Human-Robot Triage

Lack of First Responder Safety at the 9/11 World Trade Center Site

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

One of the most challenging aspects of being a first responder is the balance between personal safety and helping those in danger. In instances of disaster, first responders must make decisions in the shortest amount of time possible to minimize the number of victims. The wrong decision could cost first responders, or victims, their lives. One of the deadliest disasters for first responders was the September 11, 2001 attacks on the World Trade Center (WTC). During these attacks, 413 first responders lost their lives; however, the death toll for first responders would continue to rise due to health conditions related to the WTC site. Over 800 first responders have died since 9/11 due to health conditions related to the inhalation of fumes and dust particles from the debris of the WTC (Smith, 2019).

To minimize the risk towards first responders, the use of a heterogenous robot system to explore and triage victims in times of disaster is a necessary advancement. This system of robots will work with human first responders; the robots will explore disaster sites, find victims, and triage them. When it finds a victim in need of medical intervention, the robot will enlist the help of a human first responder. Since the robots are performing the locating and triaging of victims, this minimizes the time that first responders are exposed to dangerous conditions. Because first responder safety during 9/11 relates to both technical and social factors, it is necessary to examine the roles these different actors played in the failure to protect first responders. I will draw on the STS framework of actor-network theory to examine how false information about safety conditions lead to the failure to enforce safety protocol for first responders at the WTC.

Even with the implementation of human-robot triage, first responders must be prepared with the correct safety protocols. Otherwise, they needlessly risk the lives of first responders. Because the challenge of first responder safety during 9/11 is sociotechnical in nature, it requires

attending to both its technical and social aspects to accomplish successfully. In what follows, I set out two related research proposals: a technical project proposal for developing human-robot triage and an STS project proposal to examine the lack of adherence to safety protocol at the 9/11 World Trade Center site.

Technical Proposal

First responders are unaware of the full scope of the danger in an unexplored disaster zone. They are taught to prepare for their own safety over those of the victims; EMT priorities are listed first as personal safety, then as the safety of their colleagues, and lastly the care of the patient (Klein, 2023). However, there will always be an element of risk involved in disaster management. Even if a site is deemed safe at first, there are often additional threats related to the unstable environments. Another element to consider in disaster exploration is the time pressure. Victims have a limited amount of time that they can survive based on seriousness of injury. Current first responders make decisions using their "power of intuition," drawing on their previous experience as a first responder (Hintze, 2008, p. 1). This isn't true of all scenarios; for example, in instances of hazardous material spills, first responders should distance themselves entirely (US Department of Transportation, 2024). With added time pressure, however, first responders may make decisions that end up putting themselves or colleagues in danger, regardless of protocol. Although first responders draw from knowledge and similar experience, there is not an algorithmic output to each disaster scenario. Because of this, there is always an element of risk associated with first responder disaster protocols.

The aim of this technical project is to reduce the amount of time that first responders are in contact with a disaster site, thus reducing the risk of first responder injury or death; the project will accomplish this by implementing a heterogeneous robot system used to explore and triage

victims in instances of disaster, so that human first responders are only brought into disaster sites for patient care. The human-robot triage uses a mix of Unmanned Arial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) to explore and triage victims. Victims are triaged into 4 levels using the Sort, Assess, Lifesaving Intervention, Treatment/Transport (SALT) method: 1 is minimal, 2 is delayed, 3 is immediate, and 4 is dead. A UGV robot triages the victims into one of the levels based on a few key metrics. First, the robot checks if the victim is responsive. If they are, it checks if the victim can perform purposeful movement, such as standing up, or if that is not possible, waving a hand. If they can, then the victim is triaged into level 1 or level 2. If the victim is unresponsive and still alive, they are immediately triaged into level 3. After the UGV locates and triages victims, it finds a human first responder, where it communicates the coordinates of the victim. The UGV is also able to pass the coordinates to another robot, such as a UAV, so that the UAV can pass the coordinates onto the human first responder. By adopting the human-robot triage for disaster exploration, the risk towards first responders is minimized.

The project will be divided into two main parts: the physical construction of the robots and the logic required for the robots to triage and explore. Although the robots themselves exist, they need a Zigbee radio added on for communicating to each other and to the first responders. For the logic for the robots to triage and explore, simulation with UAVs, UGVs, humans, victims, and obstacles will be designed. This simulation will be coded in python, and users will be able to change different variables, such as adding more UGVs or removing obstacles. After finding the optimal solution for robot exploration and triage in the python simulation, the solution will be implemented to the physical robots.

The best solution will be determined by trial and error. Different combinations of UAVs, UGVs, and humans will be tested in the simulation. Additionally, different methods for reporting

triaged victims to first responders, such as returning after every victim vs. returning after finding the location of all the victims, will be tested. The simulation will be run multiple times for each trial, and the time it takes for the robots to explore the full area and for the first responders to treat all the victims will be recorded; the goal is to find the combination that minimizes the time.

STS Proposal

"I am glad to reassure the people of New York and Washington, DC, that their air is safe to breath," Environmental Protection Agency Administrator Christie Whitman announced to the public a week after the 9/11 attack on the World Trade Center (WTC) (Bendix, 2015). Whitman did not know how false her statement was, and how much illness and death would follow this false sense of security. September 11, 2001 was the deadliest event for firefighters in US history (NFPA, 2022). In the days that followed, 90,000 first responders would spend time inhaling the toxic fumes from the debris of the World Trade Center; consequently, over 2,000 first responders have retired from related injuries (Smith, 2019). The main reason for this was the lack of correct respiratory protection equipment (RPE). Based on a survey filled out by first responders, half of the workers did not wear RPE at all during the first day of response (Antao, 2011). For those that did wear RPE, one-third of first responders had no RPE training. As a result, 53% of first responders reported respiratory issues and 28% reported cancers (Smith, 2019). The death toll from these 9/11-related illnesses also continues to rise; as of 2023, the death toll from the day of the attacks is equal to those lost from 9/11-related illness is equal (Halpert, 2023).

Current discourse debates the cause for first responder deaths after 9/11 and whether they can be linked to the WTC site, specifically different types of cancer. Although respiratory illnesses show immediate symptoms, the latency period for cancers like mesothelioma, whose main cause is asbestos exposure, can take up to 50 years before displaying symptoms (Bendix,

2015). Up until recently, fire fighters were assumed to have higher rates of cancer regardless of involvement in 9/11. However, when compared to pre-9/11 data, first responders have cancer rates 19% to 30% higher than before (Smith, 2023). Other natural factors may have contributed to this increase, such as the overall increase in cancer in the US population over time, but it is unlikely that other factors were the sole reason.

Previous writers have examined the statistical relationship between lack of RPE and resulting health conditions, but they have not yet considered the social factors that contributed to reasons why first responders failed to follow proper safety protocols; although there are resources that analyze the resulting social factors from lack of RPE, there are very few sources that focus on the social factors that led to lack of RPE among first. The environmental protection agency, New York Mayor, US public, and respiratory equipment itself were all important factors that explain the reasoning behind the lack of safety protocols for first responders. Without considering the factors that lead to lack of RPE at the WTC site, readers may place blame on first responders. Although the first responders were partially at fault for not following standard protocols, 9/11 was an unprecedented disaster; there were no protocols for a disaster of that magnitude. First responders felt a false sense of security at the WTC site, which ultimately lead to lasting health conditions, some of which led to death.

Although the first responders were partially at fault for not following safety protocols, pressure from public figures, the time pressure from New York citizens eager to return to normalcy, and lack of preparedness in supplies and training were the main factors that lead to lasting health effects for first responders. To support my analysis, I will draw on the concept of actor-network theory (ANT). ANT focuses on the connection of different actors, both human and non-human, brought together by a network builder; the network builder brings the actors together

to accomplish a goal (Cressman, 2009). Ultimately, the success or failure of a network is dependent on the network builder. In this case, the network built by head of the Environmental Protection Agency (EPA) Christie Whitman overlooked the safety of the first responders and citizens of New York. Whitman falsely declared that the air at the WTC site was safe to breathe, even though the EPA had no basis behind their claim. Other actors who contributed to the unsafe environment at the WTC site include the New York City Mayor at the time, Rudy Giuliani, First Responders, and the time pressure to find citizens as quickly as possible. Although Whitman declared the air safe to breathe, first responders should have been wearing RPE regardless; Giuliani, as the leader of the work at the WTC site, should have been enforcing proper RPE (Walters, 2016). The RPE is also an actor in this network, but it is rogue actor, since it protected first responders who wore it against unsafe conditions. The intended goal of the failed network was to explore the WTC site as quickly as possible to save as many lives as possible; although the network accomplished the goal of speed, it overlooked the safety of first responders, which ultimately failed the goal of saving as many lives as possible. The evidence I will draw on to support my argument are accounts from first responders working at the WTC, from both news articles and surveys (Bendix, 2019).

Conclusion

Although first responders are told to minimize personal risk, there is an inherent amount of risk in helping those struck by disaster. The human-robot triage is an important advancement in technology towards providing safer conditions for first responders by limiting the amount of time exploring disaster sites. Using the 9/11 World Trade Center as a case study for the social factors that led to lack of first responder safety, the consequences of poor first responder safety show what happens when safety is not a priority. This helps put the technical project in

perspective; the human-robot triage can save not only victim lives, but it helps protect first responders as well. ANT helps put the different roles at play during times of disaster into perspective; there are so many other factors that are important to the success, or failure, of the exploration and triage of victims in instances of disaster.

References

Antao, V. C., Pallos, L. L., Shim, Y. K., Sapp, J. H., Brackbill, R. M., Cone, J. E., Stellman, S. D., & Farfel, M. R. (2011). Respiratory protective equipment, mask use, and respiratory outcomes among World Trade Center Rescue and Recovery Workers. *American Journal of Industrial Medicine*, *54*(12), 897–905. https://doi.org/10.1002/ajim.21009

Bazyar, J., Farrokhi, M., & Khankeh, H. (2019). Triage Systems in Mass Casualty Incidents and Disasters: A Review Study with A Worldwide Approach. *Open access Macedonian journal of medical sciences*, *7*(3), 482–494. https://doi.org/10.3889/oamjms.2019.119f

Bendix, A. (2015, September 10). *The link between 9/11 and cancer has become increasingly clear*. Bloomberg.com. https://www.bloomberg.com/news/articles/2015-09-10/the-link-between-9-11-and-cancer-has-become-increasingly-clear

Cressman, D. (2009). A brief overview of actor-network theory: Punctualization, heterogeneous engineering & translation.

Halpert, M. (2023, September 25). *Over 340 first responders have died from 9/11 illnesses*. BBC News. https://www.bbc.com/news/world-us-canada-66917700

Hintze, N. R. (2008, March 1). *First Responder problem solving and decision making in today's asymmetrical environment*. First responder problem solving and decision making in today's asymmetrical environment. https://hdl.handle.net/10945/4230

Klein, T. A., & Tadi, P. (2023). EMS Scene Safety. In *StatPearls*. StatPearls Publishing.

National Fire Protection Association. (2022, January). *Incidents resulting in the deaths of 8 or more firefighters: NFPA*. nfpa.org. https://www.nfpa.org/education-and-research/research/nfpa-research/fire-statistical-reports/fatal-firefighter-injuries/deadliest-incidents-resulting-in-the-deaths-of-8-or-more-firefighters

Smith, E. C., Holmes, L., & Burkle, F. M. (2019). The physical and mental health challenges experienced by 9/11 First Responders and Recovery Workers: A review of the literature. *Prehospital and Disaster Medicine*, *34*(6), 625–631. https://doi.org/10.1017/s1049023x19004989

US Department of Transportation. (2024) *Emergency response guidebook (ERG)*. PHMSA. https://www.phmsa.dot.gov/training/hazmat/erg/emergency-response-guidebook-erg

Walters, J. (2016, September 10). *Former EPA head admits she was wrong to tell New Yorkers Post-9/11 air was safe*. The Guardian. https://www.theguardian.com/us-news/2016/sep/10/epa-head-wrong-911-air-safe-new-york-christine-todd-whitman