico e alluvionale
- + Valutazione corpi di frana attivi
- + Danni strutturali
- + Attendibilità
- Costoso

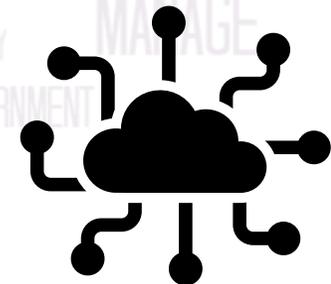
(Tommasi, 2020)



Wireless Sensor Web & Internet of Things

- + Miglioramento tempi di risposta
- + Comunicazioni efficienti
- + Trasmissione affidabile
- + Sistemi di allerta
- + Collegamenti vittime e soccorritori
- + Integrazione tra WSW e IoT
- Coordinamento

(Erman, Hoesel, Havinga, & Wu, 2008)



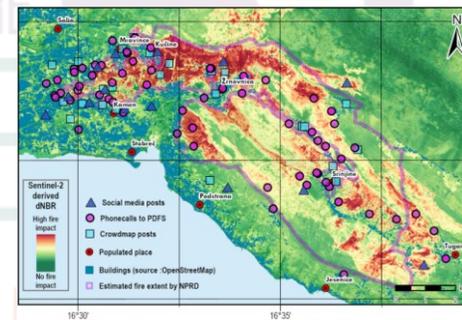
Crowdsourcing

- + Piattaforme online
- + Contributi *attivi*
- + Aggiornamenti in tempo reale dalla popolazione colpita
- + Migliore comunicazione e coordinamento
- + Sensibilizzazione, preparazione e recupero
- + Identificazione aree vulnerabili e supporto alle decisioni
- Dati non strutturati e disorganizzati

(Poblet, García-Cuesta, & Casanovas, 2018)

(Yu, Yang, & Li, 2018)

Figure 1. The role of crowdsourcing and social media in crisis mapping: a case study of a wildfire reaching Croatian City of Split



Social Media

- + Contributi *passivi*
- + Supporto in tempo reale in tutte le fasi del disastro
- + Dati testuali, immagini, video su aree colpite
- + Geolocalizzazione in tempo reale
- + Ampia copertura
- + Diffusione di allerte
- Attendibilità, accuratezza
- Utenti anonimi

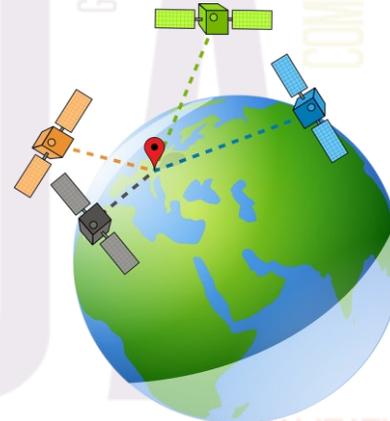
(Poblet, García-Cuesta, & Casanovas, 2018)

(Yu, Yang, & Li, 2018)



GPS

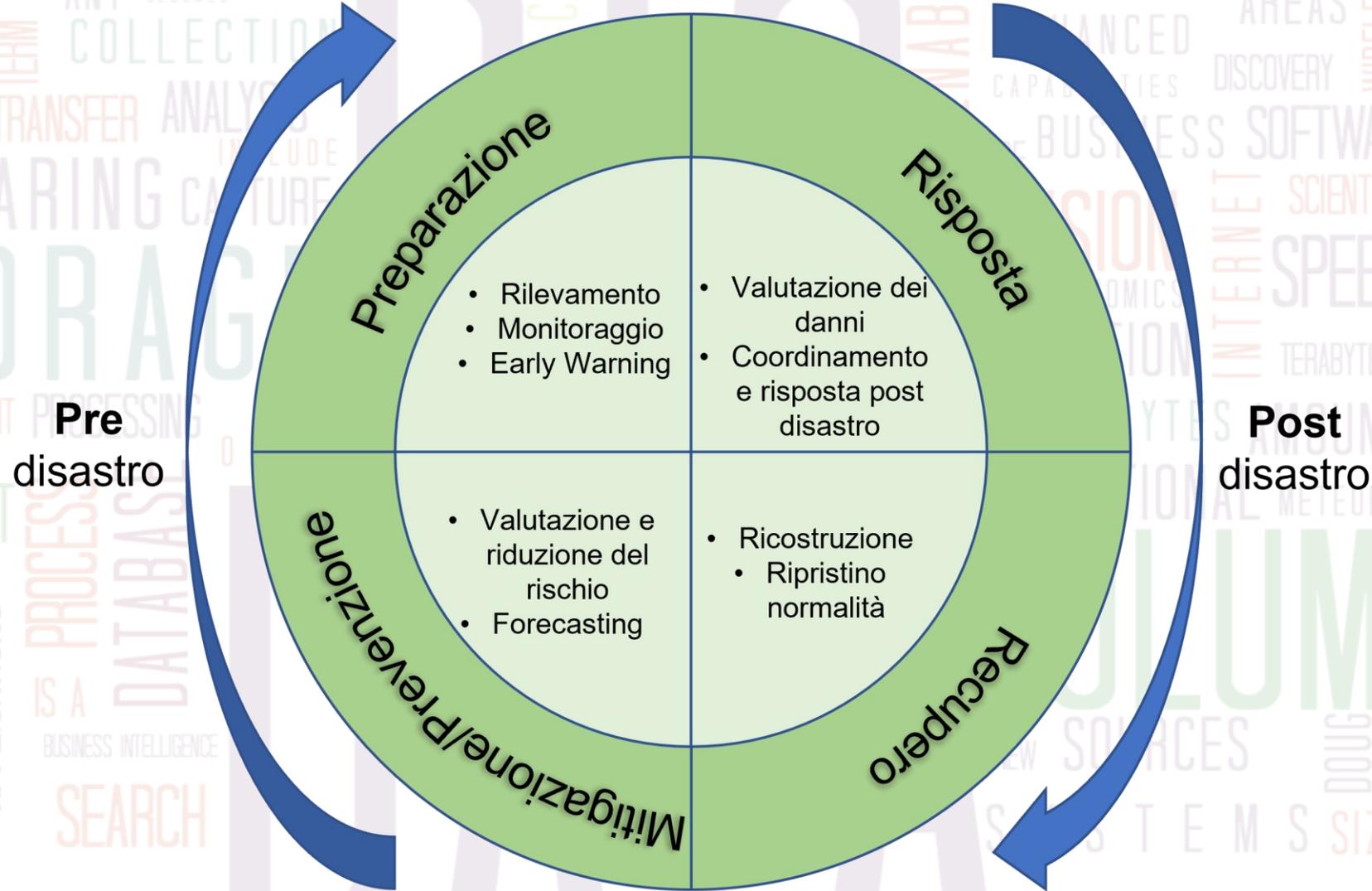
- + Tracciare posizione popolazione colpita
- + Localizzazione, altitudini
- + Andamento evacuazioni



CDR: Call Data Records

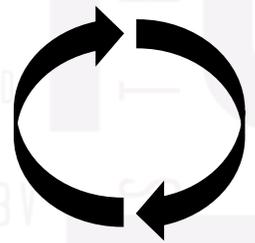
- + Dati in tempo reale dai servizi di telecomunicazione
- + Dati su comunicazioni effettuate con identificazione di mittente e destinatario
- + Stimare densità popolazione di un'area e quella colpita;
- + Calcolare esposizione ai rischi
- + Costi marginali
- + Ampia copertura

3. Utilizzo dei Big Data nei disastri per la resilienza



Mitigazione/Prevenzione	
Valutazione e riduzione del rischio	Forecasting
Satelliti Crowdsourcing Disastri naturali in genere Sensor web, IoT Terremoti Social media Oil spill GPS e CDR Alluvioni	Satelliti Sensor web, IoT Uragani Social media Alluvioni

Preparazione	
Rilevamento Monitoraggio	Early Warning
Social media Sensor Web, IoT Incendi Satelliti Alluvioni Integrazione dati vari Terremoti LiDAR Frane GPS, CDR Eruzioni Vulcaniche Crowdsourcing	Social Media Sensor web, IoT Alluvioni Crowdsourcing Tsunami Satelliti



Recupero	
Ricostruzione e Ripristino	
Integrazione dati vari Crowdsourcing Satelliti	Terremoti Uragani Tornado

Risposta	
Valutazione dei danni	Coordinamento e risposta post disastro
Satelliti Terremoti UAV Alluvioni Social media Tornado Sensor web, IoT Uragani Crowdsourcing	Social media Satelliti Sensor web, IoT Disastri naturali in genere Crowdsourcing Alluvioni UAV LiDAR Terremoti GPS, CDR Integrazione dati

4. Criticità

➤ **Raccolta, Privacy, attendibilità**

Volume, varietà e velocità: Analisi in tempo reale;

Veridicità: Filtrazione;

Privacy: specifici protocolli.

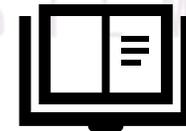
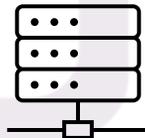
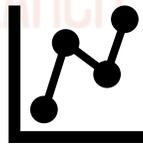
➤ **Big Data Analytics**

Integrare dati da crowdsourcing e da sensori fisici e caratterizzare rischi e disastri → resilienza della comunità.

➤ **Infrastrutture adeguate**

Condivisione veloce e visualizzazione, piani di emergenza, supporto operatori. Piattaforme di comunicazione efficienti.

➤ **Esperti**



5. Strategie

➤ Selezione tecnologia in base a costi/efficienza

➤ Social media

➤ Collaborazioni enti pubblici-enti privati

➤ Strategie e tecnologie sito-specifiche

➤ Programmi di sensibilizzazione

➤ Supporto legale per l'utilizzo dei Big Data e regolamentazioni sulla privacy

➤ Esperti, budget, tempi, decisi a priori nel piano di gestione dei disastri

6. Conclusioni

Resilienza delle comunità → punto di partenza per un futuro sostenibile

La presente tesi ha mostrato come l'impiego dei Big Data sia fondamentale per gli operatori nelle fasi del ciclo del disastro:

- Supporto nella previsione e mitigazione per minimizzare gli impatti
- Riduzione vulnerabilità
- Aumento resilienza delle comunità
- Evitare che una situazioni di crisi evolva in emergenza (The Resilient City, 2012)
- Contributo nella gestione dell'emergenza
- Rapido ripristino delle condizioni pre disastro

Improving Resilience to Emergencies through Advanced Cyber Technologies



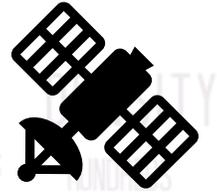
<https://linksfoundation.com/for/i-react/>

- Piattaforma che integra dati da satelliti, servizi meteorologici e climatici, da cittadini con i social media e crowdsourcing e consente il loro coinvolgimento nelle attività di Protezione Civile (Unione, s.d.).
- Calcolare rischi a livello europeo
- Applicazione mobile per segnalazioni dai cittadini
- Condivisione di allerte

Riassunto

Il continuo aumento dei cambiamenti globali, tra cui quelli climatici, provoca un incremento in termini di frequenza e intensità delle catastrofi. Ciò richiede nuovi approcci e strategie per minimizzare gli impatti e ripristinare la normalità nel più breve tempo possibile: fattore chiave è la **Resilienza** delle comunità. L'accesso ad una vasta gamma di risorse, soprattutto di tipo tecnologico, fa sì che una situazione di crisi non si trasformi in un'emergenza. La Global Facility for Disaster Reduction and Recovery (GFDRR), ha dimostrato come l'accesso a **Big Data** chiari sui rischi da parte di comunità e governi, sia essenziale per rafforzare la resilienza. I **Data** sono importanti sia per caratterizzare pericoli, esposizione e vulnerabilità nelle aree geografiche sia per valutare l'efficacia delle misure di riduzione dei rischi e di adattamento (Zuccaro, Leone, & Martucci, 2020). Gli sviluppi tecnologici e scientifici hanno migliorato le capacità di condivisione e analisi di dati per comprendere e prevedere come i sistemi naturali rispondono agli impatti antropici e relativi pericoli.

Questa tesi presenta una revisione della letteratura scientifica riguardo l'utilizzo dei Big Data estratti da una vasta gamma di fonti (*satelliti, GIS, LiDAR, UAV o Unnamed air Vehicles, Wireless Sensor Web & Internet of Things, Crowdsourcing e social media, GPS e CDR*) nella gestione dei disastri con l'obiettivo di rendere le comunità resilienti, mitigare i rischi e gli impatti che tali fenomeni hanno sulle vulnerabilità socioeconomiche, per un futuro sostenibile. Vengono analizzati inoltre i principali punti critici nel coinvolgimento dei Big Data nel campo dei disastri e strategie per un loro utilizzo ottimale.



Bibliografia

- Bello, O. M., & Aina, Y. A. (2014). Satellite Remote Sensing as a Tool in Disaster Management and Sustainable Development: Towards a Synergistic Approach. *Procedia - Social and Behavioral Sciences*, 120, 365-373. doi:<https://doi.org/10.1016/j.sbspro.2014.02.114>.
- Correia, H. R., da Costa Rubim, I., Dias, A., França, J., & Borges, M. (2020). Drones to the Rescue: A Support Solution for Emergency Response.
- Erman, A. T., Hoesel, L. v., Havinga, P., & Wu, J. (2008). Enabling mobility in heterogeneous wireless sensor networks cooperating with UAVs for mission-critical management. *IEEE Wireless Communications*, 15(6), 38-46. doi:10.1109/MWC.2008.4749746
- Greene, T., & Peter, J. (2021). 2020 Tied for Warmest Year on Record, NASA Analysis Shows. NASA. Tratto da <https://www.nasa.gov/press-release/2020-tied-for-warmest-year-on-record-nasa-analysis-shows>
- Poblet, M., García-Cuesta, E., & Casanovas, P. (2018, 12 01). Crowdsourcing roles, methods and tools for data-intensive disaster management. *Information Systems Frontiers*, 20. doi:10.1007/s10796-017-9734-6
- Sarker, M. N., Peng, Y., Yiran, C., & Shouse, R. C. (2020). Disaster resilience through big data: Way to environmental sustainability. *International Journal of Disaster Risk Reduction*, 51. doi:<https://doi.org/10.1016/j.ijdr.2020.101769>.
- The Resilient City. (2012, August). *TeMA Journal of Land Use Mobility and Environment* 2, 5(2). doi:10.6092/1970-9870/946
- Tommasi, E. (2020, Maggio 19). *LIDAR: cos'è, come funziona e a cosa serve la tecnologia*. Tratto da Internet4things: <https://www.internet4things.it/iot-library/lidar-cos-come-funziona-e-a-cosa-serve/>
- UNDRR, & CRED. (s.d.). *Human Cost of disasters: an overview of the last 20 years 2000-2019*.
- Unione, e. (s.d.). *Improving Resilience to Emergencies through Advanced Cyber Technologies*. Tratto da <https://cordis.europa.eu/article/id/247441-crowdsourcing-emergency-management-services/it>
- UNISDR. (2009). UNISDR Terminology on Disaster Risk Reduction.
- Yu, M., Yang, C., & Li, Y. (2018). Big Data in Natural Disaster Management: A Review. *Geosciences*, 8(5), 165. doi:10.3390/geosciences8050165
- Zuccaro, G., Leone, M., & Martucci, C. (2020). Future research and innovation priorities in the field of natural hazards, disaster risk reduction, disaster risk management and climate change adaptation: a shared vision from the ESPREsSO project. *International Journal of Disaster Risk Reduction*, 51(101783). doi:<https://doi.org/10.1016/j.ijdr.2020.101783>