SOCIAL MEDIA SENSING FOR FOREST WILDFIRES - A CASE STUDY FROM GREECE

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ABSTRACT

Climate change intensifies wildfire risk and impact, leading to more frequent and extreme events that profoundly affect the environment, society, economy, and vital ecosystem services. Wildfires have both consequences, such as loss of life, pollution, and damage, and beneficial effects, including organic material clearance, improved soil fertility, and eradication of invasive species. Technological advancements and mobile devices have proven invaluable for disaster readiness, prevention, and response, with successful real-life applications of social media and sensing tools in emergency management. In this paper, a social media sensing tool is presented that consists of a Social Media Analysis Toolkit, that includes fire event detection and visual analytics, enabling the collection, analysis, and visualization of fire-related tweets. The effectiveness and usability of the tool were tested for the pilot area of Evia in Greece. The social media sensing tool collected fire-related tweets the summer of 2021, analyzed them and filtered them in order to provide an enhanced situational awareness tool the massive wildfire incident that occurred in August 2021. The results illustrate a significant increase in Twitter activity during the wildfire period, demonstrating the tool's effectiveness in monitoring and analyzing social media data for wildfire detection.

Keywords: wildfires, social media, Twitter, fire event detection

1. INTRODUCTION

Climate change has been a major factor in increasing the risk and impact of wildfires, through more frequent and extreme wildfire phenomena, with far-reaching implications for the environment, society, and economy, as well as for essential ecosystem services provided by forests. The paradox of wildfires recognizes that wildfire impacts can be both damaging and beneficial. Negative impacts, indicatively, include loss of human lives and animals, pollution, loss of biodiversity, damage to human assets, soil erosion, and social impacts. The costs resulting from these impacts are substantial. Under circumstances, beneficial impacts exist (e.g., clearing out of the organic materials, increasing soil fertility, clearing out of invasive species). The negative impacts highlight the importance of effective wildfire preparedness and prevention, detection and response, restoration, and adaptation. Technology and the use of mobile devices in our daily lives have been proved as a valuable tool towards preparedness, prevention and response against disasters. There are several real-life cases where social media and social media sensing

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tools have been used effectively for emergency response. Some indicative examples include emergency events from the past and social media platforms: Boston Marathon Bombing (2013), Nepal Earthquake (2015), Hurricane Harvey (2017), California Wildfires (2017 and 2018), COVID-19 Pandemic (2019-2021), Ushahidi platform , Twitter's Lifeline project in Japan. Numerous scientific studies have been conducted, focusing on the utilization of social media sensing tools to address emergency situations such as fires and floods [1]. For instance, in [2], the authors analyze the use of Twitter during emergency situations, while another study [3] provide a concrete case study of how social media was used for crisis communication during the Zika virus outbreak and an additional work [4] define a methodology supported by a tool-flow, which combines machine learning techniques for identifying informative tweets, in conjunction with a semi-automated mechanism of dispatching information to first responders in [5] found that social media could be used as a human-centric sensor network for early wildfire detection. Moreover, social media sensing could support the coordination of first responders, the efficient allocation of resources and to create situational awareness. Social media can support the provision of real-time information, locate people in danger and monitor the public sediment. On the other hand, the use of social media sensing tools in emergency situations presents limitations and potential ethical implications, including privacy issues, the need to confirm information, and the associated risk of being misled by misinformation [6]. In this light, and in comparison to previous efforts and studies, our work presents the following advantages and distinctive characteristics: a) it focuses on the needs of first responders in cases of wildfires; b) it is co-designed together with the end-users and practitioners, following a user-centered approach; c) it considers privacy and misinformation risks; and d) it is implemented as an interoperable service integrated into an open framework for wildfire prevention and response.

2. **METHODOLOGY**

The development of the SILVANUS social media sensing tool has been based on a concrete co-design methodology. The initial step involved identifying key stakeholders, including wildfire first responders, forestry departments, social media experts, residents living in wildfire-prone areas. The next step involved defining the requirements of the social media sensing tool to identify specific needs for wildfire scenarios. In this process, it was determined the key data to extract from social media, such as locations of interest, preferred platforms, search criteria, interval for fire event detection, and approaches to handle misinformation and noise. A prototype was developed and tested using simulated wildfire scenarios, with feedback received from first responders and stakeholders regarding its effectiveness and usability.

2.1. **Social media sensing tool**

The social media framework consists of the following modules: a) a Twitter Crawler that collects tweets based on user defined search criteria (keywords, phrases, accounts); b) a Social Media Analysis Toolkit where the visual and textual content of tweets are analyzed; c) a fire event detection module that filters and clusters the tweets that refer to the same incident with the aim of creating a condensed report for fire incident; and d) a visualization dashboard where the fire events are visualized in graphic user interface. Figure 1 depicts the social media sensing framework. Twitter Crawler is module that retrieves tweets in almost real time by performing complex queries to the filter stream endpoint. It captures tweets that include keywords or phrases that indicate fire incidents (e.g., forest fires, wildfire emergency) or tweets that are posted from official Twitter accounts associated with fire news (e.g., @WildFires, @pyrosvestiki). The focus is on tweets in English, Italian, Greek, Indonesian and French.

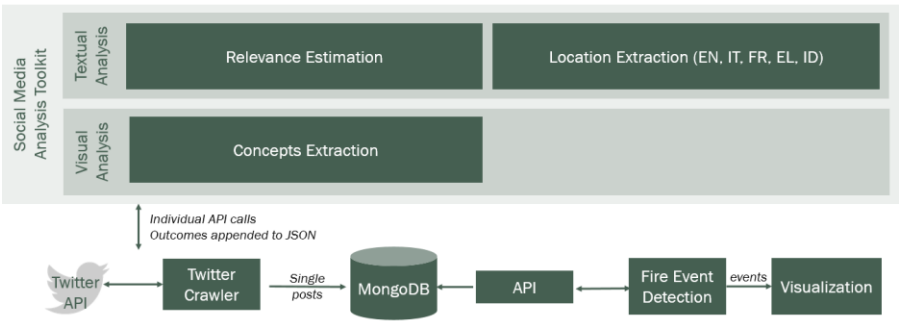


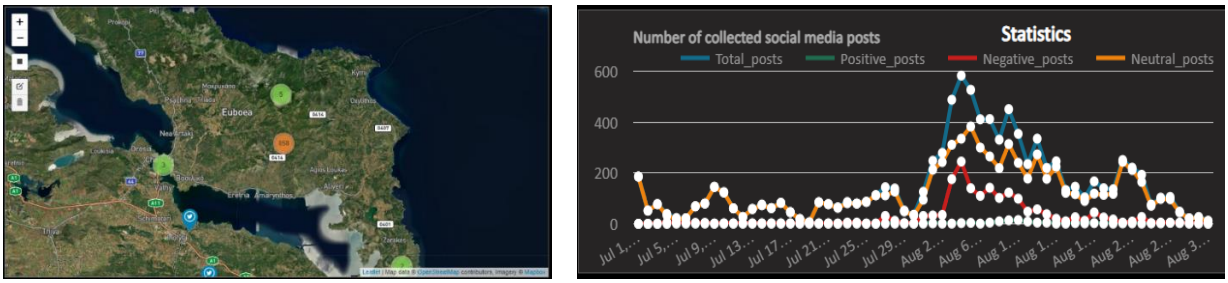
Figure 1: Social media sensing framework.

Collected tweets are sent to the Social Media Analysis Toolkit which consists of several modules using textual and visual analysis to extract higher-level knowledge. Specifically, the Relevance Estimation module analyzes tweet text to determine its relevance to fire incidents using natural language processing and machine learning. The Location Extraction module utilizes a Bidirectional Long Short-Term Memory (biLSTM) network [7] for Named Entity Recognition, identifying locations mentioned in the tweet. These recognized locations are then georeferenced using the OpenStreetMap API. Finally, a visual concept extraction module extracts meaningful visual concepts from images. The analyzed tweets are stored in a database and processed by the Fire Event Detection module. This module has two stages: filtering and grouping. The filtering stage selects only fire-related tweets based on relevance estimation results. The grouping stage groups tweets referring to the same incident using location information. Then, a concise report called a fire event is generated, providing condensed information about the specific fire incident. Finally, the fire events are displayed as pop-ups on a map (Figure 2a) in a user interface. Each event is represented by a pin, showing its location. Clicking on a pin reveals a panel with event details, including location name, coordinates, timestamp, a short description from tweets, event type, most frequent visual concepts as tags from tweet images, and tweet content (i.e., image, text, timestamp).

3. USE OF SOCIAL MEDIA SENSING TOOL BY INVOLVED STAKEHOLDERS

The primary goal of the social media sensing tool in SILVANUS is to create a framework based on crowdsourcing technologies for detecting wildfires early and reliably, by understanding concise text and photographs. The outputs aim to provide a reliable estimation of the fire ignition location, fire severity and indirectly the fire spread through updated information. By accurately identifying the location of the fire in relation to the available resources, firefighting forces can make informed decisions on resource allocation. They can quickly assess the proximity of firefighting teams, equipment, and water sources to the affected area. This allows for a more effective response, the decision on evacuation of nearby locations and the fire severity. The social sensing algorithm will be demonstrated and tested in Evia island, in discussion-based exercise and a field demonstration. In a first testing of the algorithm the objective was to identify the mega wildfire that occured in Evia from August 3rd to 8th based on Twitter data. The tool gathered fire related tweets for the summer of 2021 in Greek and English. The retrieved tweets analyzed in order to extract the locations of the tweets and their relevance to fires. Afterwards, the tweets are filtered to include only those relevant to fires and which location are close to Evia from July 1st until August 30. Then, a chart was created showing the tweets per date (Figure 2b). The chart indicates a notable increase in activity between 1st and 15th of August, aligning with a prolonged period of intense heatwave and dry weather in Greece. However, when specifically focusing on the Evia wildfire, it is evident

that the peak of tweets corresponds to the day and the following one of the fire start (August 5th and 6th) and the tweet activity remains notably higher throughout the duration of the Evia wildfire.



(**a**) (**b**)

Figure 2: Visualization of social media posts in a Dashboard and a line chart for the region of Evia for a period of two months (July-August 2021): (a) Social media posts visualization in Dashboard; (b) Tweets per date in a line chart.

4. CONCLUSIONS and FUTURE STEPS

This work presents the Social Media Analysis Toolkit that aims at helping the involved stakeholders in case of a wildfire in terms of providing real-time and accurate information for making crucial decisions. The toolkit is presently undergoing testing to validate and enhance its functionality, with upcoming exercises expected to generate new requirements. Moving forward, stakeholders will be trained to understand how to use it, interpret its data, and know what to do if they encounter issues. The performance of the tool and its added value will be assessed with user surveys, interviews, and analysis of incident reports. Part of the process will also involve informing and educating the public on how to share useful information during wildfires and how to avoid spreading misinformation.

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