Cooperative Crisis Response among Emergency Responders & AI Systems

Nitin Sawhney
The New School
79 Fifth Ave, New York
NY 10003, USA
nitin@newschool.edu

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Abstract
Emergency responders are increasingly functioning as knowledge workers relying on complex information systems, social media, and digital communication for situational awareness, coordination, and appraisal of their distributed efforts in crisis contexts. How should AI systems and HCI approaches effectively support these workers, whether in Emergency Operations Centers or in the field? What are the implications for interpreting, trusting, and engaging with AI systems to facilitate and coordinate relief efforts in crisis? How do we design better tools, methods, and best practices that fuse cooperative distributed knowledge among fieldworkers and autonomous systems in disaster settings? We examine prior work to illustrate the key challenges, conditions, and unexplored opportunities emerging in these distributed workplaces, that increasingly rely on real-time communication, mobile applications, and social media analytics. Designing for current and future scenarios that incorporate machine learning to better augment crisis response, presents many challenges, risks, and opportunities that must be carefully explored.

Author Keywords
CSCW; AI; Machine Learning; HCI; Ethnography; Social Media; Situational Awareness; Emergency Response

CSS Concepts

• **Human-centered computing** → **Computer supported cooperative work**;

Introduction

On June 3, 2018 Guatemala's Volcán de Fuego erupted catastrophically spewing a 5-mile stream of lava and billowing smoke and ash into dozens of villages over a 12-mile radius. Over 165 people were killed, 260 missing, and nearly 1.7 million affected in what was Guatemala's most severe volcanic eruption in 45 years. The majority of victims died after their homes were collapsed by powerful torrents of lava and mud, triggered by the pyroclastic flows of fast-moving gas and volcanic matter. Over the course of two weeks, dozens of search and rescue teams conducted unrelenting relief efforts in the region, evacuating nearly 3,100 people into 13 newly-opened shelters. For over 9 months, aid organizations led humanitarian efforts to resettle, rehabilitate and provide livelihoods for these displaced survivors in Guatemala [1].

Responding to such devastating crises requires not only well-prepared rescue/humanitarian relief teams and critical resources, but also timely information, situational awareness, and complex coordination among decision makers, emergency responders and affected communities. Researchers have been examining the role of information technology in disasters as part of an emerging field of crisis informatics [2, 3]. Social media continues to play a key role for rapid awareness, dissemination and information sharing among affected people and emergency responders, however such information is not always readily integrated into operations, logistics, and planning efforts [4, 5]. Researchers have undertaken efforts to develop computational tools for processing large-scale social media data emerging in such disasters and support better decision-making for rapid response [6, 7, 8, 9]. Emergency responders and decision makers increasingly rely on information and communication technologies as part of their work practices throughout the many stages of disaster awareness, relief, and management efforts, whether in operations centers or in the field. Machine learning and AI platforms will continue playing a larger role in filtering information, supporting communication, and providing tools to monitor, assess, and coordinate the distributed nature of relief and humanitarian efforts, both in the early phases of disasters and extended durations of crises.

In this paper, I examine the domain of crisis response constituted as a varied workplace, with many decision makers, emergency responders, and volunteer relief workers engaging with information and communication technologies in their work practices. As the workers involved in crisis contexts increasingly begin adopting AI systems to facilitate and support their activities, there are many HCI/CSCW challenges for designing and integrating such technologies and practices to improve crisis response. Through brief examples and speculative scenarios, I examine some of the emerging ethical, socio-technical, cultural, and organizational implications. What does this reveal about the complex conditions in such workplaces, adoption of new technologies, and how we should study them as HCI researchers? What are the methodological challenges for examining such mixed human/AI systems in real-time and distributed contexts? I believe we should consider both design opportunities and critical research questions for cooperative crisis response among emergency responders using AI systems.

Increasing Role of Technology-Mediated Work Practices in Crisis Response

During an extended crisis like the volcanic eruption and relief efforts in Guatemala, as in most such disaster contexts, there are many stages where decision makers and emergency responders are engaged with communication and information systems; these include 1) training and preparation, 2) early warning and awareness of potential crisis events, 3) determining the response strategy at the outbreak of the crisis to dispatch emergency responders and resources, 4) monitoring and coordinating relief efforts with responders, local volunteers and affected communities, 5) supporting the rehabilitation and resettlement efforts for survivors in conjunction with governmental and nonprofit aid organizations, and finally, 6) evaluating and re-calibrating the crisis response and ongoing impact of humanitarian relief work conducted.

There are many crucial facets of the work practices undertaken by the diverse professional and non-professional workforce engaged in crisis response during these different stages, which may vary based on their experience, expertise and responsibilities, whether working in Emergency Operations Centers (EOCs) or distributed in the field. While there are a range of ad hoc and enterprise-level information systems currently used by emergency responders in each stage of their work, several aspects including situational awareness, decision support, and operational logistics are being augmented by AI-based approaches and will likely incorporate them to a greater extent in the near future.

In recent years, social media has become an invaluable source of information during crisis, providing real-time alerts and testimonial evidence of emerging events (often corroborated from multiple sources), geo-locations of people in disaster-struck areas, and images showing potential injury and damage, among other crucial details, as the crisis unfolds [10, 11, 12, 13]. Emergency responders and humanitarian relief workers have begun to utilize social media formally in their work practices for awareness of unfolding events, communication of emergency preparedness, and real-time updates with potential or affected communities, and for identifying and countering misinformation about disasters [14]. Social media has also been successfully used to organize and coordinate grassroots relief efforts among thousands of volunteers by Occupy Sandy, an ad hoc activist humanitarian group, during Superstorm Sandy in New York City and New Jersey in 2013 [15].

Systematically integrating social media into crisis awareness, communication and operations presents many challenges, in particular due to the massive volume, speed and diverse sources of social media streams emerging during disaster events across multiple platforms such as Twitter, Facebook, Snap Chat, Instagram and WhatsApp. Many researchers have been developing computational techniques to automatically process such high-volume social media streams, identify relevant information, and prioritize credible alerts to disseminate in real-time, using both supervised and unsupervised machine learning [6, 7, 8, 9, 10]. Most of these systems have not currently been incorporated into the work practices of emergency responders as they don't critically handle the *context and complexity* of the unfolding crisis event [4, 16] and related sub-events [17], nor understand how best to direct relevant alerts with the right level of actionable information to emergency responders in a timely manner. Advances in machine learning are beginning to

address some of these computational issues to better incorporate social media into the formal work practices of crisis response, however there are many other concerns regarding how information from social media is extracted to determine the needs of affected communities during crisis or directed to the distinct experiences, roles, locations, and situational context of emergency responders. Researchers have begun to conceptually examine how the utility of social media data in crisis contexts can be improved by enhancing situational awareness [18] and framing different models of actionability (i.e. delivering the right information to the right person at the right time) for better decision support among responders [19].

Once there is better awareness of a crisis unfolding and actionable information to leverage, emergency responders must be effectively deployed to critical locations in a timely manner and relief efforts carefully coordinated with a distributed network of professionals and volunteers in the midst of a disaster. During the wildfires in California in August 2018 dozens of agencies and emergency response teams (from 16 states and 2 foreign countries) needed to coordinate their relief efforts, fire rescue resources, and medical supplies; these teams used different IT and radio communication systems, which made this task even more challenging. Computer-aided dispatch systems (CADs) have begun to be used in crisis contexts by decision makers to direct emergency responders based on information about their availability and expertise; many such CAD systems are also being made interoperable to support large-scale operations among diverse teams working in disaster settings. These systems can be augmented by AI-based tools to enable better modeling, optimization, routing and monitoring of distributed emergency responders and medical supplies based on the capacity, locations, and needs of fast unfolding natural disasters like wildfires. Some recent research has developed frameworks for forecasting people's needs during disasters using social media data from Hurricane events and related weather reports [20]. Based on these forecasts and data on availability/expertise of actual response teams on the ground, AI systems could support decision makers in monitoring and modeling the capacity and resources needed to respond to crisis events. This should allow for better predictions, validation with actual evidence observed on the ground, and on-demand dispatching of emergency responders across distributed locations.

Implications of Integrating AI Systems in Work Practices around Crisis Response

Technological interventions using AI systems clearly offer many crucial benefits to augment the work practices of decision makers and emergency responders during fast-paced crisis response settings. However, they may also pose many risks and unanticipated consequences for communities affected by disasters and endanger the lives of emergency responders dispatched on the ground. There are several concerns and questions that we, as part of the HCI/CSCW and AI research communities, must grapple with carefully as we examine the implications of introducing or studying the impact of AI systems in both existing and emerging work practices around crisis response. There are at least three aspects to reflect on for further deliberation:

1. **Valuing the experience and agency** of humanitarian relief workers, emergency responders, and seasoned managers coordinating crisis response work must be

central to introducing new technologies and AI-based approaches. How should such systems be carefully integrated into existing individual and cooperative work practices? In what ways does it affect the decision-making capabilities, flow of information, agency, and situational needs of workers and volunteers on the ground? There is a risk that over-reliance on external data and algorithmic models may de-emphasize the experiences and real-time challenges encountered in the midst of unfolding disasters. In addition, Computer-aided dispatch systems (CADs) may impose a top-down hierarchy on logistics and operations, where in many cases horizontal, distributed and grassroots approaches to crisis response may be more effective in many disaster contexts such as Superstorm Sandy [15].

2. Emergency responders and decision makers must **learn to carefully collect, interpret and integrate signals** from social media data into their work practices to handle the potential information overload, misleading rumors or false alerts about crisis events, verify and authenticate sources of information, seek out wider contextual or historical relevance, and derive actionability for effective crisis response and coordination [19]. This means that while AI systems can augment these capabilities for filtering and extracting relevant data from social media, this should not be a substitute for alternative information gathering on the ground, say among affected communities and survivors. Narratives and testimonies offered by vulnerable people or volunteers (who may not have access or capacity to engage in social media) in the early stages of disasters often provide invaluable evidence that should remain integral to information gathering practices, dissemination on social media (as validation or counter evidence), and assessment of outcomes in crisis contexts. How do we ensure that such on-site evidence is well captured and integrated with data from AI and social media? This has implications for how crisis workers should be trained and supported in collecting, interpreting, analyzing, disseminating, and contesting data emerging from social media, AI systems, and testimonies on the ground.

3. The **complexity of AI systems and range of individual and cooperative work practices** in crisis contexts makes it quite challenging to research, design and conduct evaluation of both existing and novel approaches in these contexts. The high stakes and urgency of emergency response in disaster settings, not to mention the distributed and longitudinal nature of operations and logistics involved in crisis work makes this kind of research even more difficult. Hence, there is a need to devise research studies that either examine the implications of distinct aspects of AI systems in existing work practices (e.g. how forecasting of supplies needed by affected communities from social media is effectively used by emergency responders) or designing an inquiry examining the emergence of new work practices to incorporate novel technologies (e.g. aid workers using semi-autonomous drones for identifying areas in need and delivering

medical supplies in disasters). In most of these cases researchers must examine not only efficacy of the algorithmic predictions offered by machine learning, their inherent scope and limitations, as well as how they impact situational awareness, operations, and work practices among emergency responders. Researchers must also examine how individual and cooperative crisis response is conducted over time across many different workplace contexts in EOCs and on the field. Observing and collecting data and interviews in actual disaster contexts is particularly challenging, but in addition the fast pace of information being provided and interpreted by emergency responders in their decision making, makes conducting such studies even more difficult.

While not all these challenges are easily surmountable, they should not dissuade the design of impactful AI systems that improve work practices in crisis contexts. HCI/CSCW researchers can devise rigorous studies combining both ethnographic insights from the field with empirical and retrospective data from social media and crisis informatics systems. The use of speculative [21] and participatory design strategies [1] may offer other means to engage potential workers in co-devising practices that incorporate novel AI-based prototype systems. This can be conducted in focused scenarios of use among emergency responders in the context of their training workshops and disaster preparedness. Finally, there is a need to critically examine the ethical implications of agency, responsibility, and trust [21, 22] emerging in these mixed human/AI systems and how they could radically transform the nature of cooperative crisis response in the future.

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