Adopting AI to support Situational Awareness in Emergency Response: a Reflection by Professionals

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Abstract. Incident commanders on emergency scenes need to make decisions in high-risk, high-consequences, time-compressed settings. The current ways AI is integrated in these life-risking scenarios is limited, requiring lots of brain and time-efforts of the commanders interacting with it. We present these limitations in terms of the AI methods that are used, the quality of the data that these methods used, how such data is transformed into domain knowledge. We finally propose research directions for better adopting AI methods in emergency response management.

Keywords. Under-stress Decision-Making · Knowledge Management · Situational Awareness · Data Quality · Firefighter Scenarios

1. Long Abstract

The authors of this paper have been in the emergency service for more than 25 years, and are witnessing the rise of modern, hybrid (data- and knowledge-driven) AI methods. They now feel the urge of investigating the applicability of such systems in their complex and time-compressed scenarios. The rise of AI has been accompanied by an extravagant marketing campaign about the advantages of employing newer methods, technologies and datasets. The digitalisation of the information has certainly made the information more updated and easier to maintain, in comparison to the paper-printed catalogues that were present in domain organisations few decades ago. Nowadays, AI-systems provide experts with more and more information in a fast and efficient way. Yet, they do not integrate well in the neurological process that comes with decision-making in high-risk, high-consequences, time-compressed environments, as the one of emergency response.

In a typical emergency scenario, firefighters usually derive patterns from the clues in the environment that can help them predict which action to take in a time-compressed situation. This process is called Recognition-Primed Decision-Making (RPD) [2]. Patterns are matched against mental checklists for the various types of incidents (e.g. reported fire, building incident, smoke, flow path, etc.), but every commander has a unique set of experiences, which helps them perform such a matching. The adoption of AI here is still at its very early stages, i.e. tablets usually report the relevant information (ongoing dispatch, type of vehicles on scene/alarmed, incident escalation level) either

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as dashboards or, more rarely, as a digest of information using machine learning techniques.

The RPD process relies heavily on building a Situational Awareness (SA) [3]. This allows commanders to quickly recognise the environment and consequently predict what will happen, and what cause of action to take. Building SA consists largely in using one's own senses to perceive the environment. This is not a conscious process where every sense is deliberately engaged to provide input on the situation at hand, but rather a largely automated process with its own risks and pitfalls. Adopting AI solutions in these contexts presents a number of challenges.

First, incorporating the current AI methods when developing SA requires a significant amount of time and manpower, as commanders still need to align the information received with the one obtained from their own senses. These methods often rely on one single layout, i.e. they do not adhere to any of the checklists that incident commanders use to operate. This could lead to losing situational awareness, a price that cannot be paid in scenarios where lives are at risk. Additionally, systems do not acknowledge that the decision-making and SA development is highly personal. Every incident commander has in fact a unique set of experiences and training, which will give them choices from their long-term memory during the decision-making process under-stress.

Second, data-related issues such as quality, volatility and trustworthiness also play a crucial role in the challenging environment of incidents. Data that is typically used by the fire service, e.g. data about buildings, is typically not collected and maintained with high-accuracy, nor a fire department use-case in mind. Relevant information might be missing or outdated. Using such data for training machine learning models might therefore be problematic [1]. Even when collecting enough data, the AI methods would still be providing only rolled-forward assessments, where few variables are taken into account (e.g. “how quickly will the population of my city grow?”). Predicting answers to questions as “how many battery-operated heat pumps will catch fire in my city in 5 years?” is still hard, as the variables that could impact the answer (e.g. newer safety measures, newly installed pumps, new governmental subsidies) are almost endless.

Finally, domain data in emergency scenes requires to be further structured. Without a common vocabulary, it is hard for the digital assistants to explain how their conclusions are derived. Instead, information should be accompanied by the context and perspective (e.g. background, skill set, qualifications and experience) of the operators interacting with the agents, in order to improve the overall human-machine collaboration.

Based on these challenges, open questions remain to effectively integrate AI in high-risk, high-consequences decision-making processes:

1. Identifying Contextual Knowledge. How to transform the data provided into information that is relevant to a given context to support SA development?
2. Managing Information Overload. How to identifying the right portion of information in the large amounts provided, and accounting for the missing one?
3. Standardisation. How to create and maintain high-quality, up-to-date common vocabularies that can avoid misunderstandings across agents or units?
4. Human-machine Collaboration. How to integrate AI in the RPD process, for it to take into account the humans’ mental models?
5. Personalisation. How to make smart systems aware of the background of a commander?
6. Methods and Techniques. Which methods and metrics are suited for firefighter scenarios? And how to measure the performance of these intelligent systems?

7. Managing outliers. How to signal signaling the unexpected events, in contrast to predicting only how an incident is developing?

References

[1] Kinsey, K., Ahrens, M.: Nfirs incident types: Why aren't they telling a clearer story. National Fire Protection Association: Quincy, MA, USA (2016)

[2] Klein, G.A.: Streetlights and shadows: Searching for the keys to adaptive decision-making. MIT Press (2011)

[3] Okray, R.: Situational awareness: Seeing in the fourth dimension. Fire Engineering 151(9), 12–13 (1998)