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A Process Evaluation of Intelligence Gathering Using Social Media for Emergency Management Organizations in California

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A Process Evaluation of Intelligence Gathering Using Social Media for Emergency Management Organizations in California

by

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BACKGROUND

The Problem

When responding to an emergency, correct and timely information is often the difference between a successful response and a potential disaster. The information that emergency managers in California receive from the public often dictates how agencies respond to emergencies. The emergence of social media has presented several benefits to emergency managers regarding intelligence gathering during the emergency response process. Simultaneously, the emergence of social media has raised several concerns for the stakeholders involved. One major issue involves inaccurate information circulating on social media platforms during ongoing disasters. If emergency managers cannot discern incorrect information from correct information, disaster response may be less effective. Rumors and misinformation tend to circulate before, during, and after emergencies. Although incorrect information circulating on social media cannot be stopped in totality, emergency managers can use cutting-edge technology and strategies to discern and counteract false information. New technologies and intelligence gathering tools can be used as a source of intelligence to relay lifesaving information to the public. Past negative examples of inaccurate information on social media influencing stakeholder decision-making raise the focus of this research: How can emergency management agencies in California leverage the flow of valid information on social media during crisis conditions?

Role of Emergency Management Agencies

Since disasters always occur at the local level, local governments and agencies are typically the first to respond in an emergency. Local emergency management agencies are responsible for providing support to communities through disaster response, recovery, and mitigation (FEMA training, 2014). In addition, emergency management agencies supply first responders, such as fire officials, law enforcement, and medical personnel, with critical

information during disasters. Emergency management agencies also help facilitate and coordinate resources for local and state agencies, providing the public with supplies and relief during disasters (City of San Jose, n.d.). In California, emergency management offices are at the city, county, regional and state levels of government (CalOES, n.d.).

When responding to an emergency, local emergency management offices in the geographic or political area of the emergency will first activate what is known as an Emergency Operations Center (EOC) using the emergency operations plan (EOP). The EOP will act as a standard operating procedure. Emergency management agencies will then coordinate response plans with public and private organizations (City of San Jose, n.d.). Emergency management agencies are responsible for regularly submitting situation reports to the operational area for consolidation into a region and state report. Depending on the nature of the emergency that an emergency management office is responding to, it may need to request mutual aid through the state's mutual aid system (CalOES, n.d.). For larger-scale disasters, emergency management agencies may declare a local emergency, request the governor to declare a state of emergency, and ask the governor to request a Presidential State of Emergency or Presidential Major Disaster Declaration. (FEMA, 2014). In the case of large-scale disasters in which local agencies require assistance, the California Office of Emergency Services may coordinate assistance to local agencies from state resources. On the national level, the Federal Emergency Management Agency coordinates assistance from federal resources through the Emergency Support Functions (FEMA, 2021a) and provides various forms of financial assistance under the Stafford Act (FEMA, 2021b).

Approaches to Disaster Management

Emergency management agencies may take several approaches when addressing an emergency or disaster. The traditional approach, also known as the command-and-control

approach, involves a strict set of objectives, policies, and a strongly defined division of roles. This top-down approach is a military-style format of operation mandated for use in California by Government Code 8607 (CSTI, n.d.). The professional approach to emergency management involves a decentralized structure in which organizations collaborate to mitigate the effects of a disaster. In the professional approach structure, public participation in disaster relief is encouraged as opposed to the traditional approach. In addition, a professional approach to disaster relief incorporates a "whole community approach" (FEMA, 2014).

Steps in Disaster Management

Researchers of disaster communications have identified four aspects of an event that are all present in a disaster. The first aspect of a disaster is the length of a forewarning. In some disasters, such as a hurricane, emergency management agencies have time to plan for a specific event, while in others, such as an earthquake, there is little to no time to plan. The second aspect is the magnitude of the impact. This aspect involves the event's severity of potential damage to life, property, and security. The next aspect of a disaster involves the geographic scope of the event. The geographic scope pertains to the physical location of the event and whether the event is contained or has the potential to spread. Lastly, researchers are concerned with the impact duration of the event. This aspect of a disaster involves the length of time a disaster takes place (FEMA, n.d.).

The first step in disaster management involves efforts to mitigate any vulnerabilities in a disaster that might cause injuries or property damage. The next step is preparedness, which focuses on educating the public about responding to a potential disaster. This step involves pre-disaster strategic planning. Next, disaster response addresses the immediate threats prevalent during a disaster. This step is the most time-sensitive in the disaster management process. Finally, the recovery process is the last phase in disaster response and focuses on restoring all

aspects of a disaster's impact. The situation has become stable at the point of recovery, and the response effort has concluded. Comprehensive response and recovery plans require response systems that focus on situational awareness, timely information dissemination, coordination, and real-time decision-making (FEMA, n.d.).

Methods of Communication During a Disaster:

Emergency management organizations disseminate information to the public during emergencies through several outlets. Traditionally, messages and critical information are communicated through in-person interaction, print media, broadcast media, and the internet. However, with the rise in popularity of social media platforms, such as Twitter, Facebook, Snapchat, NextDoor.com, and Instagram, emergency managers have found a helpful mechanism to communicate with the public during emergencies. Each of these different communication tools offers benefits and limitations (FEMA, 2014).

In-person communication in a disaster presents several benefits to stakeholders and several drawbacks. One advantage of in-person interaction during emergencies is that it allows the public and emergency managers to communicate directly, which allows emergency managers to target specific populations of stakeholders and limits the amount of inaccurate information that may occur in the chaos of an emergency. However, in-person communication during emergencies is limited by the ability of the emergency personnel to reach the public safely and effectively. In addition, environmental factors may prevent or limit the number of information stakeholders who can communicate. In-person communication is also limited to those who have access to emergency managers during emergency circumstances (FEMA, 2014).

Another traditional form of communication during emergencies is print media. Print media is a valuable tool in that it can be vetted for accuracy and detail. As a result, print media can help provide more detail and critical analysis regarding emergency events. However, due to

the nature of print media, this communication tool is most effective before and post-emergency, as opposed to during a rapidly developing incident. Newspapers and magazines help educate the public about disaster preparedness but are not viable communication tools in situations where time is critical (FEMA, 2014).

During an ongoing disaster, one of the most important forms of traditional media is broadcast media, primarily television and radio. Television and radio are used to communicate up-to-date information promptly to a broad audience. Many organizations send alerts through broadcast media using an emergency alert system, public service announcements, and traditional news stations. Due to the ability to send out messages quickly and accurately, broadcast media is often the preferred method of communication by emergency managers when interacting with the public during an ongoing disaster. One limitation to broadcast media is that the potential receiver must have a television or radio available during an ongoing disaster. Unfortunately, access to television or radio is not always the case during an ongoing disaster, which limits the benefit of broadcast media as an effective communication platform. Like many other traditional forms of crisis communication, broadcast media is primarily a one-way communication tool between emergency managers and the public, which means that the public cannot easily access the parties responsible for sending out mass alerts. Even though traditional broadcasting is more accurate than other emergency communication tools, it is still subject to filtering or editing based on time availability. As a result, broadcast media does not always offer emergency managers immediate information as events unfold (FEMA, 2014).

The internet and social media have emerged as a tool for emergency managers during disasters. Social media allows emergency managers to receive, update, and send out information quickly and effectively. Social media platforms can be used to communicate with the public

directly and for all stakeholders to share information. Information may come in photographs, audio, video, and live stream. Video and live streams present advantages to emergency managers, as they allow emergency managers to view what conditions are like in real-time. With wireless data on cell phones, social media as a form of information sharing during a disaster has become increasingly important. Even though a television, radio, or Wi-Fi connection may not be available during an emergency, stakeholders using wireless data often can still access critical information through their devices (FEMA, 2014). The main concern regarding stakeholders using social media during disasters is that once a member of the public pushes out information, the message is tough to control (Civelek, Cemberci, & Eralp, 2016). If a message is wrong or inaccurate and reaches a large segment of the public, if not adequately verified, or quicky corrected, the inaccurate message could have disastrous consequences.

Intelligence Gathering Methods Used by Emergency Managers

One challenge for emergency managers regarding collecting information during an emergency is that emergency management agencies need to stay up to date regarding what websites and social media applications are popular with the public. Staying up to date allows emergency managers to gather the critical information that may help during a disaster more effectively. Members of the public provide information to emergency managers by geotagging locations, leaving time stamps, mentioning keywords or phrases on posts, and creating hashtags (Bennett & Sharpe, 2014). Social media allows members of the public to generate potential lifesaving information, such as what areas to avoid, building damage, or road closures (FEMA, 2014). Geotagging enables emergency managers to pinpoint the exact location of disasters, such as fires, tornados, hurricanes, and mass shootings (Bennett & Sharpe, 2014). Data scraping, also known as data mining, is a helpful technique for emergency managers to use for gathering data, creating crisis maps, and people counting (Zheng, Shen, Tang, Li, Luis, & Chen, 2011).

Emergency managers can gather data through various social media websites using data scraping. Data scraping is the practice of analyzing large databases to generate new information. Emergency managers receive information posted on social media platforms and then look for anomalies, patterns, and correlations. The first step in data mining for emergency management purposes is to collect raw data from social media platforms. This raw data is collected using algorithms that identify vital information that may be relevant to the emergency manager. During a disaster, raw data is generated in large quantities due to the public's attention on social media events. The next step in data scraping is data selection. Data selection is determining what raw data is relevant or valuable and what raw data is useless. The selected data then becomes target data once chosen by the emergency manager. The target data is then processed to determine whether the data is accurate or credible. Finally, target data is compared with other data or information collected on social media to determine if it is an outlier or if any information is available to support the target data. Emergency managers can then use this information to determine how to respond to a given event and send out large-scale public warnings. When data scraping, the challenge that arises for emergency managers involves deciphering what information coming in from social media is accurate and what information is inaccurate (Zheng et al., 2011).

Disinformation on Social Media

During an ongoing disaster, misinformation on social media is spread primarily due to four underlying causes: intentionally and unintentionally inaccurate information, insufficient information, opportunistic disinformation, and outdated information. Inaccurate information is often caused when valid information is challenging to confirm. During a disaster, inaccurate information may start as a rumor before being posted to social media. These posts then have the potential to go viral, causing many problems for emergency managers. Incorrect information can

also be circulated on social media by individuals or groups who wish to create chaos and confusion during an emergency scenario (Department of Homeland Security, n.p.).

Another cause of rumors spreading on social media stems from insufficient information being made available by emergency managers to targeted populations. Insufficient information is often due to limited information available to emergency managers through intelligence sources. In such situations, the public may search for unverified information through non-official communication outlets, such as what strangers post online. Additionally, opportunistic disinformation occurs when individuals or groups use social media to capitalize on a particular situation during a disaster. Opportunistic disinformation is often motivated by financial, political, or malicious incentives. The final underlying cause of misinformation stems from the public relying on outdated information. Outdated information often spreads when individuals quickly seek to communicate information over social media during an ongoing disaster. An individual discovers information that may have been true at one point but is no longer accurate and then shares that information with a group of people. Individuals who spread outdated information on social media often have good intentions. However, the spread of outdated information has the potential to go viral and cause harm during an ongoing disaster (Department of Homeland Security, n.p.).

The Usefulness of Social Media for Emergency Management

A potential benefit of leveraging social media during emergency response involves disaster detection, since members of the public have access to critical information much faster than traditional news outlets. Social media also may help emergency management organizations monitor public reaction. Monitoring public reaction could help determine in which areas a response effort may be efficient and in which areas the public may see it as inadequate. Sentiment analysis could be used to understand public opinion better. Social media may be able

to help in identifying eyewitnesses to a particular event. Eyewitnesses often have the most credible information and play a vital role in all phases of the disaster relief effort (Luna & Pennock, 2018).

Situational awareness is also key to handling a crisis and is one way in which social media may be able to help the stakeholders involved. Validated social media information may provide a high-level overview of a situation. Two-way communication allows for authorities to communicate with the public and vice versa. Communication through social media can aid in rescuing members of the public who are in danger and most vulnerable. Geotagging presents a unique opportunity for detecting missing, found, and displaced members of the public (Imran, Ofli, Caragea, & Torralba, 2020). Creating crisis maps using information from social media websites can help the public and emergency managers visualize and stay up to date on new developments regarding a disaster. Emergency management organizations can also post important information and timely social media alerts. Social media can aid damage assessment through text analysis and examining photo and video footage (Luna & Pennock, 2018).

Laws, Limits and Constraints of Data Scraping

When gathering social media as a source of intelligence in disaster response, emergency managers also must consider rules and regulations. These considerations include data protection rights, human rights, copyright laws, licensing restrictions, and other legal constraints. Emergency managers must be cautious of using sensitive data when collecting, storing, processing, or posting on social media. Emergency managers must also be cautious of data minimization and only use the minimum amount of data needed for a specified purpose. Data collected through open-source data scraping for disaster response should only be used during a disaster. When using data from social media, emergency managers need to consider intellectual property rights and any information that may be protected by copyright. Additionally, public

policy regarding the regulation of access to social media is still a relatively new phenomenon (Berger, De Stefani, & Oriola, 2016).

Treating a privately controlled service as part of public emergency response presents several considerations and concerns that should be further explored. One limitation is that each social media website allows for different levels of data availability. An example would be that Facebook provides limited access to data and closely controls data collection through its terms and agreements. In contrast, Twitter allows publicly available tweets to be accessed freely. Finally, the problem with implementing new techniques in data scraping by emergency managers involves liability. Many of the techniques involving data scraping described in academic literature have been experimental and have not been applied to active emergency events. Therefore, before implementing a new procedure in an emergency management organization, the proper liability concerns must first be addressed (Berger et al., 2016).

LITERATURE REVIEW

Current Research on the use of Social Media for Disaster Response

Kelly (2014) examined the effectiveness of social media as a risk and crisis communication tool. This project developed a set of best practices that agencies could use to better leverage social media. He determined that, although social media is a helpful tool in crisis communication, traditional ways of disseminating information remained valuable to emergency managers. Kelly (2014) recommended that emergency managers use social media to engage with the community, which would enhance emergency managers' ability to serve the public.

Roshan, Warren, and Carr (2016) looked at how public organizations currently use social media for disaster communication. They found that many organizations did not use the total potential value of social media for disaster communication. They looked at 15,650 Facebook posts, as well as Twitter messages, and examined the content under the lens of Situational Crisis Communication Theory. Researchers found that organizations often did not respond to stakeholder messages or selected disaster response strategies that increased reputational risk. Researchers then provided six disaster response positions and taxonomy of social media disaster messages that stakeholders may send to organizations (Roshan et al., 2016).

Graham, Avery, and Park (2015) highlight the role of local government in crisis communications. More than 300 local government officials were surveyed in the United States in their study. Graham, et al (2015) found that social media use is positively associated with a government's ability to control a disaster. An additional case study by Bratchen, Mirbabaie, Stieglitz, Berger, Bludau, and Schrickel (2018) looked at social bots and their influence during disaster events. Researchers initially looked at the Manchester bombing in 2017. Results suggested that mainly benign bots are active during disaster situations, and while the quantity of bots is relatively low, their tweet activity indicates high influence (Bratchen et al., 2018). One

additional case study by Wang, Wang, Ye, Zhu, and Lee (2015) examined how public organizations in China disseminated information through social media during the 2012 Beijing Rainstorm. The article presents tools, methods, and models to work with text streams from social media so that disaster management experts can better respond to emergency events (Wang et al., 2015).

Social Media Gone Wrong: South Napa Earthquake 2014

On August 24th, 2014, a 6.0 magnitude earthquake occurred near Napa, California, and much of the northern San Francisco Bay Area felt it. The earthquake prompted residents who lived in that area to post about the event nearly instantaneously on social media. Within minutes, two hashtags regarding the earthquake began circulating through social media, which were used by the public and emergency managers: #NapaQuake and #NapaEQ. Shortly after these two hashtags began gaining in popularity, "spammers" began using the hashtags to promote unrelated and often disturbing messages. During the initial days of the response phase, various individuals from non-official and private Twitter accounts began using the hashtags and posting images of disfigured bodies to bring attention to U.S. military misconduct. These tweets made it increasingly difficult for members of the public to receive up-to-date, accurate information from official government outlets. Social media monitors effectively mitigated much of this opportunistic disinformation by filtering out geolocated and geographic information discovered on the posts that did not seem to be related to the earthquake. In addition, much of the politically motivated content being posted using the hashtags came from outside of the United States (The Department of Homeland Security, n.p.).

Social Media Gone Wrong: Boston Marathon Attack 2013

On April 15th, 2013, two explosions occurred at the Boston Marathon in Boston, Massachusetts. After the attack occurred, news outlets around the country began reporting on the

incident. Additionally, the public began posting about the event on social media websites. Many of the posts contained information from inaccurate rumors. Some of these posts went viral, attracting the attention of large segments of the public. The news media began to pick up on the rumors circulating online and were able to debunk false and inaccurate claims. However, it took the mainstream media approximately two days before they could address the most popular claims being made online, including made-up stories, conspiracy theories, and other potentially harmful claims. Debunking websites examined some of the less popular claims, but these websites took even longer to release reports on what information was credible or inaccurate.

About one week after the Boston Marathon attack, the Twitter account of the Associated Press was hacked. The hackers released a tweet stating two explosions had occurred in the White House, and the President of the United States had been injured. This post spread throughout Twitter and other social media platforms. The initial panic caused by the event resulted in a brief crash in the stock market (Gupta, Lamba, Kumaraguru, 2013).

Social Media Gone Wrong: Oroville Dam Evacuation 2017

In February of 2017, more than 180,000 residents living downstream of the Oroville Dam in Northern California were ordered to evacuate immediately due to potential damage compromising the dam's emergency spillway. During the initial period in which the evacuation was ordered, a large amount of misinformation began to spread through social media. Before the evacuation announcement, the Sacramento Valley had been experiencing significant amounts of rainfall. During this time, the National Weather Service in Sacramento posted a photograph on Twitter that displayed the flooding area due to the rainfall. This image spanned the whole of Sacramento County, including the areas around the Oroville Dam. After the evacuation announcement had been issued, the image circulated on social media, leading some of the public to believe that all of Sacramento County was under an evacuation order. Members of the public

began calling Sacramento County 9-1-1 dispatch centers. The Sacramento County Emergency Operations Center issued a Facebook live video and a Periscope video to correct the inaccurate information that had been circulating through social media platforms. Working in conjunction with the Sacramento County Emergency Operations Center, local news sources began broadcasting messages from the live stream videos, which led to the end of the spread of misinformation (The Department of Homeland Security, n.p.).

Ultimately, misinformation spread due to the believability of the mis-constructed flood map. Due to the immediate nature of the evacuation warning, members of the public who needed time-sensitive information mistook the map as being accurate. By using the live stream technology provided through social media platforms, emergency managers could correct the misinformation. Emergency managers were then able to provide accurate information to the public by working with traditional media outlets. Traditional media outlets, which were viewed by the public as being more credible than social media sources, led to the containment of the misinformation.

Additionally, emergency managers can take advantage of the self-regulating aspect of social media. Once inaccurate information is corrected, it can spread as quickly as misinformation. When members of the public post inaccurate information, other members of the public with correct information are often quick to correct the inaccurate post (The Department of Homeland Security, n.p.).

Benefits of Social Media to Emergency Management

When used as a tool in conjunction with traditional information gathering, social media can have several benefits for emergency management agencies. One benefit is that social media can help to increase situational awareness during an emergency. To achieve situational awareness, emergency management agencies must obtain relevant data that would aid in

achieving a goal. Emergency managers then must verify that the data they collect accurately describes the unfolding events. The data should be comprehensive enough, allowing for connections to be made regarding the components of a disaster. The data should also facilitate decision-making and aid emergency management agencies in future situations. Social media helps to facilitate these goals through sharing images, videos, and conversations during all phases of a disaster (Luna & Pennock, 2018).

Social media also can aid emergency management agencies with information diffusion. The very nature of the internet and social media allows emergency managers to reach a broad audience exceptionally quickly. Using social media platforms such as Twitter, Facebook, and Instagram in conjunction with traditional media outlets allows emergency managers to reach large portions of the public. Social media allows for quick two-way communication between emergency management agencies and the public. In traditional media, such as news broadcasts, reporters often depend on members of the public calling a news station to provide updated information. Social media decreases the time it takes for emergency management agencies to receive information from the public and directly communicate with those at the most risk or who may provide valuable information. Social media also has the potential to aid stakeholders who are responding to events by providing communication. Communicating through social media allows agencies to get messages through to first responders or those involved in time-sensitive relief efforts. Social media can provide communication in situations in which stakeholders cannot hear phone calls due to explosions or general pandemonium. Social media can provide valuable updates to individuals who are stuck in critical situations and cannot communicate verbally. Social media can play a critical role for emergency management agencies to conduct needs assessments and damage assessments (Luna & Pennock, 2018).

Crisis Mapping Using Geoparsing

Crisis Mapping, a tool that has become increasingly popular in recent years, is a tool in which social media data is collected, analyzed, categorized, and displayed in a visual representation. Popular crisis mapping platforms include Ushahidi, Mapbox, CrisMap, Google Crisis Map, SensePlace2, ESRI, ArcGIS, Zonehaven, and Criscomms. Many of these systems allow members of the public to upload information in a participatory way but also can draw from information on social media. Crisis mapping can benefit all stakeholders involved in disaster response, including the public and emergency managers. Programs such as CrisMap extract potential crisis-related information from Twitter and classify the tweet based on word embedding and geoparsing. The selected tweets are then placed on a web-based dashboard to be visualized. These mapped visualizations can help estimate the impact of a disaster in all phases of disaster response. For example, crisis maps can help emergency managers determine which geographic locations are most impacted by a disaster and can help emergency managers in decision-making. Crisis mapping can also be used as a tool for the public by providing up-to-date information in real-time. Although crisis mapping tools allow for text to be visualized, they also allow for real-time video and photos to be shared. Most crisis mapping technologies that use geoparsing are most effective in densely populated areas. More information is generally shared through Twitter and other social media sites in geographically condensed, heavily populated regions. Since information on social media is more likely to be factual when posted by a more significant number of people, crisis mapping may be less effective in more rural areas in which information cannot be as quickly verified (Avvenuti, Cresci, Del Vigna, Fagni, & Tesconi, 2018).

Avvenuti et al. (2018) made several suggestions to improve Crisis Mapping. They suggested that using software that draws information from social media should include a damage detection component that exploits word embedding. A system should also include a classifier to

detect messages reporting damage to infrastructure and injuries. Avvenuti et al. (2018) stated that to maximize crisis mapping benefits, crisis mapping technology should include a geolocation component that performs geoparsing by using online knowledge-based tools such as Wikipedia (Avvenuti et al., 2018). These tools combined can help aid in creating an interactive web-based crisis map. One crisis mapping tool that is designed to be easily used by the public is known as SensePlace2. SensePlace2 is a web-based crisis map designed to support sense-making during a crisis, using information from Twitter. SensePlace2 incorporates time filters, a heat bar, and a range slide into the platform (Calderon, Arias-Hernandez, & Fisher, 2014).

Innovative use of Social Media: Hurricane Isaac of 2012:

In 2012 during Hurricane Isaac in New Orleans, Louisiana, government agencies actively monitored social media. Early news reports indicated that Florida would be in the hurricane's path during the same week as the Republican National Convention. Social media users began using various hashtags when posting messages regarding the hurricane during that time. These hashtags included #Isaac and #NOLA. Government agencies and emergency management agencies also began to use these same hashtags when issuing alerts and warnings to the public. Emergency management agencies worked extensively with the local news outlets, who also provided information to the public on what social media accounts to follow to get the latest information on closures, flooding, and damage. Emergency management agencies and city officials also used Twitter accounts to respond to members of the public and to correct misinformation that had been circulating the internet. FEMA used photos and videos posted by members of the public to respond to damages, including outages, flooding, and road closures. News outlets encouraged members of the public to use specific hashtags, which were used to coordinate messages to stakeholders (Kirby, 2019).

Innovative use of Social Media: Port-au-Prince Earthquake 2010

In 2010, a 7.0 magnitude earthquake devastated Port-au-Prince, Haiti. One technique used by emergency personnel when responding to the disaster effort involved crisis mapping. Following the earthquake, volunteers worldwide provided technical assistance to stakeholders by creating a crisis map. The map was created by using satellite imagery. An open-source interactive mapping solution known as Ushahidi Platform was used to geotag Twitter messages and other relevant content from multiple online resources. Users of the map could view where various posts were coming from and could zoom in on the area to view the satellite imagery. In addition, the map was available through smartphones and allowed users to view reports posted by stakeholders with knowledge of the situation. This tool provided valuable information during the recovery effort (Keim & Noji, 2011).

Innovative use of Social Media: Christchurch Earthquake 2011

In 2011, a 6.2 magnitude earthquake struck Christchurch, New Zealand. Stakeholders, including members of the public, created a crisis map based on the Ushahidi Platform to establish, aggregate, and display vital information. Information on the crisis map was drawn from geotagged emails, messages, and local web forums. In addition, Google person finder was established to collect and share information about members of the public who were missing. Within several days of the earthquake, thousands of records were uploaded and tracked. Agencies were then able to use Twitter to disseminate information regarding the earthquake and missing person information from information posted on the crisis map. (Ngo, Duc, Vu, & Ban, 2014).

The Benefit of a Rumor Detection Mechanism

According to Luna and Pennock (2018), the prominent challenge emergency management agencies face regarding social media is the spreading of inaccurate information. Stakeholder actions based on inaccurate or outdated information may lead to a domino effect of

counterproductive consequences. To combat this issue, implementing a rumor detection mechanism in a data scraping program is suggested to mitigate the effects of invalid information. An emergency management agency member may fully supervise a rumor detection system, or they may be semi-supervised. Rumor detection mechanisms use algorithms to sort through social media posts regarding a specific event and determine which posts are highly probable to be accurate and those that are most likely rumors. Rumor detection systems do not all operate using the same programmed methods, and certain systems may be more suited for specific types of disasters. All rumor detection systems search for patterns within online messages and examine the context in which the message was posted (Luna & Pennock, 2018).

Data Scraping Challenges for Emergency Managers

Although the technology that detects language patterns has been available for several years, the application of this technology to social media presents several challenges. Users of Micro-blogs, such as Twitter and other social media sites, tend to use shorthand language and slang terms that are more difficult for a computer program to decipher. Posts on social media also tend to have more grammatical errors than other media, since multiple sources do not check posts before they are pushed out. Additionally, in an emergency, grammatical errors and shorthand spelling, such as abbreviations, may be used more frequently by social media users than on an average post in a normal situation. Length restrictions regarding posts, such as those on Twitter, also influence users to post smaller, shorthand messages instead of highly detailed information (Imran, et al., 2020). One challenge unique to social media posts regarding disasters is the massive number of messages flooding social media websites. With so many users from various parts of the world posting about a topic, emergency managers have the challenge of attempting to decipher what messages might be helpful (Kiatpanont, Tanlamai, & Chongstivatana, 2016).

Machine Learning Versus Deep Learning Techniques

Both traditional machine learning and deep learning data scraping techniques are supervised learning techniques that require experts with professional knowledge. Each technique intends to extract information from social media posts with objective goals in mind. Machine learning involves trigger detection, event identification, and argument role identification. Trigger detection is when a computer program detects whether an event mentioned online exists, and what trigger words or phrases are currently used in the online text (Lazreg, 2016). Once the event has been identified, it can then be classified as one of several events. The texts identified by the system can then identify which entity, time, and values are arguments. Finally, the arguments' role in the overall events can be classified based on context (Gautam, Misra, Kumar, Misra, Aggarwal, & Shah, 2019).

Deep learning data scraping techniques use multiple layers of connected artificial neurons to create an artificial network. In these networks, the lowest layer can take raw data from social media, even if that data is simple, and use that data as an input. Each layer can then extract more information from the raw data until the highest layer can use the information as an event classification (Nguyen, Mannai, Joty, Sajjad, Imran, & Mitra, 2016).

Data Scraping Techniques and Vetting

Landwehr, Wei, Kowalchuck, and Carley (2016) reviewed the strengths and limitations of using a Twitter tracking and analysis system for disaster planning, warning, and response. Landwehr collected tweets regarding a tsunami warning in Padang, Indonesia. The study's goal was to examine how organizations could use a Twitter analysis system and data scraping tactics to better support an early warning tsunami alert system. The Twitter-based tsunami warning and response social media system tested in this study was tailored to a specific community and that community's unique needs. Landwehr, et al. (2016) suggested that, in contrast to traditional

Twitter tracking systems, which follow a workflow of collection, analysis, and presentation, a revised workflow may be the best approach for supporting disaster mitigation across all response phases.

Landwehr et al. (2016) suggested that a more encompassing workflow would include data collection, management, analysis, presentation, and integration. A Twitter tracking system would essentially allow data scraping for information in this model. The tweets would then be archived, analyzed, and then assessed. Finally, the tweets would be integrated into a more extensive disaster system (Landwehr, et al., 2016).

Landwehr et al. (2016) used the data scraping tool TweetTracker, which Arizona State University first developed in 2011. TweetTracker acts as a visual analytics tool explicitly made for disaster relief purposes. TweetTracker monitors and extracts locations, as well as keywords, from online sources. TweetTracker compares those same tweets with real-time trending information, historical data, and data scraping tools. TweetTracker includes filters that allow researchers and emergency managers to focus on tweets of interest and examine retweet graphs and heat maps. TweetTracker was first used by the organization known as Humanitarian Road during Hurricane Sandy in 2012 (Landwehr et al., 2016).

Researchers were able to modify the software based on information from a previous study in which trends were analyzed to determine how many area residents used Twitter. They found 90,776 tweets from tsunami-prone regions, collected using TweetTracker, and then placed in a "bounding box" which isolated the specific area. One issue with collecting tweets using a bounding box is that the software could not isolate a geographic area based on physical or political parameters. A bounding box could only be placed as a square or rectangle, and therefore several tweets collected were outside the geographic region of interest. Once placed into a

bounding box, the software removed many of the tweets that were not of interest by using keywords (Landwehr et al., 2016).

Once several tweets containing the keywords were collected, they were then stored as summary statistics. Data was saved as summary statistics primarily for ethical reasons regarding personal information storage. Data cleaning during this study phase was done using Python script and a Java Management program. During this phase, the search for information that may help in disaster mitigation was further vetted by isolating geotagged tweets. Isolating geotagged tweets containing keywords helped to sort out inaccurate tweets that may have been collected in the bounding box process. These tweets were then placed in a separate area from the rest of the data. To further mitigate tweets by individuals or bots that may contain inaccurate information, the study then removed tweets by users outside of a given latitude and longitude. Finally, since Twitter users can set their preferred time zone, the tweets were vetted by time zone to remove bots (Landwehr et al., 2016). During this phase of vetting, 38.24% of tweets that were removed were deemed to be irrelevant. Next, Twitter data was organized by "unpacking" retweets from an original Twitter post, as retweets are essentially duplicate information (Landwehr et al., 2016).

Once vetted, researchers then analyzed the collected data for several purposes. For example, in the case of a tsunami, citizens in Padang have approximately 20 minutes of advanced notice before a wave's arrival. During this phase, researchers looked at how they could use the information they obtained from Twitter to provide the public with helpful information and the names of users providing essential information. This information can then be used to post alerts, direct relief efforts, and help provide information to members of the public that may be at most risk. Collecting and analyzing Twitter data can also streamline future disaster relief efforts

by identifying which users are credible and who can disseminate messages to a large audience (Landwehr et al., 2016).

Geoparsing for Disaster Response

One issue addressed when emergency management organizations attempt to extract data from social media, particularly Twitter, is that most users do not have their location attached to their Twitter profile. An inability to identify location is essential, since location during an emergency event significantly predicts a tweet's relevance, importance, and accuracy. Although some users may elect to list a general location on their accounts, such as a country, state, or city, only small amounts of Twitter users have a coordinated location attached. A study conducted in 2017 by Brujin, Moel, Jongman, Wagemaker, and Aerts examined geoparsing as a solution to this issue. Geoparsing is the process of converting text descriptions of places into geographical identifiers. The study examined a geoparsing algorithm known as TAGGS, which enhances the ability to identify a specific location by examining groups of tweets referencing the exact location. According to Brujin et al. (2017), the TAGGS algorithm nearly doubled the number of accurately found locations instead of individual geoparsing. Over three years, they examined 55.1 million flood-related tweets in 12 different languages, collected using the TAGGS algorithm. Although TAGGS used historical data, the study was conducted as if a disaster event occurred in real-time. Out of these 55.1 million tweets, the TAGGS algorithm accurately pinpointed the location of events in 19.2 million of these tweets (Brujin, Moel, Jongman, Wagemaker, & Aerts, 2017).

When it comes to geoparsing, there are two generally recognized steps, toponym recognition and toponym resolution. Toponym recognition is extracting words from texts and then matching them with the name of a geographic location drawn from a database. Although this method can be effective, it does have drawbacks. One issue with toponym recognition is that

many of the identifying markers society uses also may have a different meaning in other contexts. An example might be the name "Washington". Although Washington could be a place of interest for geoparsing, an algorithm can easily confuse a person, a separate location, or several uses for the word "Washington". Multiple interpretations mean that toponym recognition is not a perfect system for geo-locating for emergency response. To combat this issue, the TAGGS algorithm uses a "named-entity recognition", or NER system, which analyzes the structure and grammar of a tweet. This technique can help distinguish between a person, a place, and other intricacies used in linguistics (Grace, 2021). One setback to using the NER system is slang and abbreviations frequently used on Twitter. Another issue occurs with Toponym recognition when a disaster or event occurs in an area with a low population that shares a name with a separate, highly populated location of the same name. After vetting tweets and matching the location of a tweet to a country, city, state, or other general location, TAGGS software further examines the tweet during the toponym resolution process. During this stage, TAGGS examines individual tweets for additional information to determine the user's more accurate, precise location. Emergency managers can then use these tweets to respond during a disaster once they have been vetted through the TAGGS process (Gelernter & Mushegian, 2011).

Automated Content Analysis as Applied to Breaking News

One way to best coordinate disaster response for emergency managers is to collect information at the soonest possible moment after an event occurs. One advantage of social media is that information often gets posted online before journalists or traditional reporting outlets can arrive on the scene to verify a story. A study conducted by Middleton and Krivcovs (2016) examined how a "real-time social media analytics framework" could be applied to information circulating online before traditional media outlets can verify the information. This real-time social media analytics framework, known as the "REVEAL" project, aimed to exploit the

"wisdom of the crowd" aspect of social media, while searching for what Middleton terms as "black swan" Twitter posts. These black swan posts are specific tweets posted by individuals that might help to provide deeper insight into a breaking news story that has the potential to aid emergency management organizations. The REVEAL project uses a scalable approach to geoparsing text. The algorithm also uses geomantic technology to examine the context regarding geoparsed data. This technique then allows users of the REVEAL project to minimize the number of tweets that need to be manually filtered through, while retaining tweets that might contain critical information (Middleton & Krivcovs, 2016).

Chae, Bosch, Jang, Maciejewski, Ebert, and Aerts (2012) examined topic extraction and event detection on social media as applied to emergency management. The study's goal was to increase situational awareness and early event detection by exploring how to detect abnormal topics and events on social media websites, including Twitter, Flickr, and YouTube. While most detection systems rank events by the volume in which users online are posting about a specific topic, Chae et al. (2012) ranked topics based on a lack of correspondence with global trends and seasonal trends. Analysts ranked trends by extracting essential topics from a set of selected messages and ranked them probabilistically. Analysts then applied seasonal trend decomposition with traditional control chart methods to find outliers within a time frame. Essentially, Chae et al. (2012) were interested in anomalous events for early detection and prevention. The study showed that situational awareness could be improved by incorporating anomaly examination techniques into data scraping processes (Chae et al., 2012).

Geoparsing as Applied to Hurricane Sandy in 2012

One case study that applied real-time geoparsing using the REVEAL framework was Hurricane Sandy, which occurred in October 2012. During Hurricane Sandy, a false rumor began circulating through social media that the New York Stock Exchange had flooded and was under

three feet of water. Although New York City did experience significant flooding, the New York Stock Exchange was relatively unaffected. However, after approximately 40 minutes of the tweet going viral on Twitter, the rumor was then picked up by "The Weather Channel" and re-enforced by CNN news reporting. In this case study, the REVEAL project used spatially grounding content to trace the original tweet back to the source. Emergency managers could then contact the source to verify the information for validity (Middleton & Krivcovs, 2016).

A data set containing 7,361 tweets during the 2012 flooding of New York City was first examined for keywords involving flooding. From this initial data set, researchers then manually selected 1,000 geoparsing tweets identified as matching the New York region that referenced the Weather Channel or CNN. After this filtering process, 114 tweets were selected. Critical tweets were then labeled as either confirm or deny based on validity. These critical tweets were then examined for relevance to those interested in tracing critical tweets to their source (Middleton & Krivcovs, 2016).

Early Detection of Rumors on Social Media

Zhao, Resnick, and Mei (2016) and researchers at the University of Michigan examined techniques to identify rumors circulating through social media. Unlike the REVEAL project, this study was not necessarily interested in determining the source of the tweet. Instead, the Zhao et al. (2016) study aimed to identify rumors as early as possible so that emergency managers could determine how to respond appropriately. Although identifying the origin of a tweet may provide valuable information, it is more time-consuming than identifying rumors in real-time. For this purpose, Zhao, et al.'s (2016) study did not analyze individual tweets for validity, but rather clusters of tweets containing similar information.

Zhao et al. (2016) found that when rumors begin to circulate on social media, users will at times question the validity of the rumor in a post. These posts can be identified by crucial text

phrases such as "is this true?", "really", and "what?". By discovering tweets regarding any given event, researchers can distinguish rumors from possible truth early in the diffusion process. Zhao et al.'s (2016) study involved;

- Searching for key phrases.
- Clustering similar posts together.
- Collecting related posts that did not contain critical phrases.
- Ranking the cluster of posts by the likelihood they contain false information.

The study found that about a third of the top 50 clusters were deemed to be rumors on a typical day on Twitter. Although the Twitter community works as a collaborative filter for information, machine learning technologies can help emergency managers detect rumors through aggregate text analysis (Zhao et al., 2016).

Leveraging Social Media for Damage Assessment:

Ahadzadeh and Malek (2021) found that a learning-based support vector machine on social media data is most beneficial for earthquake damage assessment. Emergency managers can then create a damage map by using a technique that involves filtering tweets for only damage-related information. According to Ahadzadeh and Malek (2021), when using machine learning to identify damage-related tweets, researchers found that accurate tweets were discovered at a 71.03% accuracy level (Ahadzadeh & Malek, 2021).

Detecting "Fake News"

A study conducted by Liu and Wu (2018) at the New Jersey Institute of Technology looked at machine learning technologies and how algorithms can be used to detect fake news stories. Although machine learning technologies have been relatively effective in detecting fake news after it has been in circulation for some time, it has been less effective in detecting fake news in its early stages. The inability to detect fake news in the early stages is because

information required to detect validity may not be available. To address this issue, Liu and Wu (2018) suggested a model in which machine learning can classify news into propagation paths. They concluded that real-world data sets demonstrated that the proposed model could detect fake news with an 85% to 92% accuracy rate on Twitter within the first five minutes (Liu & Wu, 2018).

Application of Explainable Artificial Intelligence

An article by Turek (n.d.) sponsored by the Department of Defense examined the application of artificial technology to machine learning. Turek (n.d.) explained that although traditional machine learning techniques for intelligence gathering do have benefits, the information produced through machine learning is often difficult to understand and unactionable. Humans using machine learning often do not understand why the program produced certain information and do not understand the context in which the information belongs. Turek (n.d.) suggests that explainable artificial intelligence might help to solve this problem. He states that programs using artificial intelligence will be able to explain to human users the context behind information, why the information has been presented, and how to take action using the information (Turek, n.d.).

METHODOLOGY

Type of Analysis

A process evaluation (Sylvia & Sylvia, 2012) was used to examine what techniques and tools are available to help emergency management agencies in California leverage the flow of valid information from social media. A literature review was conducted to identify the most successful techniques that emergency managers can use to leverage the flow of valid information on social media during crisis conditions. The examples provided in this literature review came from several credible researchers and institutions, both inside and outside of the United States. Case studies were also examined to analyze best practices and mistakes made by emergency management agencies that have previously used social media during crisis conditions.

An anonymous survey was then distributed to emergency managers in California who work in emergency operations centers during an emergency activation. The goal of the survey was to determine how emergency management agencies in California are currently leveraging social media as a tool. This study hypothesizes that geotagging technology, rumor detection mechanisms, and crisis mapping can play a crucial role in emergency management agencies when it comes to leveraging valid information from social media.

Data Collection

An anonymous survey using the website Qualtrics was used to collect data regarding the methods currently being used by emergency management agencies in California to leverage information from social media. The goal of the survey was to identify whether emergency management agencies were using the most successful techniques that academic researchers have identified. The survey was anonymously distributed to members of the California Emergency Services Association. The survey results were then filtered only to include those who actively work in an Emergency Operations Center during an emergency activation. Thirty-seven respondents reported working in an Emergency Operations Center in California during an

emergency activation. In addition, a cover memo was sent out to those participating in the survey explaining the purpose of the research and how the study was intended to help contribute to collective academic knowledge regarding the use of social media in emergency response.

Data Analysis

The information gathered from Qualtrics was then placed into a Microsoft Excel spreadsheet, categorized into different groups, and transferred to the data processing program SPSS. Using SPSS, much of the collected data was then assigned a numerical value to generate the relevant figures and tables. These figures and tables were then examined to identify any potential trends regarding how emergency management agencies in California use social media. Qualtrics was also used to evaluate qualitative data for different trends. Data was primarily processed using a linear regression model to determine whether an organization's unique characteristics predict how organizations use social media. The goal of the data is to help agencies improve their current data collection methods from social media to better leverage valid information.

Data Selection

Respondents in the survey were chosen based on their direct knowledge of emergency management practices during crisis conditions. Each respondent reported that they currently worked in an emergency operations center in California during an emergency activation. Respondents were free to decide whether to participate in the survey and had the option not to answer any specific question. Respondents who stated that they did not work in an emergency operations center during an emergency activation were filtered out from the results of this study.

Study Limitations

Several limitations were present during this study. Some members of emergency management organizations may not have wanted to reveal specific data collecting practices due to liability-related reasons. For this reason, those who took part in the survey were given the

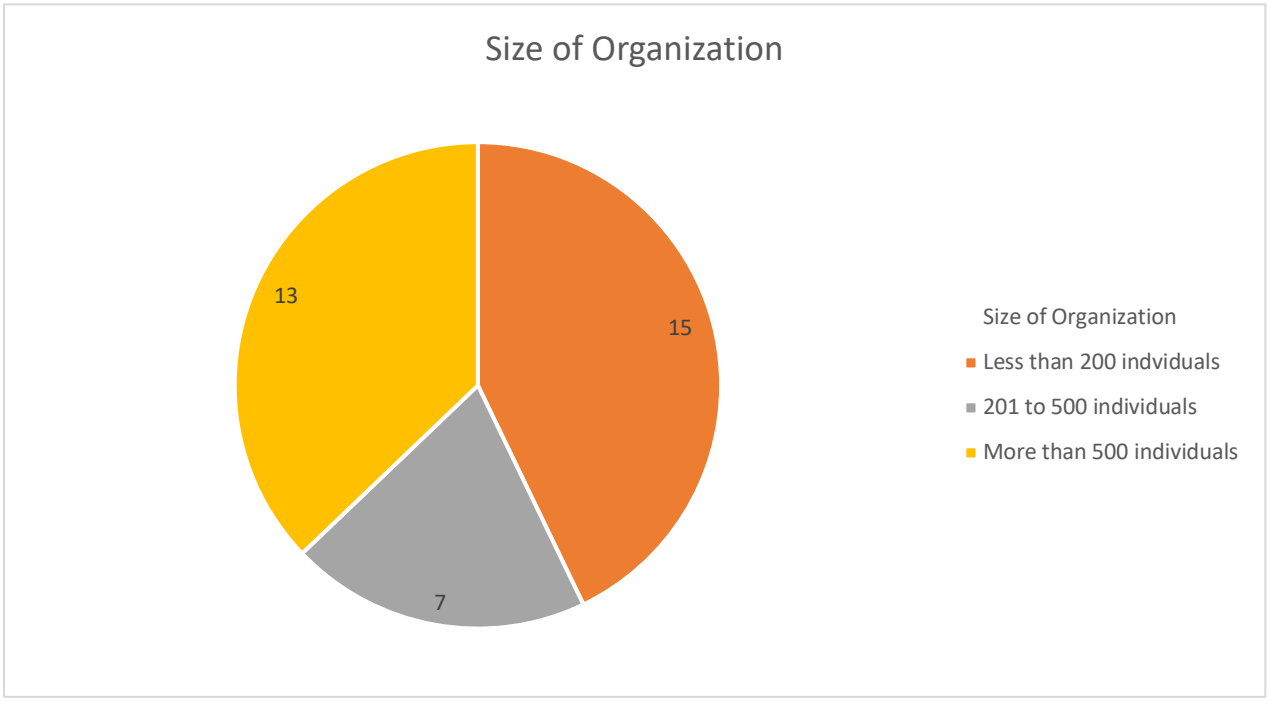
freedom not to answer a question if they did not choose to do so. Additionally, some of the respondents noted that they did not know the correct answer to certain questions regarding specific features of data scraping tools. One typical response was that some individuals reported using a data scraping tool when monitoring social media but did not know whether a filtering mechanism was built into the program to help sort data. Another factor that could have affected response rates to the anonymous survey was that the survey was distributed during the COVID-19 pandemic, which may have limited overall response rates.

IRB Exclusion

The anonymous survey using Qualtrics was designed to account for no identifiable information to be revealed for all participants involved. The survey consisted of yes or no questions, written answers, and multiple-choice questions. Because there were no human subjects, this master's project met the exclusion requirement as outlined by the Institutional Review Board.

FINDINGS

Figure 1: Size of Emergency Management Agency



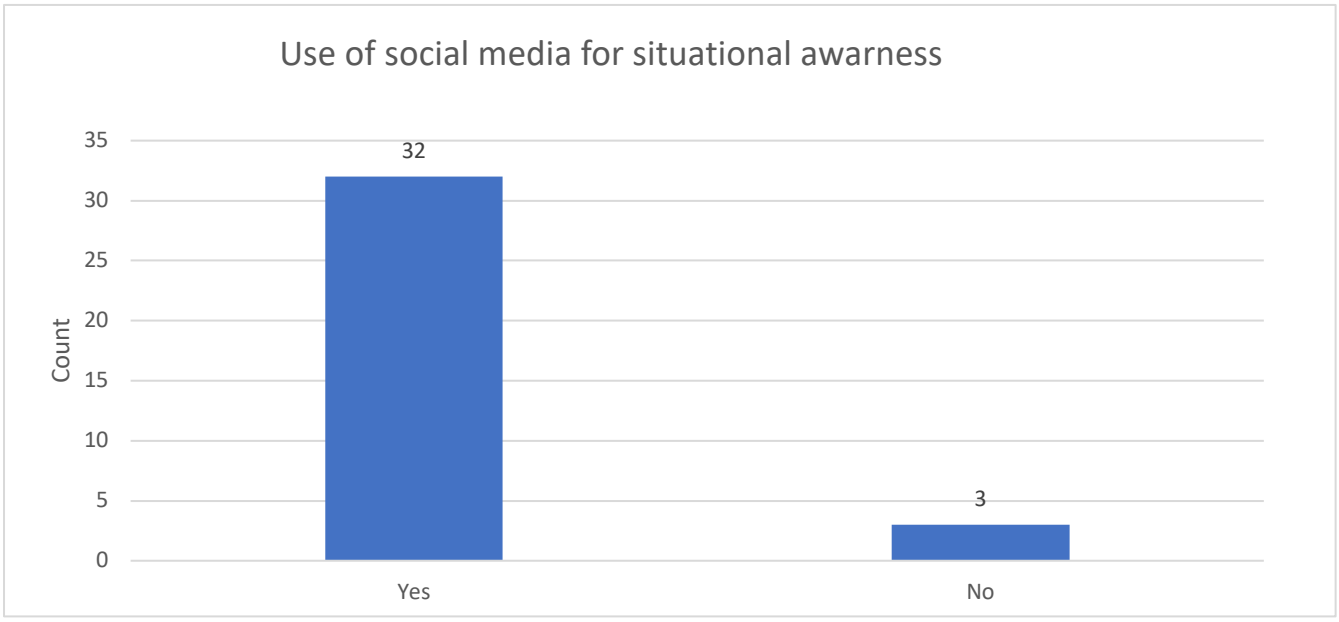
From a total of 35, 15 individuals, or 43% of respondents, reported working for an organization with less than 200 employees, which represented the most significant number of respondents. This category was representative of "small" emergency management organization. Additionally, 13 individuals, or 37% of respondents, reported working for large organizations with more than 500 employees. This category represented the "largest" emergency management organizations throughout California. Finally, 7 individuals, or 20% of respondents reported working for an organization with 201 to 500 employees representing "mid-sized" emergency management organizations.

Table 1: CESA Coastal Chapter Members

#	Answer	%	Count
2	Yes	50.00%	12
3	No	50.00%	12
	Total	100%	24

Out of 24 total respondents, 12 individuals reported working for organizations that were members of the Coastal Chapter of the California Emergency Services Association. Additionally, 12 respondents listed that they did not work for an organization that is a CESA Coastal Chapter member. CESA Coastal Chapter member counties include Alameda County, Contra Costa County, Del Norte County, Humboldt County, Lake County, Marin County, Mendocino County, Monterey County, Napa County, San Benito County, San Francisco County, San Mateo County, Santa Clara County, Santa Cruz County, Solano County, and Sonoma County.

Figure 2: Use of Social Media for Situational Awareness During an Ongoing Disaster



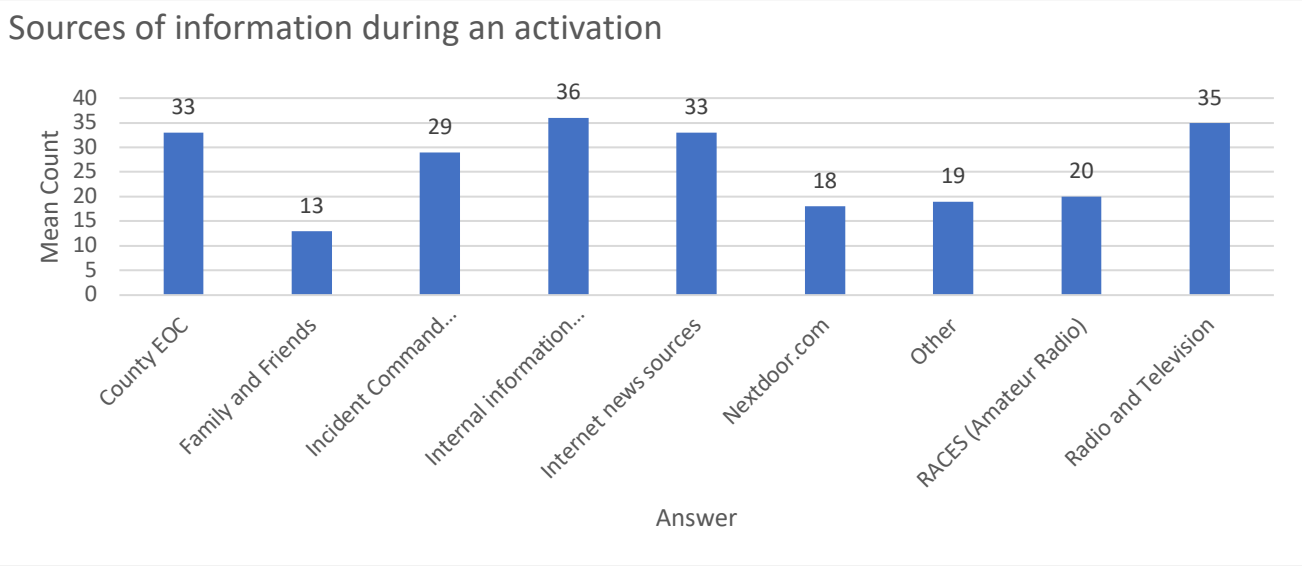
From a total of 35 respondents who reported working in an emergency operations center during an activation, the overwhelming majority stated that their organization does employ the use of social media for situational awareness. Of the 35 respondents, only three respondents reported they do not use social media for situational awareness. In this question, respondents did not specify exactly how their organization leverages social media for situational awareness during an activation, but simply that social media was used in some form. Respondents who answered this question may or may not have used data scraping tools to review social media activity during an activation instead of sorting through social media posts manually.

Table 2: Size of Organization and use of Social Media

Sample Size	McFadden's R-squared
35	.151

A linear regression model was explored to determine if the size of an emergency management organization was a predictor of the use of social media for situational awareness. In the model, the independent variable was represented as the "size of organization," while the dependent variable was represented as the "use of social media for situational awareness." With an R square of .151, there appears to be little to no indication that the size of an organization is a predictor of the use of social media for situational awareness during an activation. This result may be based on an overwhelming number of respondents reporting that their organization uses social media. Although the regression model suggests that the size of an organization is not a strong predictor of an organization’s using social media to leverage situational awareness, it does not indicate how organizations are currently using social media.

Figure 3: Most Popular Methods Used by Organizations to Gather Information for Situational Awareness During an Ongoing Disaster



Among respondents who worked in an emergency operations center during an activation, internal information sources from first responder agencies were the most popular method of intelligence gathering for situational awareness. Information from first responders was closely followed by radio and television sources as the second most popular intelligence-gathering method. Internet news sources, the county emergency operations center and incident command action plans were the most popular third, fourth, and fifth responses. Amateur Radio, Family and Friends, Nextdoor.com, and other sources of information were also cited as being used during an activation. These results suggest that although most organizations currently leverage social media during an activation, traditional intelligence sources continue to be the primary sources of information coming into emergency operations centers. More respondents reported using social media during an activation than respondents who reported using incident command action plans, family and friends, amateur radio, Nextdoor.com, and other resources.

Table 3: Usefulness of Social Media as Reported by Respondents

#	Answer	%	Count
4	Very useful	37.84%	14
5	Extremely useful	27.03%	10
3	Moderately useful	18.92%	7
2	Slightly useful	13.51%	5
1	Not at all useful	2.70%	1
6	Does not apply	0.00%	0
		100%	37

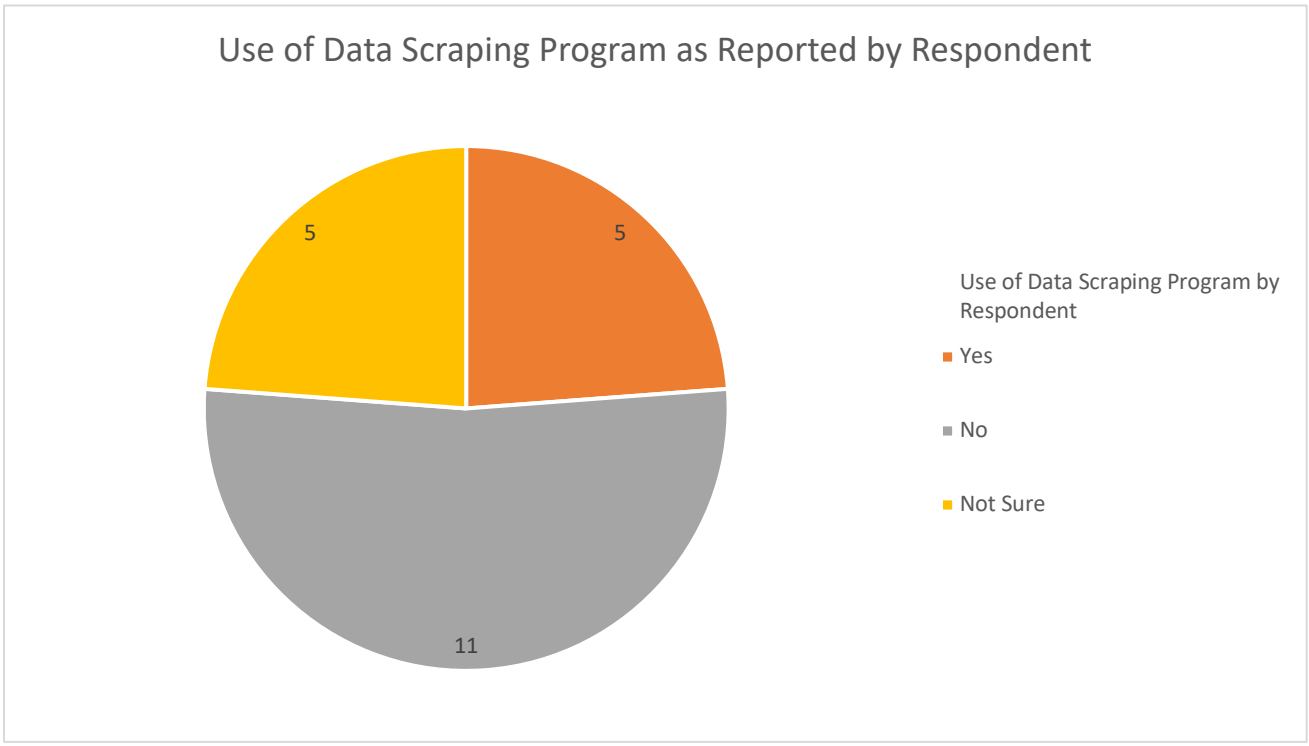
From a total of 37 responses, most respondents reported that they did find some degree of usefulness in using social media for situational awareness during an activation. Of the respondents, 64.87% stated that they found social media to be either very useful or extremely useful when used for situational awareness. An additional 32.43% of respondents stated that they found social media moderately or slightly useful. Only one respondent, or 2.7%, reported not finding any usefulness in social media. These findings suggest that respondents working in emergency operations centers during an activation find value in using social media for situational awareness. This question does not specify whether respondents value social media as a primary source of information or as a secondary source of information. Respondents may find social media useful as a complement to traditional intelligence sources, or to provide context to information that has been drawn from traditional sources of intelligence.

Table 4: Size of Organization and the Usefulness of Social Media

Sample Size	R-squared
37	.005

A linear regression model was run to determine whether the size of an organization was a predictor of how respondents viewed the usefulness of social media for situational awareness. With an R squared of .005, the size of the organization an individual respondent works in does not appear to be a strong predictor of how the usefulness of social media is viewed. This result appears to align with the fact that most respondents found some value in using social media as a tool, regardless of exactly how it is being used. Overall, the size of an emergency management organization does not appear to explain a large proportion of respondents who find social media to be a useful tool during an emergency activation.

Figure 4: Use of Commercially Available Data Scraping Programs as Reported



From 21 respondents, five respondents, or 24%, reported that their organization uses a data scraping program to filter through information from social media. This is a relatively low number considering that most survey respondents reported using social media for data collection during an activation. Although the data would suggest that only a fraction of respondents reported that their organization uses a data scraping program, it does not imply that their organization is not sorting through social media data. An additional 11 respondents, or 52%, reported not using a data scraping mechanism to filter through social media during an activation. Lastly, five respondents, or 24%, were unsure whether their organization uses a data scraping program. Two respondents stated that their organization uses multiple data scraping software to gather information from social media. Two organizations reported using Hootsuite. One organization reported using Meltwater. One organization reported using ISOS, Everstream, and

Control Risks Core. Another respondent reported using a data scraping program but was unaware of which program their organization was currently using.

The data scraping program reported as being most used, Hootsuite, draws intelligence primarily from Twitter, Facebook, Instagram, LinkedIn, Pinterest, and YouTube. Hootsuite is commercially available to both public and private organizations. Hootsuite allows emergency managers to engage in social listening or monitoring social media activity. One strength of Hootsuite is that it is presented as a dashboard in which emergency managers can monitor post engagement, conversations, likes, mentions, keywords, and hashtags. The Hootsuite interface allows emergency managers to respond to the public from the dashboard instead of going to individual profiles.

Another valuable aspect of Hootsuite is that it allows emergency managers to pick the specific streams of information that they are most interested in viewing. Emergency managers can then add additional streams, or subtract streams, based on what topic about which they want to gain more information. Finally, Hootsuite implements machine learning information filtering systems to suggest posts that the program predicts will be relevant to the platform's user. Hootsuite's Python-based algorithms use a rating system to evaluate a user's post on social media based on previous posts, pushing the post forward to the Hootsuite user's dashboard. Hootsuite does not necessarily use machine learning to filter information based on accuracy (Cooper, 2020).

Table 5: Size of Organization and Use of Data Scraping Programs

Sample Size	McFadden's R-squared
19	.71

A linear regression model was run to determine whether the size of an emergency management organization was a predictor of the use of data scraping programs. With an R squared of .71, the size of an emergency management agency appears to be a moderately strong predictor of the use of data scraping programs. This linear regression would suggest that larger emergency management organizations are more likely than smaller organizations to use a data scraping program to filter social media posts.

Table 6: Use of Information Filtering System in Data Scraping Programs

#	Answer	%	Count
1	Yes	11.54%	3
2	No	38.46%	10
3	Unsure	50.00%	13
	Total	100%	26

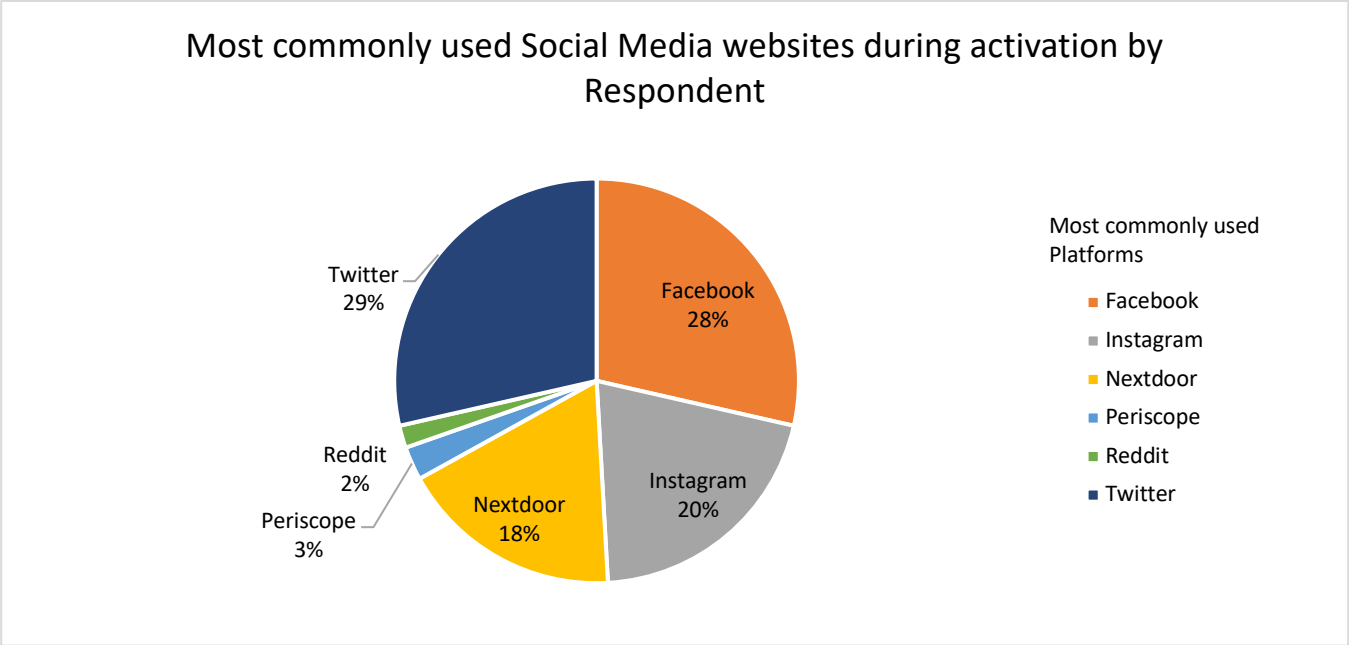
From a total of 26 respondents, 11.54% of individuals reported that the data scraping tool used by their organization uses a machine learning data filtering mechanism. This number is relatively low, given that most respondents reported utilizing social media for situational awareness during an activation. This response would also suggest that out of the five respondents who reported using a data scraping program, only about three of those individuals were aware of the programming methods used by the program to scrape social media for helpful information. Additionally, 38.46% of respondents reported that their organization did not use an information filtering system, while 50% of respondents were unsure.

Table 7: Use of Data Filtering System and Perceived Usefulness of Social Media

Sample Size	McFadden's R-squared
26	.181

A linear regression model was run to determine whether the perceived usefulness of social media by an organization was a predictor of using data filtering systems when using social media for situational awareness. With an R squared of .181, the results would suggest that the perceived usefulness of social media for situational awareness is a weak predictor of the use of data filtering systems. These results may suggest that although many organizations recognize the value of social media, they may not be taking advantage of all the resources currently available to help leverage valid information.

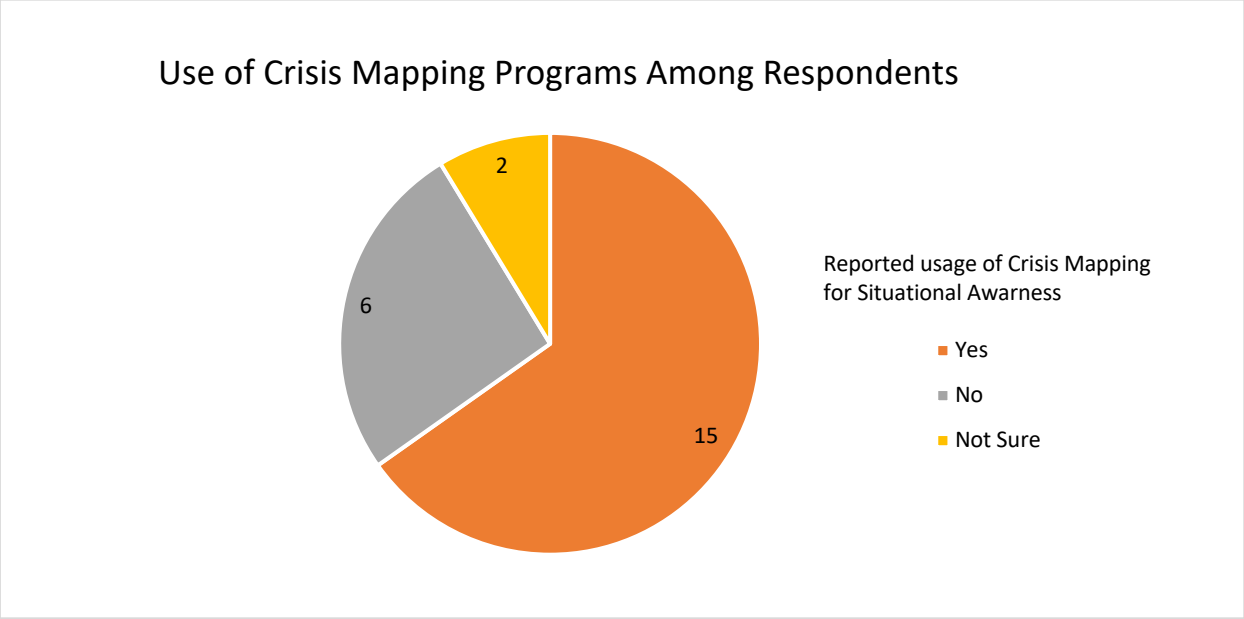
Figure 5: Social Media Websites Used During an Activation



Participants in the survey were asked which social media websites their organizations used to collect information for situational awareness during an activation, and 34 responded to this question. The most popular websites for data collection were Facebook and Twitter, each used by 28.57% of respondents. Instagram was the third most popular website with 20.54%, followed by Nextdoor at 17.86%. Periscope and Reddit were reported as being used the least of all possible options, with Periscope being used by 2.68% and Reddit by 1.79% of respondents. It was not specified whether any types of information were more widely sought based on the features of a particular website.

Additionally, the low rate of respondents reporting the use of Periscope may be explained by the fact that the application has been integrated onto the Twitter platform and is no longer being used as a solo application. Periscope technology as a live video streaming service is now solely available on Twitter.

Figure 6: Use of Crisis Mapping Among Organizations



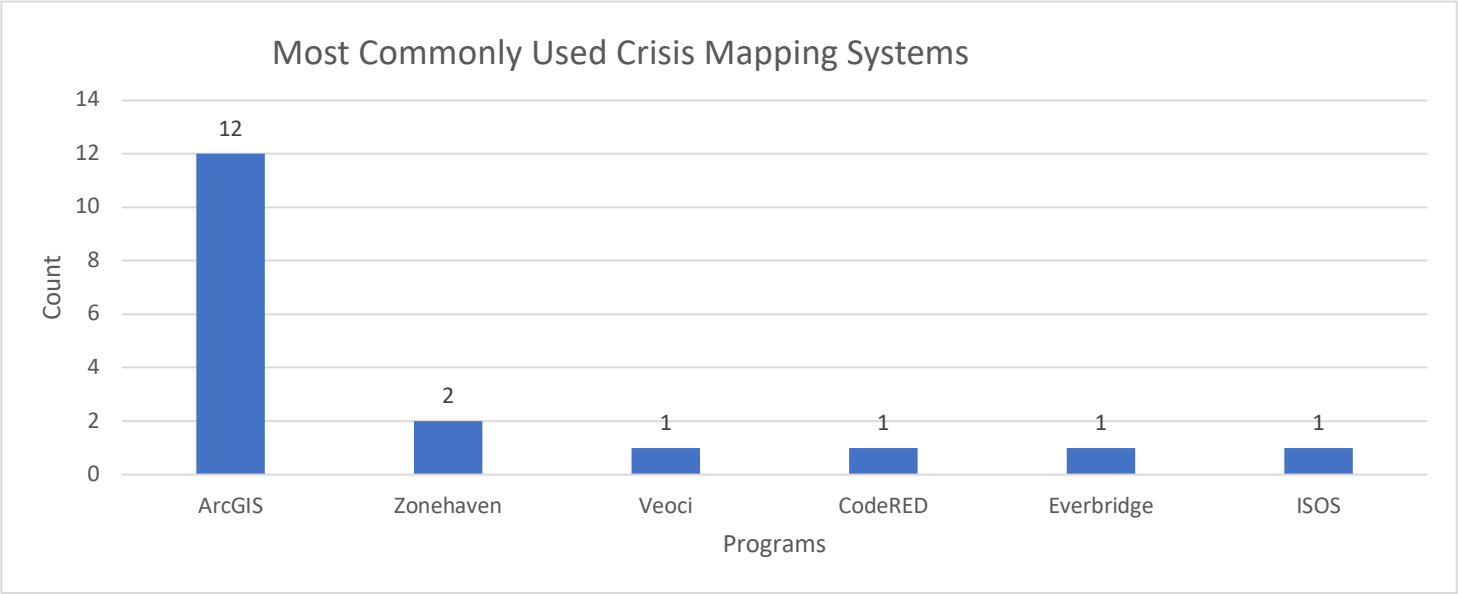
Of 23 respondents, 15, or 65%, reported that their organization uses a crisis mapping program for situational awareness. In contrast, six, or 26%, of respondents said their organization does not use a crisis mapping system, while two, or 9%, said that they were unsure. From the responses, the most used crisis mapping system was ArcGIS, with 12 respondents stating that their organization uses the program. Other crisis mapping programs used by respondents included Zonehaven, Veoci, codeRED, Everbridge, and ISOS. However, respondents did not specify whether the crisis mapping system was integrated with their organizations' data scraping tools.

Table 8: Use of Crisis Mapping Systems and use of Social Media for Situational Awareness During an Activation

Sample Size	McFadden's R-squared
23	.788

A linear regression model was run to determine whether the use of crisis mapping technologies is a predictor of the use of social media for situational awareness during an activation. With an R squared of .788, the data would suggest that organizations' use of crisis mapping technologies is a strong predictor of the use of social media during an activation. One interesting note is that only 26.3% of respondents reported that their organizations use a data scraping system.

Figure 7: Most Used Crisis Mapping Systems Among Respondents



ArcGIS, the most popular crisis mapping program reported by respondents, allows users to map data from Twitter into a specific map. This function allows users of the program to see where tweets are coming from, and the number of tweets produced in each area. Unfortunately, ArcGIS is not integrated with a traditional machine learning tool to filter information from social media to the ArcGIS platform. However, ArcGIS does allow users of the platform to gain situational awareness by drawing data from public organizations, such as responding agencies, weather services, and USGS. Zonehaven, the second most used platform as reported by respondents, is a popular crisis mapping tool primarily used to coordinate, plan, and communicate evacuations and shelter in place notifications with the public.

Table 9: Use of Social Media to Communicate to Public During Activation:

#	Answer	%	Count
1	Yes	94.59%	35
2	No	5.41%	2
3	Unsure	0.00%	0
	Total	100%	37

Of 37 respondents, 94.59% of organizations reported using social media to communicate with the public during an activation. Only two respondents reported that their organization does not use social media to communicate with the public during an activation. The number of individuals who reported using social media for communication purposes outnumbered those who reported using social media for situational awareness. This report would suggest that communicating with the public during an activation remains the most popular way emergency management organizations use social media during an ongoing disaster.

Table 10: Size of Organization and Use of Social Media to Communicate With the Public

Sample Size	McFadden's R-squared
37	.283

A linear regression model was run to determine whether the size of an organization was a predictor of the use of social media by emergency management organizations to communicate with the public. With an R squared of .283, the results suggest the size of an organization is a weak predictor of whether organizations use social media to communicate with the public during a disaster. These results do not specify how organizations communicate with the public and whether they are taking advantage of all the communication tools available on various platforms.

ANALYSIS

The Role of Data Scraping Social Media for Situational Awareness

Ultimately most emergency management agencies in California recognize the value that social media offers when leveraging valid information for situational awareness. However, the capacity of an agency to fully take advantage of commercially available tools may depend on financial and personnel resources. Larger organizations, such as emergency management agencies belonging to major cities and counties throughout the state, could benefit the most from using data scraping programs. The largest emergency management agencies appear to be taking advantage of data scraping tools based on survey results. Agencies with the financial resources to pay for the most up-to-date data scraping software also require the staff to evaluate the information produced through data scraping programs. Agencies comprised of smaller cities stand to benefit from the information shared with larger agencies during a mutual aid event. Although smaller agencies that do not have access to commercially available data scraping tools may not receive information from social media at the same rate as larger agencies, they may still receive valuable information.

Valuable Sources of Information From Social Media to Small Agencies

Twitter is a valuable resource to small public agencies based on several qualities. Twitter is one of the largest, most frequently used platforms by public agencies and private users. Most information on Twitter is openly available to the public. Twitter also attracts users from various demographics and allows for location listing, which is helpful for geoparsing. Another benefit of Twitter is that it provides specific geographic and word-based filters when searching and conducting open-source intelligence gathering. Twitter also allows emergency managers to search using hashtags. Although many of these search features are not unique to Twitter, the

combination of features benefits smaller agencies looking to filter through information quickly and those who do not have machine learning software to filter information automatically.

For large agencies using machine learning data scraping technology, Facebook, Reddit, and Instagram are valuable sources of information. Unlike Twitter, much of the information contained on Facebook and Instagram profiles tends to be private. Data Scraping programs with the ability to locate publicly available information on Facebook and Instagram allow emergency management agencies to find potentially valuable information quickly. Although privacy restrictions on Facebook and Instagram mean that data scraping programs have less information to draw from, information from both sites can help verify information coming in from other social media platforms and other channels of intelligence information. Due to the user interface of Reddit, smaller agencies do not benefit much from the website.

Smaller agencies may be better off using crucial time and gathering information from websites such as Twitter. Additionally, smaller emergency management agencies looking to collect valid information do not stand to benefit from Instagram and Facebook as much as they do from Twitter, due to these same privacy restrictions. Privacy restrictions make it more difficult for smaller agencies to locate and verify information during rapidly occurring crisis conditions.

Nextdoor.com is a valuable tool for all emergency management agencies because there is a higher likelihood of the data being local, unlike other social media platforms. Users on Nextdoor.com tend to post information in and for their local neighborhood or community. If multiple individuals on Nextdoor.com post about a possible incident, it is likely because they are in or near the geographic location in which the incident is occurring. The main drawback to Nextdoor.com is that its user base is relatively small, so data scraping systems do not have a

large pool of data to draw from the way they can from Twitter or Facebook. Many posts on NextDoor.com tend to be speculative and do not paint an accurate picture of an incident.

Although less than 2% of emergency management agencies in California reported using Reddit to leverage the information available on social media for situational awareness, Reddit may be a helpful resource for larger agencies that use data scraping programs. Like Facebook and Instagram, much of the information available on Reddit tends to be private. Data Scraping tools can help agencies discover publicly available information on Reddit quickly instead of agencies that search for data manually.

When it comes to using social media to communicate with the public, most emergency management agencies appear to be taking advantage of this tool. Emergency management agencies can benefit from using the live video features offered on Twitter, YouTube, and Facebook. Each site allows users to post live video feeds, which may provide value to emergency management agencies during ongoing disasters. Users can comment and respond to live video feeds and share information in real-time.

Traditional Information Sources and Social Media

Although data-scraping social media presents several benefits when it comes to leveraging valid information for situational awareness, social media should not be viewed as a replacement for traditional intelligence sources. Information from first responders and traditional media tends to be more accurate than the information posted on social media. One area in which information from social media can be beneficial is immediately during or after an incident occurs and before first responders or media have any validated information. Information vetted through data scraping programs can provide emergency management agencies and first responders with valuable information before professionals arrive on the scene to validate any specific conditions. In addition, emergency management agencies in California can use social media to relay

information to the public, which they receive from organizations such as first responders. Another best practice, as suggested by the Oroville Dam case study, is for emergency management agencies to use social media to correct inaccurate information.

Areas of Success

Emergency management organizations in California succeed in using social media for situational awareness in several areas. According to survey results, emergency management agencies in California use social media to communicate with the public at high rates. In addition, social media allows for two-way communication with the public. Two-way communication allows emergency management agencies to provide resources to the public, but it also allows emergency management agencies to receive crucial information regarding situational awareness.

Another way emergency management organizations effectively use social media is by using the platforms that researchers have identified as being most beneficial for intelligence gathering. As technology continues to develop, emergency management agencies must stay up to date on different features within Twitter, Facebook, and Instagram, to fully leverage information gathering resources. Emergency management agencies must also monitor what platforms are emerging as popular with the public and determine how those platforms might be used.

Areas of Opportunity

An area of opportunity for emergency management agencies in California is that overall data scraping program usage rates appear to be relatively low. Although several factors might influence an agency's ability to use data scraping software to leverage information, large agencies currently not using a machine learning program might benefit from such programs. For those organizations that have the resources to use data scraping software effectively, machine learning can help increase the accuracy of information coming into the emergency operations center and reduce the amount of time it takes to gather information. For agencies currently using

data scraping software, one way to leverage valid information is to create a database of reliable social media users who have provided accurate information during past events. These users can be viewed as having a higher likelihood of producing good actionable material than those without a history of providing accurate information. Emergency managers looking to validate retweets may also benefit from tracing the retweet to the source. The source can then be judged for accuracy. An alternative technique to tracing a tweet back to a source is to examine tweets in clusters. Examining tweets in clusters can help emergency managers examine trends and help determine whether information circulating online is valid.

Agencies with the ability to examine tweets in clusters using a data scraping system may want to incorporate geoparsing techniques. Geoparsing using toponym recognition and resolution can help to identify key location identifiers. These key location identifiers can lead emergency managers to tweets where the poster is more likely to be within a specific geographic area. When users are within an area of a disaster, they are more likely to produce valid information. If emergency managers are using geoparsing tools that operate on a word or phrase recognition, they should also be aware of the potential drawbacks of such programs. These drawbacks include that toponym recognition programs often struggle to delineate words with multiple meanings, cultural nuances, and slang.

An additional area of opportunity applies to integrating data scraping programs within crisis mapping systems. Although most emergency management agencies reported using a crisis mapping system, most respondents reported not using data scraping software. Specific crisis mapping systems, such as Everbridge technologies and its corresponding Virtual Command Center, incorporate data scraped information from social media onto a visual platform. Integrated social media data allows the user to see real-time social media posts, such as tweets, on a crisis

map and frames the post in the context of a geographic setting. Everbridge is a commercially available product that allows organizations to send mass notifications to stakeholders. Different email groups can be created and tailored to the agency. The appropriate stakeholders are notified about a given incident (Everbridge Inc, n.d.).

The Virtual Command Center, an Everbridge product, acts as an integrated crisis mapping technology that draws information from data scraping technologies. Information automatically populates into the Virtual Command Center from data scraping tools and other commercially available sources, which is helpful for the early detection of an incident. Information can also be edited and manually placed into the Virtual Command Center by the user. The newly inputted information is automatically sent to an Everbridge notification template, which can quickly be edited, reviewed, and sent out to the public. Similar tools that incorporate data scraped material into a crisis mapping system may be useful for emergency management agencies in California (Everbridge Inc, n.d.).

Emergency management agencies that reported using the most popular crisis mapping system, ArcGIS, also can leverage social media by using all the available program functions. ArcGIS allows the user to integrate the number of tweets coming from an area into the visual platform. These tweets can be placed in conjunction with other integrated information, such as seismic and weather activities. Placing tweets in context allows the user to visualize where the most tweets are coming from in conjunction with heavily impacted areas. Using ArcGIS, emergency management agencies can also benefit from taking advantage of geotagging technologies. ArcGIS can also create damage assessments and damage maps, which emergency management organizations may find helpful (citation for ArcGIS).

Future Research

One area of future research involves the potential benefits and drawbacks of using artificial intelligence to help leverage accurate information from social media. The emergence of artificial intelligence may one day eliminate the need for humans to determine whether information discovered online should be used for emergency response. Developments in artificial intelligence could provide several benefits to emergency management organizations to quickly and accurately collect information.

Other potential areas for future research include how emergency management organizations can overcome the obstacle of communicating with the public on social media in a diverse setting. For example, in many large urban areas in California, residents speak several different languages and may not always be able to interpret important information released by emergency management agencies quickly. This delay in response time could potentially have negative consequences during a rapidly occurring disaster.

Lastly, more research can be done on developing machine learning techniques to overcome the obstacle of deciphering words and phrases with multiple meanings. Currently, machine learning technology often struggles with determining words, especially nouns, that could have multiple interpretations. This anomaly can lead to incorrect and potentially harmful information displayed to emergency managers. New technologies can also be developed to help decipher everyday slang or shorthand terms used on the internet.

CONCLUSION AND RECOMMENDATION

In conclusion, through a review of current literature and a survey provided to individuals working in emergency operations centers in the San Francisco Bay Area in California, emergency management agencies in California stand to benefit from using the available technology at their disposal as applied to intelligence gathering from social media. Although emergency management agencies in the Bay Area recognize the benefit of using social media for situational awareness, many agencies may not be taking advantage of the commercially available tools at their disposal. The ability to use machine learning technologies may depend on the resources an agency has access to. For this reason, machine learning tools may be most beneficial to larger agencies. Smaller agencies that seek to leverage valid information on social media without using a data scraping tool can benefit by focusing on the most popular platforms identified by survey respondents, such as Twitter, Facebook, Instagram, and Nextdoor.com. Agencies in California should continue to leverage the two-way communication capability of social media and should use live video streaming functions if they can do so. Although valid information on social media may be leveraged during all phases of an incident, agencies may find social media most useful in the early stages of a crisis, and during the damage assessment process.

Emergency managers also stand to benefit from understanding how data scraping technologies work, and how algorithms attempt to decipher the validity of a social media post. By understanding how a data scraping program produces material, emergency managers can better decipher when an error has occurred or when information may not be valid after vetting. Information collected from social media should be used as supplemental information to traditional ways of intelligence gathering. Gathering information from social media should not

be viewed as a replacement for traditional information sources. Information gathered on social media can help provide context, detail, or support to information gathered from traditional sources, such as law enforcement agencies. Finally, two-way communication persists as the most accessible way all emergency management agencies can leverage valid information and provide crucial information to the public.

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