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The Bush School
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An Inquiry into Artificial Intelligence (AI) as Related to Emergency Management

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> ***"Public service is a noble calling, and we need men and women of character to believe in their communities, in their states, and in their country."***

It is in this spirit that we have undertaken this project, driven by a shared commitment to resilience, preparedness, and the well-being of our communities.

To all who contributed—through time, expertise, or support—thank you. Your generosity and dedication made this work possible.

Executive Summary

This paper explores AI's expanding role in emergency management, analyzing its applications across the four phases of disaster management. AI has the potential to revolutionize emergency response by improving disaster prediction, optimizing resource allocation, enhancing situational awareness, and accelerating recovery efforts. However, its adoption also presents challenges, including data biases, privacy concerns, and cybersecurity risks, which must be addressed through effective policies and governance. The paper will examine AI's impact on the profession of emergency management. Real-world case studies will highlight AI's effectiveness, while ethical and practical challenges will be discussed. Finally, the paper will conclude with future trends and policy recommendations for ensuring AI is integrated responsibly and effectively into emergency management strategies.

Initial Research Questions:

1. Are there opportunities to utilize artificial intelligence platforms to benefit HCOHSEM's operations?
2. What are the risks artificial intelligence poses to the emergency management enterprise?
3. Could OpenAI-type platforms be used to perform malicious activities or expose sensitive information within the HCOHSEM network?
4. How can HCOHSEM respond to malicious or erroneous social media posts?

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Introduction

Artificial intelligence (AI) is changing industries across the globe. This expansion of technology into all sectors of our economies and communities has sparked efficiency, innovation, as well as detriment, both unintended and intended. Emergency managers and policy makers alike will no longer be effective in emergency preparedness if they ignore this rapid development of AI technologies. To ensure the continued effectiveness of emergency operations and preparedness, emergency managers across all levels of government must embrace the necessary accumulation of knowledge. Not only to safeguard our nation against the threats of AI, but to incorporate AI into preparedness and response to activate newfound levels of security.

As a rapidly developing technology, AI displaces emergency management-related practices and enhances disaster preparedness, response, recovery, and mitigation through predictive analytics, automation, and real-time data processing of events. The value of AI with regards to emergency management is extremely relevant as disasters are increasing in frequency and severity. Climate change, population growth, and urbanization have escalated risk with respect to natural and human-made disasters, also proving necessary a new methodology to plan, respond to, and build resilience to disasters.

AI provides significant value by assisting forecast needs, predicting resource requirements, and improving outdated communication systems. In doing so, AI assists emergency managers in making better decisions, executing more quickly, and saving lives. Like every other technology process related to innovations, there are inherent challenges in integrating AI into emergency management. Ethical concerns, data privacy governance, algorithmic bias and cybersecurity of AI is something that needs to be resolved for a successful deployment of AI technology towards its purposes. As emergency management agencies pursue AI-driven solutions for risks related to adaptive technology, policy makers will evolve and will be needed to establish frameworks to link innovation with accountability, public trust, and security.

In this paper, we will examine the diverse roles and uses of artificial intelligence (AI) in emergency management, including its benefits and drawbacks. The study will review real-world examples of AI applications, review policy considerations, and new trends to reveal the overall impacts of disaster response and recovery outcomes that can be associated with AI. The goal is to provide information for emergency management professionals, policymakers, and stakeholders on how to effectively utilize AI for disaster response and recovery while mitigating and minimizing potential harm.

Methodology

The methodology for this research paper on AI involved a mixed-methods approach, combining a thorough review of scholarly sources, in-depth case studies, and qualitative interviews. First, a comprehensive literature review was conducted, sourcing peer-reviewed articles, books, and academic journals to provide a foundational understanding of AI's evolution, applications, and ethical considerations. Next, the research integrated case studies from various industries where AI has been implemented, analyzing real-world examples to understand the practical impacts and challenges. To further enrich the findings, interviews were conducted with emergency management professionals and an AI management professional, allowing for firsthand insights into current trends, challenges, and the future trajectory of AI in this industry. This combination of secondary research, case study analysis, and expert opinions served to provide the research team with a well-rounded perspective on this subject, allowing us to address both theoretical and practical aspects of AI in the realm of emergency management.

Defining AI

AI is a branch of computer science dedicated to developing systems that can perform tasks traditionally requiring human intelligence, such as reasoning, learning, problem-solving, perception, language understanding, and decision-making.[1] The ultimate goal of AI is to create machines capable of simulating human cognitive functions, allowing them to solve complex problems and make decisions autonomously or with minimal human input, thereby streamlining real-world processes.

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[1] National Aeronautics and Space Administration (NASA). 2024. "What is Artificial Intelligence?" NASA.

How does AI work?

As a rough explanation, AI systems work by processing large volumes of data and applying algorithms to identify patterns and make predictions or decisions. The process often involves the following stages:[2]

1. **Data Collection:** AI systems require vast amounts of data to learn from. The data can come from various open sources (e.g., public datasets, historical records, publicly available research, etc.) and closed sources (e.g., internal data from an organization, proprietary datasets, or licensed data that is not publicly available). This data is essential for training AI models, allowing them to recognize patterns, make predictions, and improve over time. The distinction between open and closed sources is important, as it affects accessibility, privacy, and the type of data used for training AI systems, which we will continue to discuss in the next section.
2. **Preprocessing:** After the raw data is collected, it often needs to be cleaned and organized before it can be used for learning. This step involves removing noise, handling missing values, and converting the data into a format suitable for analysis.
3. **Modeling:** Machine learning models are trained on the data to recognize patterns. The type of AI model depends on the problem being solved. The most common are supervised learning models (e.g., decision trees, neural networks) for classification and regression tasks; unsupervised learning models (e.g., clustering, anomaly detection) for finding hidden patterns in data; reinforcement learning models for decision-making in

[2] Boucher, Philip. 2019. "How artificial intelligence works." European Parliamentary Research Service. Scientific Foresight Unit (STOA).

dynamic environments; and deep learning models (e.g., convolutional neural networks, transformers) for complex tasks like image recognition and natural language processing.

4. **Testing and Evaluation:** After training, the model is tested on a separate dataset to evaluate its performance. Common evaluation metrics include accuracy, precision, recall, and F1 score. The model may be fine-tuned to improve its performance based on these results.
5. **Deployment:** Once the model is refined and validated, it can be deployed in real-world applications where it can begin to make autonomous decisions or provide decision support.

Open vs Closed Source AI Systems

Among the key distinctions in AI systems are open-source and closed-source models, which differ in terms of their access to data, accuracy, flexibility, and application domains.[3] Open-source AI systems retrieve information from a wide array of publicly available sources, allowing for dynamic and flexible responses. In contrast, closed-source AI systems rely on a more restricted set of curated data, ensuring greater accuracy and reliability but at the cost of flexibility.

Open-source AI systems are designed to retrieve information from a broad range of publicly accessible sources, such as the internet, books, social media, and user-generated content. [4]These systems are inherently flexible, capable of providing responses on a wide variety of topics by drawing from diverse and often real-time data sources. For instance, chatbots like ChatGPT in its default mode can pull data from the internet, which allows them to generate answers on an almost limitless range of queries. This flexibility makes open-source AI a powerful tool for tasks such as content generation, creative writing, and exploratory research. Additionally, some AI tools, like Perplexity AI, integrate with web-search capabilities, further enhancing the ability to deliver up-to-date information on current events or trends.

However, the broad accessibility of information comes with significant risks. Open-source AI systems are prone to generating hallucinations, which are responses that sound plausible but are based on inaccurate or unreliable data. The internet contains both accurate and misleading content, and AI systems without safeguards can inadvertently pull false information

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[3] Avatavului, Cristian, Andrei-Iulian Cucu, Alexandru-Mihai Gherghescu, Costin-Anton Boiangiu, Iulia-Cristina Stanica, Cătălin Tudose, Mihai-Lucian Voncilă, and Daniel Rosner. 2023. "Open-source and Closed-source Projects: A Fair Comparison." *Journal of Information Systems & Operations Management* 17, no. 2.
[4] Chun, Jordi, Joseph Marvin, Juan A. Nolazco-Flores, Lori Landay, Matthew Jackson, Philip HS Torr, Trevor Darrell, Yong Suk Lee, and Jakob Foerster. 2024. "Risks and Opportunities of Open-Source Generative AI." arXiv preprint arXiv:2405.08597.

from questionable sources. For example, while open-source AI might be able to discuss the latest trends in technology or politics, it might also reference outdated studies or biased viewpoints. This introduces a challenge in maintaining accuracy and reliability.

The primary advantage of open-source AI lies in its broad knowledge coverage. It is suitable for tasks that require exploration across various domains or when information is sought from a wide spectrum of sources. However, it is essential to approach open-source AI with caution, as the lack of vetting can lead to errors and misinformation.

In contrast, closed-source AI operates within a defined boundary, accessing only curated, vetted, and verified data sources.[5] These systems typically pull information from internal databases, proprietary research, or trusted resources, ensuring that the knowledge they provide is accurate and consistent. For instance, IBM Watson Health and Mayo Clinic AI are medical AI systems that draw exclusively from peer-reviewed medical literature, ensuring that any advice or diagnosis generated adheres to high standards of accuracy. Similarly, legal research AI platforms such as Casetext or LexisNexis AI use verified legal databases to provide accurate and legally sound information.

Closed-source AI systems are typically used in fields where accuracy and reliability are of utmost importance.[6] For example, legal professionals, healthcare providers, and government agencies often require AI to retrieve information that has been thoroughly checked and validated. These applications benefit from closed-source AI's high degree of consistency, which reduces the risks associated with misinformation. In highly regulated industries, closed-source AI can

[5] Schöning, Julius, and Hans-Jürgen Pfisterer. 2023. "Safe and trustful AI for closed-loop control systems." Electronics 12, no. 16: 3489.
[6] Bostrom, Nick. 2018. "Strategic implications of openness in AI development." In Artificial intelligence safety and security, pp. 145-164. Chapman and Hall/CRC.

also ensure compliance with legal or ethical standards by only pulling from approved data sources.

However, closed-source AI comes with notable trade-offs. The restricted knowledge scope limits the system's ability to answer questions outside the boundaries of its curated dataset. Unlike open-source models that can draw from a vast pool of information, closed-source AI may struggle to address topics or provide insights beyond the scope of its data. Additionally, the rigidity of these systems means they require frequent updates to remain relevant, especially in fields where information evolves rapidly.

Despite these limitations, closed-source AI is ideal for scenarios where precision, reliability, and control over the data sources are essential. For example, when handling sensitive or specialized tasks—such as legal research, medical diagnoses, or government intelligence—closed-source AI ensures that the information provided is both accurate and trustworthy.

The fundamental difference between open-source and closed-source AI lies in the access to data and the resulting accuracy and flexibility. Open-source AI systems can pull from a vast range of data, but this comes with the risk of unreliable or false information. In contrast, closed-source AI systems are restricted to curated, trusted data sources, ensuring higher accuracy but limiting their ability to handle a wide variety of queries. The choice between these two models depends largely on the application at hand—whether the goal is to explore a wide range of topics or to ensure the highest level of accuracy and reliability. Understanding the trade-offs between open-source and closed-source AI can help users select the most appropriate system for their needs.

Historical Foundation of AI

AI's intellectual foundation traces back to attempts to replicate human reasoning. Philosophers like Aristotle laid the groundwork for formal reasoning systems, which later influenced the development of mathematical logic.[7] In the 20th century, the modern concept of AI began to take shape. In 1943, Warren McCulloch and Walter Pitts introduced a computational model of artificial neurons, demonstrating the potential for machines to mimic human thought. This innovation marked the first formal attempt to simulate human intelligence.[8]

AI's critical moment came in 1956 at the Dartmouth Conference, which is often regarded as the field's founding event.[9] There, pioneers like John McCarthy, Marvin Minsky, and Allen Newell solidified AI's interdisciplinary identity. McCarthy coined the term "artificial intelligence," and researchers began focusing on symbolic AI, believing human reasoning could be reduced to symbolic manipulation. Early programs such as Logic Theorist, developed by Newell and Herbert Simon, demonstrated AI's potential by solving mathematical proofs.

However, despite early optimism, AI faced significant setbacks. The first "AI Winter" occurred in the 1970s due to limited computational power and unrealistic expectations. Funding decreased, and AI's potential seemed distant.[10] Nevertheless, developments like Joseph Weizenbaum's 1966 ELIZA program hinted at the future of natural language processing, showcasing AI's ability to mimic human conversation in limited domains.[11]

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[7] Aristotle. Posterior Analytics. Translated by Hugh Tredennick. Cambridge: Harvard University Press, 1960.
[8] Warren S. McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," The Bulletin of Mathematical Biophysics 5, no. 4 (1943): 115-133.
[9] John McCarthy et al., "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence," 1956, Dartmouth College Archives.
[10] Nick Bostrom, Superintelligence: Paths, Dangers, Strategies (Oxford: Oxford University Press, 2014), 20-25.
[11] Joseph Weizenbaum, "ELIZA—A Computer Program for the Study of Natural Language Communication between Man and Machine," Communications of the ACM 9, no. 1 (1966): 36-45.

In the 1980s and 1990s, AI experienced renewed interest with the advent of expert systems.[12] These systems, based on rule-based programming, were adopted in specialized fields like medicine and engineering. However, their limitations—such as the rigidity of rule-based systems—led to their decline.

A major breakthrough came in the late 1990s with the rise of machine learning (ML).[7] IBM's Deep Blue, which defeated chess champion Garry Kasparov in 1997, demonstrated AI's ability to solve complex, strategic problems.[13]

By the 2010s, advancements in big data, improved algorithms, and computational power ushered in a new era of AI.[14] Neural networks and deep learning enabled machines to achieve unprecedented accuracy in tasks like image recognition, speech processing, and language translation.

As AI matured, its applications have expanded into public administration, where governments are increasingly recognizing its potential to enhance efficiency and decision-making. AI's integration into public systems has followed two primary pathways: automating administrative tasks and providing decision-support tools.[15],[16]

The automation of repetitive tasks is the streamlining of routine activities, such as processing tax returns, issuing permits, and handling citizen inquiries. For instance, governments use AI-driven chatbots to respond to public queries efficiently, freeing human workers for

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[12] Edward A. Feigenbaum, Knowledge Engineering: Principles and Applications (Stanford: Stanford University Press, 1981).
[13] Feng-Hsiung Hsu, Behind Deep Blue: Building the Computer that Defeated the World Chess Champion (Princeton: Princeton University Press, 2002).
[14] Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning (Cambridge: MIT Press, 2016).
[15] Tim O'Reilly, *The Future of Government in the Age of AI* (Sebastopol: O'Reilly Media, 2018), 35-37.
[16] Andrew W. Lo and Ajay Agrawal, “The Future of Public Health: AI-Driven Innovation,” *The Journal of Public Health Policy* 41, no. 1 (2020): 110-121.

complex tasks.[17] These applications reduce administrative delays, improve citizen satisfaction, and minimize errors.

AI's capacity to analyze vast datasets has made it a valuable tool for policymakers, allowing for rough data-driven decision making. Predictive analytics allow governments to anticipate trends and allocate resources effectively. In healthcare, AI algorithms are used to predict disease outbreaks by analyzing social and environmental data, enabling proactive public health measures.[11]

AI systems have also been deployed to detect fraudulent activities in welfare programs, tax filings, and healthcare claims. Pattern-recognition algorithms identify anomalies that signal potential fraud, saving millions in public funds annually.[18] Additionally, AI-driven tools assist law enforcement agencies in crime prediction and surveillance, though such applications raise ethical concerns about privacy and bias.[19] AI is integral to the development of smart cities, where it manages urban infrastructure, optimizes traffic flow, and monitors energy consumption. For example, AI-powered sensors and systems are used in public transportation networks to reduce congestion and improve service reliability.[20]

Despite its challenges, AI continues to gain traction in public administration, offering innovative solutions to complex governance issues. To harness AI's potential responsibly, governments must prioritize ethical considerations, invest in workforce training, and ensure public trust through transparency and accountability.

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[17] Andrew W. Lo and Ajay Agrawal, “The Future of Public Health: AI-Driven Innovation,” *The Journal of Public Health Policy* 41, no. 1 (2020): 110-121.
[18] Lisa G. Klein, “AI and Fraud Detection in Public Administration,” Journal of Policy Analysis and Management 39, no. 2 (2020): 230-245.
[19] Sarah Brayne, Predict and Surveil: Data, Discretion, and the Future of Policing (Oxford: Oxford University Press, 2020), 95-98.
[20] Anthony M. Townsend, Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia (New York: W. W. Norton, 2014), 45-47.

Current uses of AI

The integration of AI into emergency management is revolutionizing how disasters are anticipated, responded to, and recovered from globally.[21] AI technologies enable early-warning systems, optimize resource allocation, and enhance communication during crises, among other applications, offering solutions that were previously unattainable.[22] While the field is still evolving, AI's transformative potential in emergency management is evident through real-world applications and global case studies in the last decade.

AI-powered Large Language Models (LLMs), such as LLAMA2, are revolutionizing crisis communication by interpreting real-time social media and messaging data.[23] These systems alert emergency responders to emerging situations and overcome language barriers to disseminate timely information to the public. AI-based chatbots further support emergency communication by answering routine inquiries, guiding individuals through evacuation procedures, and alleviating human responders' workload.[24] By automating responses and providing immediate assistance, these technologies ensure vital information reaches affected populations swiftly.

AI has significantly enhanced early-warning systems by integrating vast datasets with machine learning algorithms to predict disaster events such as earthquakes, tsunamis, and wildfires. Predictive models analyze environmental factors using satellite imagery, geological

[21] Otal, Hakan, and M. Abdullah Canbaz. 2024. "AI-Powered Crisis Response: Streamlining Emergency Management with LLMs." Department of Information Sciences and Technology. University at Albany, SUNY, Albany, NY, United States.
[22] Visave, Jaideep . 2024. "AI in Emergency Management: Ethical Considerations and Challenges." Article in Journal of Emergency Management and Disaster Communications. University of North Carolina at Greensboro.
[23] Braik, Abdullah, and Maria Koliou. 2024. "Automated building damage assessment and large-scale mapping by integrating satellite imagery, GIS, and deep learning." Zachry Department of Civil and Environmental Engineering, Texas A&M University, College Station, Texas, USA.
[24] Sun, Li, Haijiang Li, Joseph Nagel, and Siyao Yang. 2024. "Convergence of AI and Urban Emergency Responses: Emerging Pathway toward Resilient and Equitable Communities." Applied Science. MDPI, Basel, Switzerland.

data, and weather patterns, providing real-time insights that alert authorities to impending disasters.[15] For example, Japan's Meteorological Agency (JMA) utilizes AI in its Earthquake Early Warning (EEW) system, one of the world's most efficient and advanced earthquake prediction systems.[16] The EEW system uses AI-driven probability algorithms to analyze seismic waves and deliver early warnings to citizens and merchants before the shaking reaches their area. This system has proven invaluable in saving lives and minimizing destruction during earthquakes and other natural disasters since its implementation. Similarly, India is leveraging AI to predict monsoon rainfall. Researchers at the Indian Institute of Technology Delhi, along with other institutions, have developed a data-driven AI model that combines historical rainfall data, El Niño-Southern Oscillation (ENSO) indices, and Indian Ocean Dipole (IOD) values to forecast the All Indian Summer Monsoon Rainfall (AISMR).[25] This model outperforms traditional physical models, offering more accurate and timely forecasts. Given that a significant portion of India's population depends on agriculture, which is highly sensitive to rainfall variability, accurate monsoon predictions are critical. These forecasts guide resource allocation, disaster preparedness, and policy decisions related to water management, agriculture, and broader economic planning. In the United States, NASA's Fire Information for Resource Management System (FIRMS) showcases another innovative application of AI in early-warning systems.[26] FIRMS utilizes satellite data and AI algorithms to detect and map wildfires in real time across

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[15] Otal, Hakan, and M. Abdullah Canbaz. 2024. "AI-Powered Crisis Response: Streamlining Emergency Management with LLMs." Department of Information Sciences and Technology. University at Albany, SUNY, Albany, NY, United States.
[16] Visave, Jaideep . 2024. "AI in Emergency Management: Ethical Considerations and Challenges." Article in Journal of Emergency Management and Disaster Communications. University of North Carolina at Greensboro.
[25] Ling, Mei, and Remi Thomas. 2022. "Data-Driven Disaster Management: Leveraging Big Data Analytics for Preparedness, Response, and Recovery." Department of Big Data in Agriculture, Bogor Agricultural University. Vishwakarma University, Department of Travel & Tourism.
[26] Ortiz, Ben, Laura Kahn, Marc Bosch, Philip Bogden, Viveca Pavon-Harr, Onur Savas, and Ian McCulloh. 2020. "Improving Community Resiliency and Emergency Response with Artificial Intelligence." Proceedings of the 17th ISCRAM Conference – Blacksburg, VA, USA.

the globe. By providing detailed information about the location and intensity of fires, the system enables firefighters and emergency personnel to allocate resources effectively to the most affected regions. These AI-powered systems are critical in reducing casualties and enhancing the efficiency of emergency response, ultimately transforming disaster preparedness and management worldwide.

The integration of AI and geospatial technologies, particularly through WebGIS, is transforming disaster management by enhancing real-time situational awareness.[27] These advanced tools allow emergency managers to monitor disaster zones, optimize evacuation routes, and allocate resources effectively, leading to more efficient and effective responses. One of the most notable advancements in this field is the fusion of satellite imagery, GIS, and deep learning, which has significantly improved the accuracy and efficiency of post-disaster damage assessments.[17] Building on these advancements, integrating geotagged building databases with GIS has further improved accuracy by eliminating errors in AI-based building identification. Such capabilities enable faster decision-making and prioritization of response efforts during emergencies when time is of the essence. Deep learning models, particularly Convolutional Neural Networks (CNNs), have revolutionized damage classification by automating the analysis of satellite imagery.[17] These models categorize damage levels as "no damage," "major damage," or "destroyed," drastically reducing the reliance on time-consuming manual inspections. Fine-tuning CNN models with manually classified samples has enhanced their adaptability to diverse disaster scenarios, ensuring greater reliability across various contexts. Recent innovations have

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[17] Braik, Abdullah, and Maria Koliou. 2024. "Automated building damage assessment and large-scale mapping by integrating satellite imagery, GIS, and deep learning." Zachry Department of Civil and Environmental Engineering, Texas A&M University, College Station, Texas, USA.
[27] Nakayenga, Harriet Norah, Brian Akashaba, Evans Twineamatsiko, Ivan Zimbe, Iga Daniel Ssetimba, Jimmy Kinyonyi Bagonza, and Eria Othieno Pinyi. 2024. "Leveraging AI for real time crime prediction, disaster response optimization and threat detection to improve public safety and emergency management in the US." World Journal of Advanced Research and Reviews, 23 (03), 1907–1918.

streamlined the damage assessment process, automating tasks from image acquisition to the creation of large-scale damage maps. This end-to-end automation delivers actionable insights to emergency managers with unprecedented speed and precision. Beyond damage assessments, AI is reshaping emergency response planning. By incorporating geospatial layers such as flood zones and road networks, AI-driven tools generate data-informed evacuation routes that improve operational efficiency and reduce risks for affected populations.[20]

Additionally, advancements in reinforcement learning (RL), a subset of AI, enable adaptive decision-making in dynamic post-disaster environments. For example, deep reinforcement learning (DRL) has been applied in France to prioritize critical repairs in damaged road networks, such as partially restoring key bridges to quickly reestablish functionality.[20] AI's ability to analyze diverse data sources, including satellite imagery, aerial photography, and sensor data, further streamlines disaster management efforts. Automated systems can rapidly identify damaged areas and assess severity, guiding response efforts and prioritizing repairs. This approach, successfully employed after disasters such as Hurricane Harvey in 2017[17] and the 2023 earthquake in Turkey,[15] saves time and resources while ensuring recovery efforts remain comprehensive and objective. By integrating AI-driven damage assessments with RL-based planning systems, emergency managers can optimize resource allocation, prioritize recovery efforts, and enhance overall response efficiency. This seamless combination of AI and geospatial technologies highlights their transformative potential in disaster management, paving the way for more resilient and adaptive response systems.[28]

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[28] Narang, Udit, Kushal Juneja, Pankaj Upadhyaya, Popat Salunke, Tanmoy Chakraborty, Swadhin Kumar Behera, Saroj Kanta Mishra, and Akhil Dev Suresh. 2024. “Artificial intelligence predicts normal summer monsoon rainfall for India in 2023.” Nature Portfolio. Scientific Reports, 14:1495.

Building on these advancements, Microsoft Copilot Studio's capability to develop AI-driven agents presents significant opportunities for government entities managing complex administrative, security, and policy-related tasks.[29] One notable application is in automated policy analysis and legislative drafting. By integrating AI-driven natural language processing (NLP) models, government agencies can streamline the creation and review of policies and legislative documents, enhancing efficiency and accuracy in the policymaking process.[30] This approach allows for the rapid analysis of extensive textual data, facilitating more informed decision-making. In emergency response coordination, AI-driven agents developed through Copilot Studio can play a crucial role. These agents can facilitate real-time data analysis and support decision-making in disaster management scenarios, improving response times and coordination across various agencies.[31] For instance, during natural disasters, AI agents can analyze incoming data to provide actionable insights, assisting emergency management teams in deploying resources more effectively.[25] This capability enhances the overall responsiveness and effectiveness of governmental emergency operations.

AI is revolutionizing emergency management by enhancing predictive capabilities, optimizing resource allocation, improving crisis communication, and streamlining damage assessment. As technology continues to advance, AI’s role in disaster preparedness, response, and recovery is poised to grow, offering unprecedented opportunities to save lives and resources. There is so much actively being done with AI that we have yet to fully explore, like how the International Federation of Red Cross and Red Crescent Societies are actively exploring AI for

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[29] Khan, Adeel. 2024. Introducing Microsoft Copilot for Managers: Enhance Your Team’s Productivity and Creativity with Generative AI-Powered Assistant. Inside Copilot. Apress.
[30] Microsoft. 2024a. "What is Microsoft Copilot?" Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/fundamentals-what-is-copilot-studio
[31] Rosén, Fabian, and Moritz Rübner. 2024. “Augmented Large Language Models for Software Engineering.” LUP Student Papers, Lund University, INTM01 20241, Innovation Engineering.

needs assessment and resource distribution.[16] For the second half of this Capstone project, the team plans to build on this foundation by conducting interviews with emergency managers across the state—and potentially nationwide. These interviews aim to provide firsthand insights into the practical, real-world applications of AI in the United States, complementing the academic research already reviewed. This approach will help bridge the gap between current theories and practices, shedding light on how AI is actively shaping emergency management strategies today.

Interview responses of AI being implemented in emergency management

To gain a deeper understanding of how AI is being integrated into emergency management, we conducted interviews with professionals actively working in the field. Their insights shed light on AI's real-world applications, ongoing challenges, and emerging opportunities. While some agencies have embraced AI for operational efficiency, planning, and cybersecurity, others are still in the early stages of adoption, cautiously navigating its risks and benefits.

The following accounts highlight AI's evolving role in emergency preparedness, response, and recovery across different organizations. They illustrate how AI is enhancing decision-making, streamlining administrative tasks, and even detecting cybersecurity threats—while also revealing the limitations, ethical considerations, and gaps in training that agencies must address as they move forward with AI integration.

Wise County Office of Emergency Management, Cody Powell

Rather than starting with specific problems in mind, Wise County Emergency Management began its AI journey by exploring the technology's possibilities. Through hands-on testing of various AI platforms, the county identified numerous potential applications. Cody Powell from the Wise County Emergency Management Office shared insights into AI's current use, future potential, and associated challenges for the county. The first implementation of AI in Wise County is a chatbot designed as a digital phone book for county employees. Over time, this chatbot will evolve into an FAQ assistant, helping direct citizens to the correct offices—such as for ticket payments, which currently involve multiple locations and often cause confusion.

Beyond chatbots, Wise County EM is working on AI-driven tools for legal document review, project management, and grant research. These implementations underscore the county's commitment to leveraging AI for operational efficiency and improved public service delivery.

The notion of eliminating bias in AI systems is often presented as a universal goal, but Wise County EM challenges this premise. AI bias can be strategically utilized to drive positive change. For instance, if an AI model is subtly biased toward technology adoption, it could facilitate smoother transitions for employees as the county modernizes its systems over the next few years.

Wise County EM maintains that AI models should not be stripped of all bias indiscriminately. Instead, the organization will assess specific biases on a case-by-case basis, eliminating them only when necessary and justified. This perspective acknowledges that bias, when understood and managed correctly, can serve as a tool for organizational change rather than an inherent flaw.

Cybersecurity is not an area where Wise County EM balances AI with risk—it is an area where AI is actively enhancing security measures. Shortly after deploying an AI platform, the county's IT department tested its capabilities by analyzing server logs. Within hours, the AI detected an ongoing botnet attack that had previously gone unnoticed. This real-time detection exemplifies how AI is an integral part of Wise County's cybersecurity framework rather than a competing priority.

State-level bans on platforms like TikTok and Da-Jiang Innovations (DJI) have had no effect on Wise County's AI strategy. The county never relied on these technologies for official use, and their prohibition has not influenced AI adoption within local government operations.

This demonstrates the county's independent approach to technology selection, focusing on tools that align with its operational needs rather than external regulatory actions.

Wise County EM currently does not engage in formal collaboration with state or federal agencies to standardize AI use in emergency management. While open to sharing its AI initiatives with higher-level organizations, the county prefers to maintain autonomy to avoid bureaucratic delays. Given the rapid evolution of AI, Wise County believes independent innovation allows for faster, more effective adoption than waiting for centralized directives. However, the county remains willing to cooperate with other entities should meaningful collaboration arise.

Wise County EM anticipates that public concerns regarding AI will diminish as AI tools become integrated into daily operations. Rather than framing systems as "AI," the county foresees these technologies being recognized by their specific functions, such as a phone directory bot or a memo generator. This shift mirrors past technological adoptions—just as people stopped referring to computers as "computers" and instead referenced specific software like Zoom or ESRI, AI will become an embedded, unremarkable aspect of government operations. As AI becomes normalized, transparency concerns will likely subside, reducing the need for extensive public outreach or oversight committees dedicated solely to AI-related issues.

Wise County EM has built funding into its AI project for "developer tools," allowing for continued exploration of emerging AI technologies. While specific platforms have not yet been selected, potential options include Mindix, GitHub Co-Pilot, and JetBrains. The county intends to use GovAI as its core AI platform while building custom tools on top of it. This approach ensures flexibility and adaptability as AI capabilities continue to expand.

City of Dallas Office of Emergency Management, Josh Tincopa

AI is gradually making its way into local government emergency management strategies, including in the City of Dallas. However, its use remains in its early stages, with a primary focus on assisting with planning rather than direct response operations or public communication. Josh Tincopa from the City of Dallas provided insights into how AI is currently utilized, its future potential, and the challenges associated with its adoption.

At present, the City of Dallas employs ChatGPT as its sole AI tool in emergency management. The application of ChatGPT is primarily limited to assisting in planning efforts by providing initial drafts and brainstorming ideas for emergency response strategies. While the AI-generated content serves as a useful starting point, it undergoes thorough review and modification by staff to ensure accuracy and relevance. This cautious approach highlights the importance of human oversight in leveraging AI for emergency preparedness.

Despite the use of AI, there is currently no formal training for local government employees on how to operate AI tools. The adoption of AI remains limited, with only a few individuals incorporating it into their workflow. AI has not yet been integrated across the entire department, reflecting the early stage of its implementation. However, there is an expectation that AI will become a fundamental tool in emergency management in the future, necessitating a structured training program to enhance proficiency and ensure responsible use.

One notable gap in the City of Dallas's AI strategy is the lack of coordination with state or federal agencies regarding AI-related cybersecurity concerns. Cybersecurity remains a critical aspect of AI adoption, particularly in emergency management where sensitive information and real-time decision-making are involved. As AI adoption grows, collaboration with higher-level government entities will likely become necessary to establish security protocols and safeguard against potential cyber threats.

One promising area for AI application in emergency management is crisis communication. The City of Dallas is actively working on developing standardized message templates for different emergency scenarios. AI could play a significant role in streamlining the creation of these messages, ensuring consistency and efficiency. However, the city does not currently plan to use AI to directly communicate with the public. The potential risks associated with misinformation and the need for human oversight remain key concerns. As AI capabilities advance, implementing safeguards to verify the accuracy of AI-generated content will be essential before expanding its role in public communication.

San Jacinto College Emergency Management Office, Ali Shah

Ali Shah from the San Jacinto College Emergency Management Office shared insights into AI's current use, future potential, and associated challenges for the college. At present, the only AI tool utilized in our college's emergency management strategies is ChatGPT. This tool serves primarily as a starting point for planning efforts, providing initial drafts and frameworks for various emergency planning items. However, AI-generated content is not used verbatim; rather, staff members refine and edit the outputs to ensure accuracy and relevance. While AI plays a minor role, its potential for greater integration in emergency management is evident.

Despite the use of AI, there is no formal training in place for local government employees to understand or operate these tools effectively. The current application of AI remains very basic and limited to specific tasks. As AI technology continues to evolve, it is likely to become a staple tool in emergency management. However, adoption is still in its infancy, and its use is not widespread across departments or among all staff members. In the future, structured training programs may become necessary to maximize AI’s benefits while ensuring proper implementation during emergencies.

Coordination with state and federal agencies on AI-related cybersecurity issues in emergency management is currently lacking. There has been little engagement with these partners to address AI-specific challenges in cybersecurity. Given the increasing reliance on AI tools, establishing clear communication and collaboration with higher government levels will be essential to developing robust cybersecurity measures. AI’s role in emergency management will likely expand, necessitating enhanced cooperation to mitigate potential risks associated with its use.

One of the most promising applications of AI in local emergency management is its potential role in crisis communication. In the near future, AI could be instrumental in developing message templates for various emergency scenarios. Standardized messaging would ensure consistency and efficiency in public communications. However, while AI-generated content may assist in drafting messages, direct AI communication with the public is not anticipated in the immediate future. Safeguards will need to be implemented to prevent misinformation and ensure that AI-generated messages align with verified emergency protocols.

The integration of AI in local government emergency management is still in its early stages. While ChatGPT is used as a planning tool, its application remains limited, and formal training on AI tools is not yet in place. There is also a lack of coordination with state and federal agencies regarding AI-related cybersecurity. However, the future holds promise, particularly in the development of standardized crisis communication templates. As AI technology continues to advance, emergency management agencies must consider structured adoption strategies, training programs, and cybersecurity collaborations to maximize AI's benefits while mitigating potential risks.

Texas A&M University Emergency Management Office, Amanda Fox

Cody Powell from the Texas A&M University Emergency Management Office shared insights into AI's current use, future potential, and associated challenges for the university. Currently, AI is utilized in limited capacities within our emergency management office. Most applications involve built-in software for basic tasks such as spelling and grammar checks. Additionally, AI-powered tools like ChatGPT are used to generate preliminary structures for documents, such as tables of contents, which are then refined based on human expertise. These AI-generated drafts serve as comparative baselines rather than final products, ensuring that human judgment remains central to the decision-making process.

In the realm of security and surveillance, AI plays a more prominent role. Our audio-visual surveillance technology employs AI to track and analyze movement, placing identification boxes around individuals and detecting vehicle speeds. However, the primary function of this AI is to assist in counting and monitoring rather than actively making decisions about emergency response. Other campus entities, such as University Police and Transportation Services, may leverage this data further, particularly for managing large events.

AI has also been used for social media planning when creative inspiration is lacking. While AI-generated plans provide a useful foundation, they are never fully implemented without human revision. This reflects a cautious approach, ensuring that messaging remains relevant and appropriately tailored to the target audience.

Looking ahead, AI presents numerous possibilities for enhancing emergency management. However, concerns persist about the limitations of AI-generated content. A key example is FEMA’s use of AI for course creation, which has led to overly generic templates designed to accommodate national needs. These templates often include information irrelevant to specific jurisdictions, such as guidance on earthquakes or volcanoes in areas where those threats are nonexistent.

If AI is to be effectively integrated into emergency preparedness and disaster response education, it must be adaptable to local conditions. AI's ability to process large datasets could improve risk assessments, optimize resource allocation, and enhance situational awareness. However, any AI-generated outputs would require careful human oversight to ensure their applicability and accuracy for specific communities.

At this stage, discussions regarding AI bias in emergency management decision-making have not been a major focus within our institution. However, the potential for bias in AI-generated crisis communication is a significant concern. Effective emergency messaging requires an understanding of the audience, context, and cultural nuances—areas where AI still struggles. Given AI’s reliance on pre-existing datasets, it may inadvertently reinforce biases present in historical data, leading to skewed assessments of risk and resource distribution.

While AI bias is more widely recognized in image generation, text-based AI models also require rigorous scrutiny. In the future, any AI-generated messaging would need extensive human editing to maintain clarity, relevance, and inclusivity.

Cybersecurity remains an area outside of our direct expertise, but it is an essential consideration for AI adoption. Protecting student and faculty data is a priority, and any AI-driven tools implemented in emergency management must adhere to stringent data security standards. As AI becomes more integrated into emergency response systems, institutions must collaborate with cybersecurity experts to mitigate risks associated with data breaches, hacking, and misinformation.

State regulations have influenced our institution's approach to technology adoption, though not necessarily AI. For example, Texas has banned TikTok at the state level, preventing any emergency management outreach on the platform. However, this policy has not significantly impacted our overall perspective on AI's role in emergency planning, student alerts, or training simulations.

Currently, AI usage in emergency management is more of a discussion topic than an operational reality. Among higher education emergency management professionals, conversations are ongoing about how AI might be standardized for campus emergency preparedness and response. No formal guidelines or protocols have been established yet, though this will likely change as AI becomes more prevalent.

The topic of AI in emergency management is scheduled for discussion at the Southeastern Conference (SEC) Police Chiefs & Emergency Managers meeting in April. While it may not provide immediate updates for current research projects, it highlights the growing interest in AI's role in emergency preparedness.

At present, our emergency management program at Texas A&M University has not engaged in public discussions regarding AI in emergency management. However, from a personal standpoint, verifying AI-generated information remains a crucial practice. Just as with any online information, AI-generated content should be scrutinized for accuracy, reliability, and potential misinformation.

Texas Department of Public Safety and Texas Rangers, Eric Baker and Ryan Sollock

In a joint interview with the Chief Data Officer of the Department of Public Safety, Eric Baker, and Texas Ranger, Ryan Sollock, we were able to gain valuable insight into how artificial intelligence is being utilized in investigations, law enforcement operations, and emergency management. The integration of AI has transformed emergency management operations, presenting both challenges and opportunities. Insights from the Texas Rangers, a division of the Department of Public Safety (DPS), highlight key considerations in AI governance, data security, inter-agency collaboration, and ethical implications. These lessons can be applied to enhance operational efficiency while ensuring legal and ethical compliance.

A structured approach is essential for introducing AI into emergency management. Agencies must establish clear policies governing data collection, processing, and use while adhering to relevant laws and ethical standards. A data classification framework should be implemented to differentiate between public information, sensitive criminal justice data, and health records. This will help secure appropriate levels of access and ensure data protection. Additionally, an oversight committee should be formed to evaluate new AI tools, mitigate bias, and promote transparency in decision-making.

AI has already proven valuable in border security and criminal investigations. The Texas Rangers have successfully deployed AI models to identify individuals, narcotics, and vehicles with 98% accuracy in surveillance operations. Expanding AI-assisted drone operations could further enhance real-time intelligence gathering and law enforcement response capabilities. AI filtering could also help distinguish between environmental triggers and genuine security threats, reducing false alarms in surveillance systems.

However, data-sharing limitations between agencies often hinder collaboration. To address this, a centralized platform should be developed, enabling authorized personnel to securely share information. The “Bridge to Public Safety” verification project aims to facilitate inter-agency communication while safeguarding personal data. Additionally, tools like the Team Awareness Kit (TAK) should be expanded to allow emergency responders to share plans, images, and locations in real time.

Training is a crucial component of AI integration. Emergency management personnel must receive training not only on AI tools but also on ethical AI use, data handling, and the limitations of AI-generated reports. Vendors should be required to provide practical, field-based training to ensure effective implementation. AI-powered tools can significantly enhance public safety by improving data analysis capabilities.

For example, systems like First Alert by Dataminr can monitor social media and public data for potential threats, while AI-driven data feeds can enhance decision-making within virtual command centers. Predictive modeling can identify high-risk areas, allowing agencies to allocate resources more effectively. However, human oversight remains critical in all AI-driven decision-making processes.

Public trust is essential for AI adoption in emergency management. Agencies must ensure transparency by documenting decision-making processes and conducting public awareness campaigns to inform citizens about AI use in law enforcement. Guidelines should be established to prevent AI bias and discrimination, and procurement processes should remain accessible to the public, except in cases involving classified security matters. Policies should align with recommendations from the Governor’s AI Council to ensure compliance with state and federal mandates.

Despite its benefits, AI can also be exploited by criminal organizations. Cartels, for instance, use AI and drones for drug trafficking and other illicit activities. Law enforcement must collaborate with federal agencies to counteract these threats, utilizing technologies such as drone-jamming and AI-assisted forensic analysis.

To strengthen national security, intelligence-sharing agreements must be implemented to combat AI-enabled criminal activity. By adopting these strategies, emergency management agencies can leverage AI while maintaining transparency, accountability, and public trust. The lessons learned will serve as a foundation for developing responsible AI policies and practices that enhance both security and operational efficiency.

City Detect, Gavin Baum-Blake

In the aftermath of Hurricane Helene, Greenville, South Carolina, leveraged cutting-edge artificial intelligence (AI) technology developed by City Detect to rapidly and effectively manage recovery efforts. Gavin Baum-Blake, representative of City Detect, provided comprehensive insights into how this innovative AI technology significantly enhanced the city's emergency response capabilities.

City Detect, established in 2021, was inspired by a challenge from a municipal official who asked whether computer vision and AI could be utilized to manage urban issues, particularly blight. According to Baum-Blake, "Blight is effectively urban decay. So basically anything that's wrong with the property," encompassing various issues like graffiti, abandoned vehicles, and structural deterioration. Over the ensuing years, the company expanded its technological capabilities significantly, developing approximately 45 specialized AI models capable of identifying about 145 distinct municipal concerns. Baum-Blake noted, "We've developed about 45 AI models that do just that. We found about 145 different things. It's not relegated to simply property decay; we're able to detect all sorts of different issues throughout communities."

The real-world test for City Detect's adaptability occurred following the devastating impact of Hurricane Helene on Greenville. Utilizing their sophisticated camera infrastructure mounted on municipal vehicles such as street sweepers and trash trucks, City Detect rapidly identified, cataloged, and mapped storm-related damages throughout the city. Baum-Blake highlighted, "Following Hurricane Helene, we were able to use our camera infrastructure to pick up all of the different instances of storm damage to properties in the city. We've identified this mechanism to detect and map out where all sorts of different issues are, adapting quickly to what's happening in real time." Specifically, he mentioned, "In just one-week post-Hurricane Helene, our AI models successfully detected around 3,000 piles of debris and delineated over 1,200 miles worth of damage collection routes."

A report created by City Detect for the City of Greenville titled "Greenville Hurricane Helene Recovery & FEMA Audit Solution"[32] substantiates Baum-Blake's claims, underscoring the efficiency of AI-driven assessments. By swiftly identifying and mapping damages, the city could streamline resource allocation, prioritize cleanup activities, and better document the recovery process for FEMA audits. Such documentation is crucial in ensuring transparency and efficiency in recovery operations, ultimately benefiting the affected residents through accelerated restoration of normalcy.

The proactive nature of City Detect's AI technology offers substantial benefits beyond immediate disaster response. Baum-Blake emphasized that the approach significantly enhances efficiency, reduces carbon emissions from fewer municipal vehicles conducting separate

[32] Baum-Blake, G. 2024. City Detect - City of Greenville. Greenville Hurricane Helene Recovery & FEMA Audit Solution. Interview with Gavin Baum-Blake (2025).

inspections, and optimizes human resource deployment. He explained further, "We're able to proactively identify issues without running additional sweeps, increasing efficiency, reducing carbon emissions, and reducing boots-on-the-ground time. Municipalities can spend more time efficiently responding to complaints rather than searching for problems."

Security concerns associated with AI technologies, particularly regarding data integrity and privacy, were also addressed comprehensively. Baum-Blake assured, "Our data center is fully encrypted. It's a cloud-based organization, everything is stateside, and we have strict access controls. We have end-to-end encryption for everything we do, and all of our users are required to use two-factor authentication."

The use of City Detect’s AI solutions in Greenville serves as a testament to the transformative potential AI holds for municipal management. Particularly in scenarios of crisis management, such as the aftermath of Hurricane Helene, AI’s capacity to enhance responsiveness and operational effectiveness cannot be overstated. Baum-Blake emphasized the importance of municipalities embracing technological innovations, stating, "Cities adopting such technologies are better positioned to manage crises efficiently, enabling faster recovery and significantly minimizing long-term disruptions to community life."

Looking forward, Baum-Blake expressed City Detect’s ambition to expand and refine their technology further, with plans already underway to engage additional municipalities nationwide. He concluded, "We're excited to continue expanding and refining our technology to help more communities nationwide."

Copilot and Copilot Studio: Generative AI Tools for Government

Generative AI has seen significant advancements in recent years, particularly in business and government applications.[33] Microsoft's Copilot and Copilot Studio represent two major developments in this space. Copilot is a ready-to-use AI assistant integrated into Microsoft 365 applications, while Copilot Studio is a platform that allows users to customize and extend the capabilities of Copilot according to their specific needs.[34] Copilot Studio serves as a graphical, low-code tool that facilitates the creation of AI-driven agents, empowering organizations to build tailored AI solutions that align with their operational goals.[35] This paper analyzes Copilot and Copilot Studio, emphasizing their functionalities, compliance with government regulations, and their potential role in transforming administrative processes.

Microsoft Copilot and Copilot Studio: Functionalities and Capabilities

Copilot is designed as an AI-powered assistant embedded within Microsoft 365 applications to enhance productivity and efficiency.[33] By leveraging large language models (LLMs), Copilot assists users with document drafting, email responses, data analysis, and other workplace tasks.[36] It works within Microsoft applications without user customization.[37] Unlike Copilot, which is a predefined AI assistant, Copilot Studio offers a customizable AI-building platform, enabling users to create "agents" that handle complex interactions and automate decision-making processes.[33]

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[33] Linkon, A. A., Shaima, M., Sarker, M. S. U., Nabi, N., Rana, M. N. U., Ghosh, S. K., and Chowdhury, F. R. 2024. "Advancements and Applications of Generative Artificial Intelligence and Large Language Models on Business Management: A Comprehensive Review." Journal of Computer Science and Technology Studies 6 (1): 225–232.
[34] Microsoft. 2024. "What is Microsoft Copilot?" Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/fundamentals-what-is-copilot-studio
[35] Microsoft. 2024b. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc
[36] Khan, Adeel. 2024. Introducing Microsoft Copilot for Managers: Enhance Your Team's Productivity and Creativity with Generative AI-Powered Assistant. Inside Copilot. Apress.
[37] Rosén, Fabian, and Moritz Rübner. 2024. "Augmented Large Language Models for Software Engineering." LUP Student Papers, Lund University, INTM01 20241, Innovation Engineering.

A key feature of Copilot Studio is its graphical, low-code environment, which allows users to develop AI agents without extensive programming knowledge. Copilot enhances productivity apps, i.e., Word, Excel, Outlook, PowerPoint, by leveraging Microsoft Graph and Semantic Indexing to refine prompts and personalize responses.[33] These agents integrate multiple AI models, contextual instructions, knowledge sources, and user-defined triggers to facilitate autonomous decision-making and response generation.[34] The tool is particularly beneficial for organizations that require customized AI solutions to manage workflows, customer service, and compliance-related tasks.

Microsoft Copilot Architecture

Microsoft's Copilot is an AI-powered assistant designed to enhance user productivity by leveraging Large Language Models (LLMs) trained on extensive text datasets. This AI-driven tool operates through a structured three-step process.[38]

First, it employs Natural Language Processing (NLP) to analyze and interpret user inputs, enabling it to comprehend and contextualize the task at hand. Second, based on its training data and underlying AI models, Copilot processes the input to generate relevant suggestions or actions. [37] Lastly, it delivers the generated responses in various formats, such as text, code, or structured data, assisting users in completing their tasks efficiently.[34] By seamlessly integrating into Microsoft applications, Copilot provides a streamlined and intuitive user experience without requiring extensive customization.

[33] Microsoft. 2024. "What is Microsoft Copilot?" Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/fundamentals-what-is-copilot-studio
[34] Microsoft. 2024. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc
[38] Khan, Adeel. 2024. Introducing Microsoft Copilot for Managers: Enhance Your Team's Productivity and Creativity with Generative AI-Powered Assistant. Inside Copilot. Apress.

Microsoft Copilot is integrated across a variety of Microsoft applications, including Word, Excel, and Teams, enabling real-time AI-powered assistance for document creation, data analysis, and communication. [34] Copilot leverages generative AI models to assist with drafting emails, summarizing meetings, and automating repetitive tasks within business workflows.[34] By doing so, it enhances user efficiency and reduces the cognitive load associated with manual operations.[39]

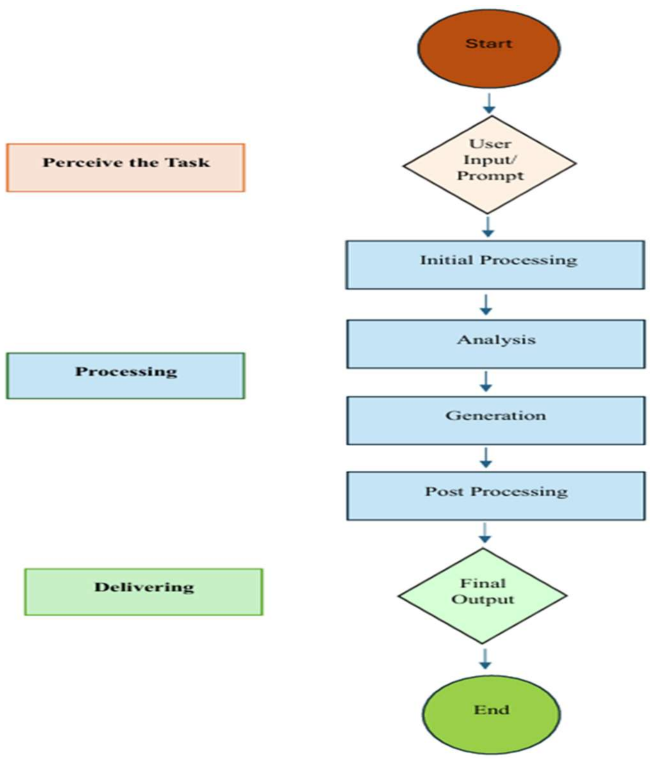

Figure: Copilot Functional Diagram
Source: Khan, Adeel. 2024. *Introducing Microsoft Copilot for Managers: Enhance Your Team's Productivity and Creativity with Generative AI-Powered Assistant.* Inside Copilot. Apress.

[34] Microsoft. 2024. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc
[39] Lahnalampi, Aino. 2024. Utilizing Large Language Models in Rail Design Projects. Master's thesis. Insinööritieteiden Korkeakoulu, Master's Programme in Spatial Planning and Transportation Engineering (SPT), Aalto University.

The AI assistant continuously refines its outputs based on contextual cues, ensuring that responses are tailored to user needs and improving accuracy over time.[40] These capabilities make Copilot a critical tool in modern digital workspaces, where automation and AI-driven insights play an increasing role in productivity.[41]

Microsoft Copilot Studio is a low-code platform that empowers users to create and customize AI-driven Copilot experiences tailored to specific organizational needs.[42] This customization platform enables the development of AI agents capable of handling a range of interactions and tasks without requiring extensive technical expertise.[43] Users can design these agents to perform various functions, from resolving complex conversations to autonomously determining the best actions based on context and instructions.

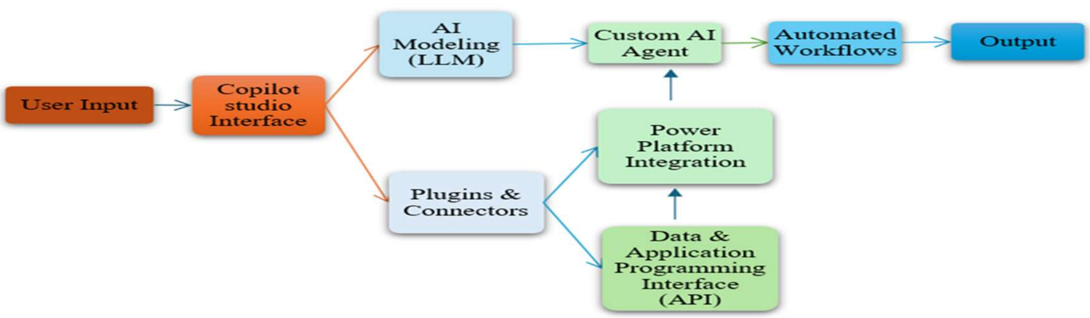

Figure: Copilot Studio Functional Diagram

[40] Khan, Adeel. 2024. Introducing Microsoft Copilot for Managers: Enhance Your Team's Productivity and Creativity with Generative AI-Powered Assistant. Inside Copilot. Apress.
[41] Lahnalampi, Aino. 2024. Utilizing Large Language Models in Rail Design Projects. Master's thesis. Insinööritieteiden Korkeakoulu, Master's Program in Spatial Planning and Transportation Engineering (SPT), Aalto University.
[42] Microsoft. 2024. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc
[43] Deena, D., C. Prasad, and J. Geetha. 2024. "Intelligent Conversational AI for Microsoft Teams with Actionable Insights." In 2024 8th International Conference on Computational System and Information Technology for Sustainable Solutions (CSITSS), 1–5. IEEE.

A significant feature of Copilot Studio is its seamless integration with Microsoft's Power Platform, including tools like Power Automate, Dataverse, and Power Virtual Agents.[44] This integration allows users to automate workflows, manage data efficiently, and deploy conversational AI agents across multiple channels.[45] For instance, by connecting with Power Automate, users can design multi-step workflows that streamline business processes, while Dataverse provides a unified data repository to support these applications.[46] Power Virtual Agents enable the creation of intelligent chatbots that can engage with both employees and customers, providing real-time assistance and information.[47] These integrations improve the functionality and adaptability of AI-powered automation within businesses.

Copilot Studio also offers support for plugins and connectors, facilitating the development of custom Copilot solutions for internal or external use. Users can integrate external databases and services, such as Dynamics 365, Salesforce, ServiceNow, and SAP, to enhance the functionality of their AI agents. [43] The platform’s environment management capabilities ensure scalability and allow for role-specific configurations, enabling organizations to tailor their AI solutions to meet diverse operational requirements. [45] Additionally, Copilot Studio supports the creation of AI chatbots and workflow automation, extending its utility beyond standard productivity tools and enabling the deployment of conversational AI and task automation across various business functions.[43]

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[44] Microsoft. 2024. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc
[45] Bahmed, Bruna Moema. 2024. Integrated Development Environments: Exploring the Impact of Implementing Artificial Intelligence on Workflow Efficiency and Its Potential for Developer Displacement. Laurea magistrale thesis. Università di Bologna, Corso di Studio in Digital Transformation Management [LM-DM270] - Cesena.
[46] Parnin, C., G. Soares, R. Pandita, S. Gulwani, J. Rich, and A. Z. Henley. 2023. “Building Your Own Product Copilot: Challenges, Opportunities, and Needs.” arXiv preprint arXiv:2312.14231.
[47] Zhang, C., S. He, J. Qian, B. Li, L. Li, S. Qin, and Q. Zhang. 2024. “Large Language Model-Brained GUI Agents: A Survey.” arXiv preprint arXiv:2411.18279.

Challenges of AI in Emergency Management

As artificial intelligence becomes increasingly integrated into critical sectors, such as national security, emergency management, and public policy, the risks associated with AI-generated misinformation grow in parallel. Two primary concerns emerge: deliberate misinformation crafted by adversaries leveraging AI for information warfare and unintentional hallucinations generated by AI systems themselves. Adversarial entities can exploit AI to spread disinformation, manipulate public perception, and disrupt operations, posing significant security threats. Meanwhile, AI hallucinations—instances where AI models produce false or misleading information—can undermine decision-making and erode trust in automated systems.

Adversarial AI-generated misinformation

AI has introduced new vulnerabilities into emergency management systems (EMS) by allowing for the facilitation of malicious use and abuse, especially during critical situations like natural disasters. AI-controlled or enabled attacks can disrupt information flow, manipulate public perception, and create widespread confusion during emergencies. These attacks utilize AI's scalability and speed to perform harmful actions at a larger scale than traditional methods, posing significant risks to the integrity and functionality of EMS.

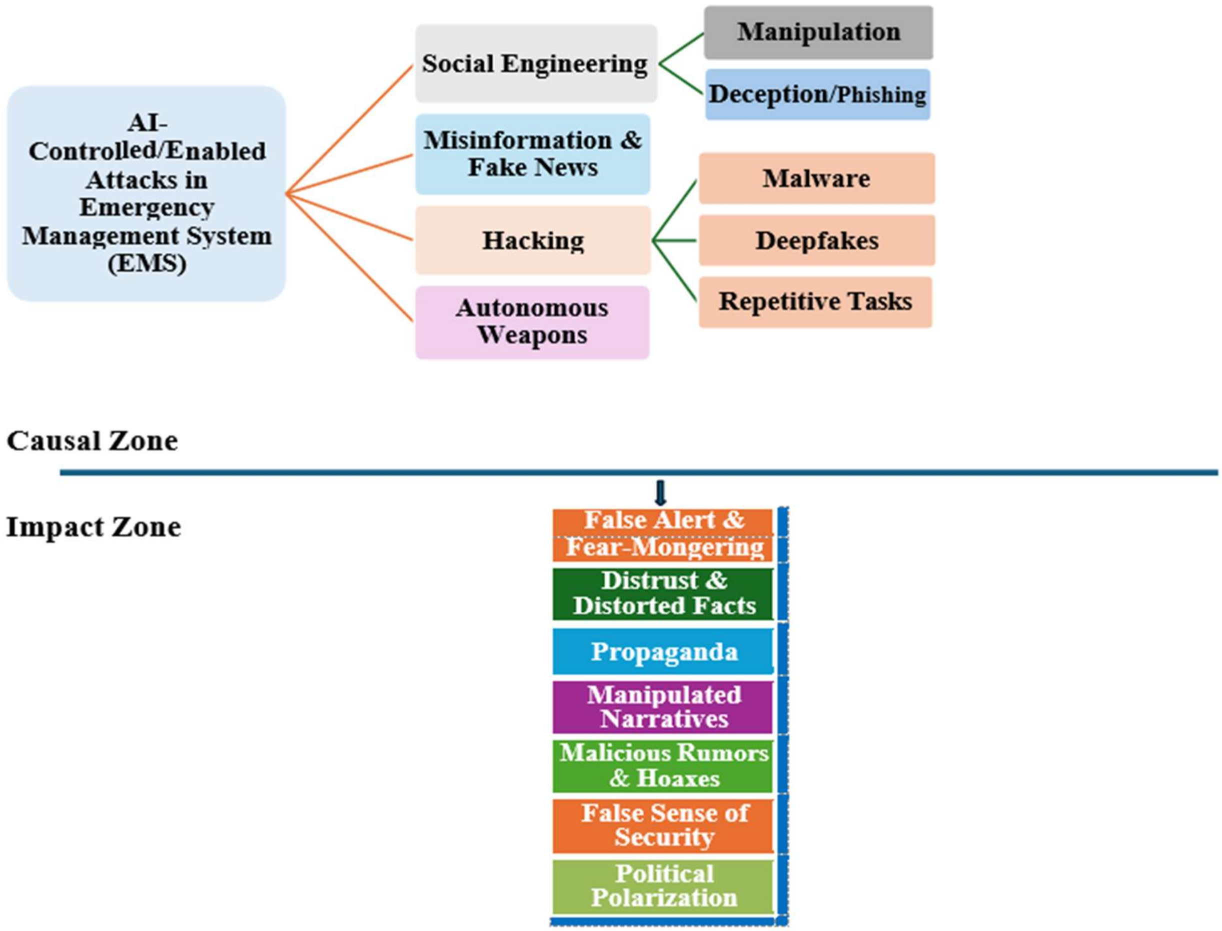

Figure 01: An Overview of Malicious Use of Artificial Intelligence [47]

AI-based attacks in EMS typically involve several types of threats. Social engineering is one of the most prominent, with AI enhancing traditional deception techniques to manipulate individuals into revealing sensitive information or taking harmful actions (See Figure 01). AI's ability to gather and analyze data allows attackers to personalize messages, making manipulation more effective. Additionally, phishing attempts, aided by AI bots, can generate fraudulent communication that appears highly convincing to the recipient, increasing the likelihood of successful attacks. [48]

[48] Blauth, Taís Fernanda, Oskar Josef Gstrein, and Andrej Zwitter. 2022. "Artificial Intelligence Crime: An Overview of Malicious Use and Abuse of AI." *IEEE Access* 10: 77110-77122.

Misinformation and fake news are particularly dangerous during emergencies, as AI can quickly create and disseminate false information, leading to public panic and mistrust. For instance, AI-generated fake alerts or narratives can spread fear, cause confusion, and erode trust in EMS and official communications. By amplifying fear and distorting facts, AI-driven misinformation campaigns can undermine the public's confidence in emergency response, delaying appropriate actions and putting lives at risk.[47] Another significant threat is AI-assisted hacking, which can exploit vulnerabilities in EMS systems. AI can automate hacking techniques, such as malware creation or password cracking, enabling faster and more efficient breaches of EMS networks. Furthermore, deepfakes—AI-generated fake videos or audio recordings—can impersonate emergency officials, misleading responders and the public alike. These attacks can cause critical failures in coordination and response, further exacerbating the crisis.[47]

In the most extreme cases, AI-enabled autonomous weapon systems pose a direct threat to EMS infrastructure. These systems can be manipulated to target critical facilities, causing physical damage and escalating emergencies. The risks of AI-controlled attacks are particularly high during emergencies, as attackers exploit the heightened state of uncertainty and fear to maximize the impact of their attacks.[47] So, by introducing chaos, impacting on emotional health, undermining trust, polarizing society, and delaying critical responses, AI-driven attacks can put lives at risk during emergencies (See Figure 01).

[47] Blauth, Taís Fernanda, Oskar Josef Gstrein, and Andrej Zwitter. 2022. "Artificial Intelligence Crime: An Overview of Malicious Use and Abuse of AI." *IEEE Access* 10: 77110-77122. https://doi.org/10.1109/ACCESS.2022.3191790.

Non-adversarial AI-generated misinformation

In the emergency management field, it is essential to convey true information to citizens when communicating preparation efforts, rescue operations, and information regarding the intensity and damage left behind from a natural disaster or intense storm. Researchers and scientists have begun to coin a term for falsified information from AI called "AI hallucination" or "AI fabrication." These are simply errors generated by AI platforms in relaying accurate information and are typically found in open-source AI.

For example, platforms such as ChatGPT have seen some instances in which queries are sent into the program, and ChatGPT reports back some misconstrued information that the regular user may understand as truth and fact. This non-adversarial falsified information can be separated into three categories: input-conflicting, context-conflicting, and fact-conflicting. [49] Input-conflicting information can occur when the user inputs information that is incorrect, whether they are aware of it or not, and the AI platform does not correct it. Context-conflicting information occurs when circumstances reported by an AI platform are not structured correctly and result in faulty reporting.[48] Fact-conflicting information from AI platforms consists of instances where the platform gives distorted information of facts already known to be true. The unintentional fabrication of information by AI platforms can cause repercussions for those using the platform to report information to large groups such as their organization or the community in which they serve.

[49] Sun, Y., Sheng, D., Zhou, Z. *et al.* 2024. "AI Hallucination: Towards a Comprehensive Classification of Distorted Information in Artificial Intelligence-Generated Content". *Humanities and Social Sciences Communications* 11, 1278. https://doi.org/10.1057/s41599-024-03811-x

Types of False information

There are different types of false information that can be reported by AI depending on the intentions or lack thereof by the author/user of the platform. Generally false information is often referred to as "distorted information". When coupling in the author's intent, the type of information falls into two categories: disinformation, which describes information that was input to be intentionally false, and misinformation, false information that is not intentionally fabricated.[48] Misinformation is more common than disinformation in professional fields and organizations because sometimes AI platforms analyze the information as consistent when given an inquiry.

Table 1. Falsified AI Definitions [48]

Concept	Explanation
Al Hallucination	"Al hallucination" has not yet solidified into a university agreed-upon definition. In our research, "Al hallucination" refers to the phenomenon where artificial intelligence generates distorted information.
Distorted Information	Distorted information refers to false or inaccurate information regardless of intentional authorship.
Disinformation	Disinformation refers to deliberately fabricated distorted information.
Misinformation	Misinformation refers to inadvertently produced distorted information.

These kinds of distorted information from AI can be detrimental to the public and emergency management operations. Misinformation can commonly be seen throughout different forms of media such as social media posts and digital platforms.[48]

This occurrence seems more prominent today and puts the public at a disadvantage when they are attempting to seek out information.[48] When the public consumes misinformation from AI on media platforms, their behaviors and opinions toward emergency officials or environmental occurrences can be altered based on the false information consumed. Situations such as these are crucial to avoid, and solutions like additional safeguards employed by organizations, like authenticating access to AI platforms or utilizing an agency to mold an AI platform for a specific use by an organization, can help avoid such misinformation being spread.[48]

AI generated content like photographs and videos are also examples of falsified information from these platforms. There has been a proliferation of AI generated content being used as a tool for spreading panic and false occurrences to the public in the aftermath of natural disasters. To combat these falsities from being widely believed, emergency management operations and state and local news media agencies and governments should employ measures to prevent releasing such material and have safeguards and channels in place to inform the public of false images.

Platforms such as ChatGPT have common mistakes when it is recognized that the platform has reported false information. Aspects like wit and humor, discrimination, bias, and factual errors are the most common occurrences ChatGPT suffers from when reporting misinformation.[48] As a user of AI, it is of the utmost importance to double and triple check information that comes out of a general AI platform if the information is being passed along to others. Doing extra fact checking with verified scholarly sources can help stop the spread of misinformation and help individuals and organizations form the habit of ensuring information is indeed factual and being used to promote efficiency in the workplace and for safety reasons. Employing levels of content analysis on information reported by AI platforms like ChatGPT would be useful for identifying shortcomings in information, if any.

Verification of AI-Generated or Disseminated Rumors During Emergencies

When assessing a potential rumor during an emergency, it is essential to start by verifying the source (See Figure 2). Ensure that the information is reported by reputable news outlets or verified by official websites, government pages, or legitimate social media accounts. Rumors and false information often spread through obscure or unreliable sources that lack credibility and verification. [50] By confirming the origin of the information, especially through established media, the chances of identifying AI-generated rumors increase. AI-generated content typically lacks support or verification from trusted entities, making it easier to flag.

To further validate information, using fact-checking platforms such as Snopes, FactCheck.org, and PolitiFact can be effective. These platforms rely on experts who manually inspect and debunk rumors, making them reliable resources for identifying misinformation. [49] Many social media platforms, like Twitter (X) and Facebook (Facebook's Third-Party Fact-Checking Program), have also integrated fact-checking mechanisms that flag suspicious content with links to verified information. Using these tools early in the rumor propagation stage can prevent false information from spreading widely. [49]

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[50] Choi, D., Oh, H., Chun, S., Kwon, T., and Han, J. 2022. "Preventing Rumor Spread with Deep Learning." Expert Systems with Applications 197: 116688. https://doi.org/10.1016/j.eswa.2022.116688.

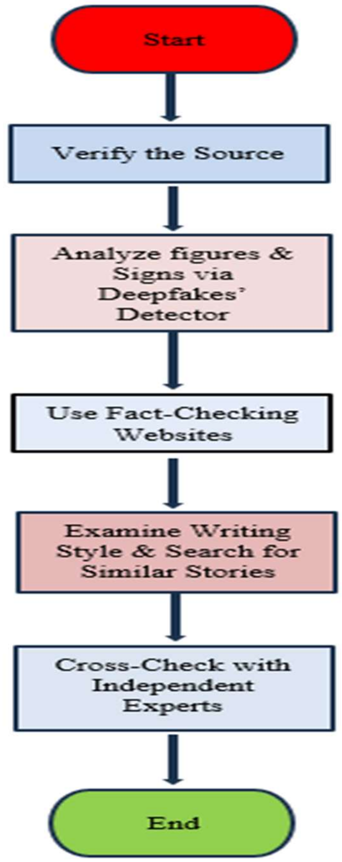

Figure 02: Flowchart of checking AI generated or spread rumors during emergencies.

In cases where rumors involve multimedia, looking for inconsistencies such as unnatural facial movements, mismatched lighting, or awkward audio syncing can help identify AI- generated deepfakes. AI-driven technologies, particularly deep learning-based models are adept at generating fake content. [49] Tools like Deepware Scanner or Deepfake Detector can assist in identifying tampered media by analyzing such details. The study proposes models for early detection, which can accurately identify these patterns before a rumor goes viral. AI-generated text often carries distinct characteristics, such as repetitive phrasing, a lack of context, or a robotic tone. The use of deep learning-based models, such as the Bidirectional Encoder Representations from Transformers (BERT) pre-trained model, analyze claim sentences and extract linguistic features to distinguish true from false claims. [49] Tools like

GPT-2 Output Detector can help assess whether a text was generated by AI, offering further insight into the information's authenticity.

When encountering suspicious claims, reverse image searches on platforms like Google Images or TinEye can trace the origin of any associated pictures. This approach helps determine whether images have been manipulated to support a false rumor. It is important to note to analyze textual and visual features to detect manipulated claims, especially in categories like "fauxtography," where fake images are commonly spread. [49] Searching for similar stories or quotes in credible sources can also help verify the legitimacy of a claim. For a more thorough verification, consulting independent experts in the relevant field can be valuable. Independent analysis from industry experts or scholars adds another layer of credibility and helps ensure that false claims are refuted accurately.

During crises, AI-generated misinformation and rumors, such as fake evacuation orders, false casualty reports, or manipulated visual content, can spread rapidly, creating chaos. For example, social engineering-based cyberattacks during the COVID-19 pandemic leveraged AI to produce credible-looking misinformation that exploited human vulnerability and trust in digital platforms. [51] In response, cross-verification with official sources is essential (See Figure 02). Information must be compared against trusted government websites, verified social media accounts, or official hotlines to prevent the amplification of false information.

Studies during the COVID-19 pandemic highlighted that false AI-generated news regarding lockdowns or medical treatments quickly circulated on social media, forcing

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[51] Hijji, Mohammad, and Gulzar Alam. 2021. "A Multivocal Literature Review on Growing Social Engineering Based Cyber-Attacks/Threats During the COVID-19 Pandemic: Challenges and Prospective Solutions." *IEEE Access* 9: 7152-7167. https://doi.org/10.1109/ACCESS.2020.3048839.

government health departments and fact-checking agencies to continuously debunk these false reports through official statements and press conferences. [52]

Moreover, detecting and verifying AI-generated deepfakes and fake audio/visual content is another challenge. In some cases, AI-edited videos or images can make false events, such as explosions or fabricated emergency broadcasts, seem believable. Human intervention remains necessary for analyzing inconsistencies in this content to confirm its authenticity. Research shows that during disaster-related emergencies, transparency about the identity of AI-generated content is critical to maintaining public trust in the information disseminated. [53] Engaging communities to report suspicious or unverified claims is an effective strategy to dispel rumors. For example, after the 2020 Beirut explosion, local communities helped flag and debunk false claims, enabling authorities to respond quickly and control panic.

Having a set framework used for identifying false information and ensuring information is factual can be extremely helpful when delivering information to an organization and the public. Defining what falsities are being researched can help narrow the investigation and make it more efficient. Choosing your samples based upon the type of research can aid in the accuracy of the analysis. These steps can then result in identifying which of the distorted information categories the errors fall into, whether they be factual, contextual, biased, etc. After identifying these characteristics, organizations can then determine how the issue occurred and what technology/coding mechanisms can be put in place to avoid similar outcomes in the future. It is important to review the success of such

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[52] Almomani, H., & Al-Qur'an, W. (2020). The extent of people's response to rumors and false news in light of the crisis of the Corona virus. *Annales Médico-Psychologiques, 178*(7), 684–689. https://doi.org/10.1016/j.amp.2020.06.011
[53] Tao, Xin. 2023. *Exploring Trustworthiness Issues About Disaster-Related Information Generated by Artificial Intelligence*. PhD diss., University of South Carolina. ProQuest Dissertations & Theses Global.

measures over time to determine whether or not they are successful in preventing false information from AI platforms. [54] Again, these stages should be adjusted according to the kind of errors present and the organization utilizing the platform and conducting the content analysis.

For emergency management purposes, being aware of the different types of false information that can be derived from AI, as well as the common mistakes made by these platforms, can be beneficial for organizations who are determining whether to employ AI technology in day-to-day operations. Organizations should thoroughly investigate which platforms are most suitable for their mission and purpose and ensure safety measures and policies for use are established when implementing AI platforms into workplace practices.

Ethics and Moralities: Reducing Political Polarization in Emergency Situations

In the realm of emergency management, particularly in the face of AI-generated misinformation, ethical communication becomes pivotal. Reducing political polarization within emergency response communication is not only an ethical imperative but a practical necessity. The politicization of emergencies can distract from critical public health and safety priorities, potentially undermining trust in official channels. Ethical guidelines for AI applications in emergency management, therefore, emphasize the importance of maintaining neutrality and fairness in disseminating information to the public. This approach aligns with the broader ethical responsibility to focus on collective welfare, as discussed in humanitarian ethics,

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[54] Sun, Y., Sheng, D., Zhou, Z. *et al.* 2024. "AI Hallucination: Towards a Comprehensive Classification of Distorted Information in Artificial Intelligence-Generated Content". *Humanities and Social Sciences Communications* 11, 1278. https://doi.org/10.1057/s41599-024-03811-x

where overcoming the humanitarian-political divide enhances ethical standards in crisis response.[55]

AI-driven emergency communication tools should be structured to uphold values that foster unity rather than division. By adopting frameworks grounded in moral philosophies like utilitarianism—which prioritizes the greatest good for the greatest number—AI systems can be programmed to filter out bias in emergency alerts and avoid language that might provoke division or misinterpretation along political lines. For example, AI applications should aim to reinforce messages that are empathetic and universally relevant rather than ideologically charged. Research on the COVID-19 crisis has shown that utilitarian decision-making often aligns with prioritizing public health over individual liberties, reinforcing the value of impartiality in decision-making under crisis. [56]

The ethical use of AI in managing misinformation also implies transparency and accountability. The public must trust that AI-generated information is both factual and devoid of partisan influences, especially when addressing sensitive topics like health risks or evacuation protocols. By upholding these ethical standards, emergency communication can serve as a stabilizing force in times of crisis, reducing societal divisions and reinforcing a collective commitment to public welfare.

Systematic Discipline: Avoiding Partisan Conflict During Emergencies

Systematic discipline within political discourse during emergencies refers to the commitment by political parties to set aside differences and refrain from divisive rhetoric that

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[55] Givoni, Michal. 2011. "Beyond the Humanitarian/Political Divide: Witnessing and the Making of Humanitarian Ethics." *Journal of Human Rights* 10(1): 55-75. https://doi.org/10.1080/14754835.2011.541394.
[56] Navajas, Joaquin, Facundo Álvarez Heduan, Gerry Garbulsky, Enzo Tagliazucchi, Dan Ariely, and Mariano Sigman. 2021. "Moral Responses to the COVID-19 Crisis." *Royal Society Open Science* 8(210096): 1-14. https://doi.org/10.1098/rsos.210096.

could undermine the crisis response. When political entities use emergencies to critique or denounce each other, the risk of public confusion and erosion of trust increases significantly. Disciplined communication ensures that information disseminated to the public remains focused on immediate safety and recovery, thereby minimizing the potential for AI-generated misinformation to exploit inter-party conflicts.

Historically, successful emergency responses have often involved bipartisan cooperation, where parties unite to reinforce the same message. For instance, just as public support can drive Congressional approval for humanitarian interventions despite political divides, bipartisan solidarity in crisis management can maintain focus on essential public welfare rather than political differences. [57] This discipline is especially critical in AI, as sophisticated AI tools can detect patterns in speech and amplify narratives that attract engagement—potentially escalating polarization if political figures use charged language. Thus, systematic discipline in avoiding incendiary commentary is essential to prevent AI from reinforcing divides and to promote a unified, credible front during times of crisis.

Parties that commit to disciplined and unified communication set an example, promoting stability and assuring the public that the focus remains on resolution rather than partisanship. Ultimately, systematic discipline in crisis communication builds a more resilient emergency management framework, enabling clearer, more effective responses that are less susceptible to the risks posed by AI-driven misinformation campaigns.

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[57] Hildebrandt, Timothy, Courtney Hillebrecht, Peter M. Holm, and Jon Pevehouse. 2013. "The Domestic Politics of Humanitarian Intervention: Public Opinion, Partisanship, and Ideology." Foreign Policy Analysis 9(3): 243–266. https://doi.org/10.1111/j.1743-8594.2012.00189.x.

Case Study: Hurricane Helene Response

The aftermath of Hurricane Helene presented many demonstrations as well as opportunities missed for the utilization of AI technologies during the recovery effort. It also comes as no surprise that AI technologies were employed with counterproductive motivations. The US Army's immediate response, particularly in the Southern Appalachia region, was littered with examples of AI integration. In the initial phases of response and recovery, the Army utilized AI to map road closures, cellular outages, and other data. Most beneficially, the Army was able to develop a triage order of distribution for aid and scarce resources.[58] The Army developed the Maven Smart System to combine geolocation data and satellite imagery into an AI tool to inform ground conditions. Initially this tool was developed to inform battlefield tactics and support target identification, but great use was found in natural disaster response. The Maven Smart system was able to provide more isolated levels of support apart from what was largely benefiting the centralized command. Smaller ground units were able to calculate appropriate amounts of water aid to bring along their route or where to send medical supplies.[59] The Army's experience with the Marven System is best moralized by stressing the importance of situational awareness. These AI technologies were able to provide data to support decision-making that was otherwise in question.

The response to Hurricane Helene was heavily scrutinized. Many argue that conditions have remained unattended for far too long, and that the federal government has underdelivered as the chief authority or even further burdened the effort to address the aftermath. These

[58] Wentling, Nikki. "How the Army Is Using AI during Hurricane Helene Relief." Defense News, October 8, 2024. https://www.defensenews.com/news/your-military/2024/10/08/how-the-army-is-using-ai-during-hurricane-helene-relief/.
[59] "Maven Smart System." Missile Defense Advocacy Alliance. Accessed March 18, 2025. https://missiledefenseadvocacy.org/maven-smart-system/.

observations can be boiled down to either a failure of policy or a failure of communication and cooperation. Perhaps the types of AI technologies we discuss in this paper cannot remedy failures of policy, but there is evidence to support that AI integration in intragovernmental relationships and communication lines can provide beneficial outcomes. Many AI technologies have been deemed capable of taking data collected from several different entities and generating a singular report for data collection. This can be especially beneficial for situations that involve missing pieces, differing technologies, and depth of material. Additionally, AI sources can be utilized to streamline communication, establish protocol, and coordinate amongst a conglomerate of agencies and or centers of operations, thus limiting confusion or redundancy in service delivery.[60]

It is important to note the prevalence of misinformation during Hurricane Helene. Specific AI tools were deployed in a counteractive measure to response efforts and public relations by developing fake images of damage and current conditions. The most likely detriment that these images had for emergency management was in public perception and the spreading of false information. There are ways AI can be used to counteract these fake images including AI systems that can process and identify AI generated images such as Hive Moderation or Sightengine.[61]

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[60] Guzman, Andrea L. "Artificial Intelligence and Communication: A Human–Machine Communication Research Agenda." Sage journals: Discover world-class research. Accessed March 18, 2025.

[61] "Fake Hurricane Helene Images Go Viral, Experts Discuss the Problem and How to Counteract." Virginia Tech News | Virginia Tech, October 7, 2024. https://news.vt.edu/articles/2024/10/AI-fake-hurricane-helene-photo-images-experts.html.

Case Study: California Wildfires

The California wildfires of early 2025 were among the most destructive in recent history, with over 35,000 acres burned, at least 24 confirmed deaths, and thousands of structures destroyed. [62] However, alongside the devastation caused by the fires themselves, a flood of misinformation emerged on social media platforms, much of it amplified by AI and political narratives. This section explores the various forms of misinformation surrounding the California wildfires, the role of AI in generating and spreading false information, and the consequences for public perception and emergency response.

AI-generated misinformation became a significant issue during the California wildfires. One of the most striking examples was the spread of deepfake images depicting the Hollywood sign engulfed in flames. McAfee threat researchers verified that these images were AI-generated and traced them back to the AI-based platform Gemini, which allowed the creation of fake images within seconds. [63]A particularly convincing deepfake video of the Hollywood sign on fire accumulated over 1.3 million views on Facebook within 24 hours, highlighting the speed at which misinformation can spread when combined with AI technology. [61]

Bill Chappell described how AI-generated images of the Hollywood sign were not only widespread but also poorly executed, with one widely shared image even misspelling "Hollywood". [64] Despite these obvious errors, the realistic nature of AI-generated content led many to believe the Hollywood sign was burning. Jeff Zarrinnam, chair of the Hollywood Sign

[62] Klug, T., & Wesolowski, K. (2025). Fact check: Viral claims on California wildfires. DW.
[63] McFarland, C. (2025). The Hollywood Sign is Not on Fire: Deepfakes Spread During L.A. Wildfires. McAfee Blog.
[64] Chappell, B. (2025). LA's wildfires prompted a rash of fake images. Here's why. NPR.

Trust, confirmed that the sign was never in danger, though the misinformation created panic and overwhelmed emergency response systems with false reports. [62]

The sophistication of AI-generated content and the ease with which it can be produced contribute to its potential to mislead. Farid, a professor at the University of California, Berkeley, noted that creating AI-generated deepfake images has become so simple that they can be produced on a smartphone, which increases the likelihood of their use in misinformation campaigns. [62]

In addition to AI-generated misinformation, political narratives further complicated the public understanding of the wildfires. President-elect Donald Trump claimed that California's wildfires were exacerbated by Governor Gavin Newsom's refusal to sign a "water restoration declaration" that would have allowed more water to flow from Northern California to Los Angeles for firefighting purposes. [60] This claim was widely circulated after Elon Musk reshared it on his platform, X (formerly Twitter), where it received nearly 38 million views. [60]

Fact-checkers quickly debunked the claim, confirming that no such "water restoration declaration" existed. According to Erik Scott, Public Information Officer for the Los Angeles Fire Department, the actual issue stemmed from infrastructure limitations rather than a lack of water. While water supplies were strained due to high demand, there was no evidence that Governor Newsom's policies were to blame. [60] Similarly, Mark Gold, a water scarcity expert at the Natural Resources Defense Council, stated that California had sufficient water reserves, but the local water system's infrastructure could not deliver water quickly enough to meet firefighting demands. [65]

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[65] Cercone, M., & McCullogh, T. (2025). Fact-checking misinformation about the Los Angeles wildfires and California water policy. PBS News.

In another misleading claim, Donald Trump Jr. alleged that the Los Angeles Fire Department's shortage of equipment resulted from donations of supplies to Ukraine. Fact-checkers confirmed that while surplus equipment had been sent to Ukraine in 2022, this did not affect firefighting capacity in California. The real issue was understaffing and the scale of the wildfires, which exceeded the local firefighting capacity. [60]

The consequences of this misinformation were significant. First, it undermined public trust in official sources of information and emergency response efforts. Chappell noted that the flood of fake images of the Hollywood sign caused unnecessary panic and confusion, distracting emergency services from actual threats. [62]

Second, misinformation about water policy and firefighting capacity threatened to politicize the response to the disaster. By blaming Governor Newsom for infrastructure problems beyond his control, Trump's statements shifted attention away from the broader issues of climate change and emergency preparedness. [63]

Finally, AI-generated misinformation highlighted the need for improved public awareness and technological tools for detecting deepfakes. McAfee researchers recommended increased skepticism when encountering viral content and the use of AI-based detection tools to identify manipulated media. [61]

The California wildfires of 2025 highlighted the dangerous intersection of AI-generated misinformation and political narratives. Deepfake images and misleading political claims not only distracted emergency responders but also fueled public confusion and mistrust. Combating this growing threat will require a combination of technological solutions, stronger media literacy, and more responsible political communication. The rapid rise of AI-generated misinformation underscores the urgent need for comprehensive strategies to manage its impact on both public perception and disaster response.

Policy and Governance of AI

AI is changing the way we manage emergencies through better predictions, automatic processes, and improved decisions. However, AI can improve disaster response and recovery operations through integration only with all-encompassing policies. Using AI will require regulations, reliable data, ethics, and the cooperation of different agencies. To ensure the effective use of AI in responding to disasters, governments must create clear rules to regulate this technology use. When not used properly, people will lose trust in technology, and it will not be useful in handling disasters. One significant issue is transparency and accountability since the decisions driven by AI should be explainable and auditable. Agencies involved in emergency responses should use Explainable Artificial Intelligence (XAI) approaches, which will ensure that humans can interpret and justify the recommendations generated by AI. [66]

In emergencies involving AI, its role should be to support human decision-making rather than operate autonomously. For example, decisions such as issuing evacuation orders or determining priorities in search and rescue efforts should remain under human authority, with AI serving as an advisory tool to enhance situational judgment. It is important for regulations to ensure AI compliance with privacy and civil rights laws. AI technology used in disaster response relies on real-time information from social media, CCTV, and satellite imagery, which can trespass on privacy. AI usage that involves data collection should be consistent with the Privacy

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[66] Brundage, M., Avin, S., Wang, J., Belfield, H., Krueger, G., Hadfield, G., & Dafoe, A. (2020). Toward trustworthy AI development: Mechanisms for supporting verifiable claims. *AI & Society, 35*(3), 61-80. https://doi.org/10.1007/s00146-020-00930-3

Act and the Freedom of Information Act to prevent unauthorized surveillance. [67] Clear parameters for the use of AI in public safety help ensure that activities do not encroach on civil liberties.

Data Security and Ethical Considerations

AI-based emergency management systems utilize extensive datasets, which means that cybersecurity is an important policy issue. Cyber threats could result in a data breach/AI model adversary attack that may significantly hinder disaster response. Cybersecurity threats, data breaches, and adversarial attacks on AI models could greatly affect response to disasters and require public policies around it. Emergency management systems must be patched up to shield them against all possible data breaches (like zero-day breaches). Thus, policies must force encryption, multi-factor authentication, and continuous threat monitoring. Agencies should also ensure that the AI system's predictive models that forecast disasters are not hacked. Otherwise, tampered disaster forecasts may misdirect emergency responders and worsen threats to lives.

One data point shows that bias occurs when an AI model has unfair assumptions built in. Further, Historical data for disasters can introduce bias into machine learning models, leading to allocating fewer resources to poorer people. Research indicates that biased AI models may lead to delayed assistance or reduced disaster relief in underserved areas. [68] Thus, fairness tests and auditing algorithms should become mandatory through government policy for emergency response usage of AI.

The sharing of data must be governed by protocols. Standardized policies on how AI-generated insights are shared are necessary to ensure smooth functioning of emergency response

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[67] National Institute of Standards and Technology (NIST). (2023). AI risk management framework. *U.S. Department of Commerce*. Retrieved from https://www.nist.gov/itl/ai-risk-management-framework
[68] O'Neil, C. (2016). Weapons of math destruction: How big data increases inequality and threatens democracy. Crown Publishing Group.

of federal, state, and local agencies. If unrestricted data sharing occurs, we could have privacy violations or misuse of sensitive information. Data-sharing pacts must balance transparency with confidentiality with details on who can access, for how long, and for what purpose. [69]

Interagency Coordination and AI Standardization

Emergency management involves multiple stakeholders, including government agencies, nonprofit organizations, and private-sector partners. To avoid experimentation by various agencies, an effective AI policy must create mechanisms for interagency coordination. AI adoption guidelines can boost interoperability among the AI tools being used by FEMA, DHS, and other emergency management agencies. A common policy framework for AI may result in efficiencies in disaster response by reducing the lag and variances in data interpretation.

It is critical that AI governance for emergency management includes public-private partnerships (PPPs). Working with governance experts from technology companies and research organizations can help innovate while preventing regulatory capture and other proprietary lockouts. [70] For instance, the EU's AI Act facilitates public-private cooperation on the use of AI in critical infrastructure while safeguarding ethical aspects. [71] Similar frameworks need to be instituted in the U.S. to ensure that AI innovation is accompanied by accountability in disaster response. Lastly, it's important to prioritize workforce readiness and AI training. Without training on AI uses, emergency responders may misuse AI recommendations or misread their significance.

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[69] European Commission. (2024). The European Union AI Act. *EU Regulation on Artificial Intelligence*. Retrieved from https://ec.europa.eu/ai_act

[70] Brundage, M., Avin, S., Wang, J., Belfield, H., Krueger, G., Hadfield, G., & Dafoe, A. (2020). Toward trustworthy AI development: Mechanisms for supporting verifiable claims. *AI & Society, 35*(3), 61-80. https://doi.org/10.1007/s00146-020-00930-3

[71] European Commission. (2024). The European Union AI Act. *EU Regulation on Artificial Intelligence*. Retrieved from https://ec.europa.eu/ai_act

The proper operation of AI tools must be included in mandatory training programs for emergency response professionals, as per AI governance. [72] If agencies invest in building up AI literacy, they will be able to use AI better in emergencies and ensure that effective decisions are made.

AI's integration into emergency management offers unprecedented opportunities for enhancing disaster preparedness, response, and recovery. AI-driven systems can create unnecessary risks regarding transparency, security, algorithmic bias, and data ethics without a governance framework. In order to ensure the responsible use of AI in emergencies, a thorough AI policy framework must prioritize compliance, security, and interagency coordination.

Uniform AI adoption as well as regulations, along with public-private partnerships and investments in workforce training, will encourage emergency management agencies to harness AI's full potential while maintaining the confidence of the public. Implementing these policy initiatives will mean that AI will be used as a strong tool to increase the national resilience and effectiveness of disaster response.

Workplace Policy Regarding Use of Open AI

The use of open AI has found its way into the workforce across all sectors. Open AI and related technologies have been utilized as a method of enhancing business practices by means of generating ideas, problem-solving, spell-checking, and compiling data, to name just a few. The relative ease of use and the great implications open AI has on efficiency have resulted in widespread hesitancy and an ambiguous ethical dilemma regarding the technology's utilization. This has been especially true in academic spheres.

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[72] National Institute of Standards and Technology (NIST). (2023). **AI risk management framework**. *U.S. Department of Commerce*. Retrieved from https://www.nist.gov/itl/ai-risk-management-framework

Nonetheless, Open AI has been moving forward in workplace settings across the nation and beyond. There have been a plethora of speculated concerns relating to the use of Open AI, many of which stem from the fear that Open AI sources can be meticulously breached and jeopardize sensitive data. A justification as innocent as spell checking could result in a massive breach of sensitive data depending on what project a given employee was attempting to spell check. In acknowledgment of this heavy issue, many private sector companies have taken the initiative to formulate and implement an Open AI policy completely adapted to their needs, concerns, and desire to utilize efficient processes.

Private Sector Policy and Open AI Adaptations

The actions that private sector companies are taking can be summarized in these three pursuits. First, there are companies that enact full bans on open AI sources. JP Morgan chose this path citing a need to protect customer data and prevent instances of fraud. Apple banned Open AI and other AI tools in consideration of its confidential data.

Second, there are companies that take hybrid approaches to an AI ban. This method is often utilized after extensive considerations into the company's unique risk and opportunities to gain efficiency or reap other benefits. Accenture, an IT contracting company, has a partial ban restricting their coding workforce in order to safeguard their intellectual property as well as coding language that belongs to their clientele. Spotify purged all AI-generated songs from its platform, finding them in contradiction to their priorities and affecting artists' royalty rights.

Third, private sector companies take the path of constructing their own Open AI technologies. Amazon built and installed its own Open AI source, deemed "Code Whisperer," to secure control of the AI source's data storing. Amazon took action of this extent after internal research found that Open AI sources were generating responses that directly mirrored their internal data. Constructing Code Whisperer allowed Amazon employees to continue interacting with Open AI in efficient and beneficial manners while securing the company's sensitive data and assuming sole responsibility for any possible breaches. Of course, this option is not always readily available for any entity to mimic. The construction of Code Whisperer required ample resources that are often the benefit of companies as big as Amazon.

Cybersecurity Hierarchy in AI and Emergency Management

The adoption of AI in emergency management will require cybersecurity measures for appropriate protection. This includes protection from sensitive data threats and cyber-attacks. The creation of a layered cybersecurity framework will assist government agencies and emergency responders in coordinating cyber defenses with the resilience of AI Systems.

National-Level Cybersecurity Policy and Oversight

Federal agencies that operate at the highest level—for instance, the Cybersecurity and Infrastructure Security Agency (CISA) and the National Security Agency (NSA)—issue overarching cybersecurity policies/frameworks for AI adoption. Under the Cybersecurity Information Sharing Act[73] and Executive Order 14028 (2021) on Improving the Nation's Cybersecurity[74], these agencies issue risk management directives, facilitate cyber threat intelligence sharing, and establish compliance requirements.

State-Level Cybersecurity Coordination

The emergency management offices at the state level work with state CIOs (chief information officers) and the state's homeland security office to implement and tailor federal

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[73] Cybersecurity and Infrastructure Security Agency (CISA). (2015). Cybersecurity Information Sharing Act. Retrieved from https://www.cisa.gov

[74] White House. (2021). Executive Order 14028: Improving the Nation's Cybersecurity. Retrieved from https://bidenwhitehouse.archives.gov

cybersecurity policies. States are in charge of protecting critical infrastructure, regulating AI emergency messaging systems, and responding to cyber threats through fusion centers that enhance information sharing between Washington and Main Street. [75]

Local Government and Emergency Management Cybersecurity

Local emergency management agencies and county-level organizations use AI-based systems to forecast disasters, send public alerts, and coordinate important responses. Encryption and secure access controls for AI-driven emergency response systems must be implemented by local agencies. Regular cybersecurity training must be done for those in charge of AI data. Work with local cyber units to secure AI against manipulation efforts during crises. Use tools that identify cyber threats to help figure out when breaches occur in real time.

AI-Specific Cybersecurity Protections

AI frameworks utilized where management of emergencies incurs various cyber risks with adversarial attacks, data poisoning, and deepfake misinformation campaigns. Agencies may put in place new advanced measures to address these risks: Using Zero Trust Security Frameworks (ZTA), agencies must continuously check who the user is and stop any unauthorized access. In order to prevent adversarial AI manipulations, secure protocols for AI model training must be employed. In the event of an AI blockchain disruption, agencies should have ransomware negotiation protocols in place.

Public-Private Sector Cybersecurity Collaboration

AI cybersecurity works most effectively in emergency management through public-private partnerships of various companies and government agencies. Firms providing AI

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[75] DHS. (2024). Cybersecurity Strategy for Emergency Management AI Systems. Retrieved from https://www.dhs.gov/topics/cybersecurity

models, such as DeepMind from Google, Microsoft Azure AI, Amazon AWS, etc. work with government agencies for development of best practices of AI security and establishment of resilience measures to cyber-attacks. According to the Biden Administration's National Cybersecurity Strategy (2023), increased investment in AI-driven cybersecurity is expected, along with cooperation between private AI developers and federal agencies to fight against AI-made cyberattacks. [76] Emergency management agencies can adopt a layered approach to cybersecurity that protects AI operations, prevents cyber-attacks, and enables the ethical use of AI for disaster response as well as recovery.

Executive Order 13960 (2020)

This order, titled "Promoting the Use of Trustworthy AI in the Federal Government," was issued in December 2020. It emphasizes the need for federal agencies to adopt AI in a manner that is ethical, transparent, and consistent with national values. "Federal agencies are required to conduct an annual inventory of their AI use cases and share their inventories with other government agencies and the public". [77] Agencies should inventory both existing and new uses of AI. The order outlines principles for the design, development, acquisition, and use of AI in government, focusing on enhancing public trust in AI applications.

H.R.1718 - Artificial Intelligence for National Security Act (2023)

This legislative proposal, introduced in 2023, aims to integrate AI technologies into national security operations. "H.R. 1718, the Artificial Intelligence for National Security Act, addresses a gap in current law that leaves ambiguity as to whether the Department of Defense can procure AI-based endpoint security tools as part of their mission to improve cyber-defenses

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[76] White House. (2021). Executive Order 14028: Improving the Nation's Cybersecurity. Retrieved from https://bidenwhitehouse.archives.gov

[77] EO 13960: Artificial Intelligence (AI) Use Case Inventories, www.cio.gov/assets/resources/2023-Guidance-for-AI-Use-Case-Inventories.pdf.

of their own systems." [78] The act proposes the development of AI tools to enhance defense capabilities, improve intelligence analysis, and strengthen cybersecurity measures. This bipartisan legislation helps ensure that the DoD can create new technologies and invest in cyber capabilities to prevent, respond to, and recover from cyber-attacks. This bill helps make sure the United States can keep pace defensively with the AI deployed by adversaries. It also emphasizes the importance of establishing ethical guidelines to ensure that AI applications align with democratic values and human rights. When introducing any type of AI into national security operations, it is important to ensure the security and trustworthiness of any type of service like it when implemented.

Executive Order 14110 (October 2023)

Signed on October 30, 2023, this order is titled "Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence." It establishes a comprehensive national strategy for AI governance, focusing on promoting competition and innovation in the AI industry, protecting civil liberties, and ensuring national security. The order mandates federal agencies to appoint chief AI officers and develop guidelines for AI use in critical infrastructure and other sectors. It directs over 50 federal entities to engage in more than 100 specific actions to implement the guidance given across eight policy areas. [79] AI holds extraordinary potential for both good and bad, but responsible use can help solve challenges. Irresponsible use could pose a risk to national security, and this is why mitigating the risks is so important.

[78] "Reps. Obernolte, Panetta Introduce Artificial Intelligence for National Security Act." *Representative Jay Obernolte*, 28 Mar. 2023, obernolte.house.gov/media/press-releases/reps-obernolte-panetta-introduce-artificial-intelligence-national-security-act.

[79] Harris, Laurie. *Highlights of the 2023 Executive Order on Artificial Intelligence for Congress*, 3 Apr. 2024, www.congress.gov/crs-product/R47843.

DHS Roles and Responsibilities Framework for AI in Critical Infrastructure (November 2024)

This framework, released by the Department of Homeland Security in November 2024, delineates the department's approach to integrating AI into critical infrastructure sectors. "The choices that organizations and individuals make regarding how AI systems are developed, how they can be accessed, and how they function within larger systems will determine the impact that AI will have when deployed to broad segments of U.S. critical infrastructure." [80] The framework recommends vital roles and responsibilities for safe and secure development and deployment of AI in U.S. critical infrastructure. It outlines the roles and responsibilities of DHS components in adopting AI technologies to enhance security measures, improve response times, and protect critical assets. The framework also addresses the need for collaboration with private sector partners to ensure the resilience and reliability of AI applications in critical infrastructure. There are huge risks posed when implementing AI within critical infrastructure, and it is essential to be aware of all possible vulnerabilities that come with such technology and systems. Poor implementation or misuse could cause harm to critical infrastructure assets, nationally significant systems, or individuals that are served by these systems. Another goal of this framework is to share the best practices through the implementation of technical risk management, routine testing, accountability, and incident response planning. [81]

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[80] "Roles and Responsibilities Framework for Artificial Intelligence in Critical Infrastructure." *Department of Homeland Security*, 14 Nov. 2024, www.dhs.gov/sites/default/files/2024-11/24_1114_dhs_ai-roles-and-responsibilities-framework-508.pdf.

[81] "Roles and Responsibilities Framework for Artificial Intelligence in Critical Infrastructure." *Department of Homeland Security*, 14 Nov. 2024, www.dhs.gov/sites/default/files/2024-11/24_1114_dhs_ai-roles-and-responsibilities-framework-508.pdf.

National Security Memorandum on Responsible AI Use (2024)

Issued on October 24, 2024, this memorandum seeks to advance U.S. leadership in developing safe and trustworthy AI. It directs federal agencies to harness AI for national security purposes while ensuring that its development and deployment adhere to safety, security, and ethical standards. It outlines the U.S. government's strategy to leverage AI for national security while also keeping in mind democratic values and ethics. The memorandum also emphasizes the importance of contributing to international AI governance and the use of AI for national security purposes. Some key objectives of the memorandum are to accelerate AI integration into national security, strengthen AI governance, and ensure responsible AI use. [82] "... the AI NSM directs the U.S. Government to "act with responsible speed and in partnership with industry, civil society, and academia to make use of AI capabilities in service of the national security mission," while ensuring "the safety, security, and trustworthiness of American AI innovation writ large." [83] Providing policy clarity and tasking for federal agencies was a primary objective. This document is by far one of the most comprehensive documents of United States national security strategy and policy towards AI.

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[82] "Memorandum on Advancing the United States' Leadership in Artificial Intelligence; Harnessing Artificial Intelligence to Fulfill National Security Objectives; and Fostering the Safety, Security, and Trustworthiness of Artificial Intelligence | The White House." *National Archives and Records Administration*, National Archives and Records Administration, 24 Oct. 2024, bidenwhitehouse.archives.gov/briefing-room/presidential-actions/2024/10/24/memorandum-on-advancing-the-united-states-leadership-in-artificial-intelligence-harnessing-artificial-intelligence-to-fulfill-national-security-objectives-and-fostering-the-safety-security/?utm_source=chatgpt.com.

[83] Burnette, Ryan. "White House Issues National Security Memorandum on Artificial Intelligence ('AI')." *Covington & Burling LLP*, 13 Nov. 2024, www.cov.com/en/news-and-insights/insights/2024/11/white-house-issues-national-security-memorandum-on-artificial-intelligence-ai.

Role of DHS and FEMA

The role of the Department of Homeland Security (DHS) is to collaborate with state and local governments, private sector partners, and agencies to help during an emergency. It develops partnerships with organizations and authorities as well as preparing for, responding to, and recovering from disasters. It is responsible for cybersecurity, critical infrastructure protection, and emergency preparedness. Under DHS falls the Federal Emergency Management Agency (FEMA) and is the primary emergency management agency. FEMA manages disaster assistance programs and coordinates federal disaster relief and response. They oversee the National Response Framework and National Disaster Recovery Framework (NDRF). [84]

More recently, DHS has released an AI roadmap to help maximize the benefits of technology and advance their mission. "DHS Will Launch Three Pilot Projects to Test AI Technology to Enhance Immigration Officer Training, Help Communities Build Resilience and Reduce Burden for Applying for Disaster Relief Grants, and Improve Efficiency of Law Enforcement Investigations."[85] The three pilots launched will be in Homeland Security Investigations (HSI), Federal Emergency Management (FEMA), and United States Citizenship and Immigration Services (USCIS). These three pilots are evaluating the effectiveness of large language models and generative AI technology at DHS. The most notable pilot of the three is the deployment of AI through FEMA to help communities plan for and develop hazard mitigation plans to minimize risk. "The pilot will specifically support State, Local, Tribal, and Territorial governments' understanding of how to craft a plan that identifies risks and mitigation strategies

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[84] "Disasters: Homeland Security." *U.S. Department of Homeland Security*, www.dhs.gov/topics/disasters.

[85] "Department of Homeland Security Unveils Artificial Intelligence Roadmap, Announces Pilot Projects to Maximize Benefits of Technology, Advance Homeland Security Mission: Homeland Security." *U.S. Department of Homeland Security*, 18 Mar. 2024, www.dhs.gov/archive/news/2024/03/18/department-homeland-security-unveils-artificial-intelligence-roadmap-announces?.

as well as generate draft plan elements—from publicly-available, well-researched sources — that governments could customize to meet their needs."[86] This pilot could lead to more communities having the ability to submit grant applications for funding and being better prepared for disasters that may occur.

Department of Information Resources (DIR)

The DIR has published guidelines to prepare for AI adoption, emphasizing the implementation of risk management frameworks, incorporation of AI considerations into existing processes, and the establishment of acceptable use policies. The DIR tracks technology-related legislation and bills specific to DIR that impact state government. It develops guidelines for AI adoption in government, including disaster response application and establishes policies for responsible AI use. The primary role is to oversee IT policy, cybersecurity, and technology innovation for Texas and state agencies. [87]

NIST AI Risk Management Framework

"The Framework is designed to equip organizations and individuals…with approaches that increase the trustworthiness of AI systems, and to help foster the responsible design, development, deployment, and use of AI systems over time" (NIST). The framework is designed to help organizations manage the risks associated with AI systems. This useful document provides guidance on responsible AI development, deployment, and governance to minimize harm and enhance security. This is a voluntary framework but widely adopted by government agencies to ensure ethical and responsible AI use. "Released on January 26, 2023, the

[86] "Department of Homeland Security Unveils Artificial Intelligence Roadmap, Announces Pilot Projects to Maximize Benefits of Technology, Advance Homeland Security Mission: Homeland Security." *U.S. Department of Homeland Security*, 18 Mar. 2024, www.dhs.gov/archive/news/2024/03/18/department-homeland-security-unveils-artificial-intelligence-roadmap-announces?.

[87] "About Dir." *Department of Information Resources*, dir.texas.gov/about-dir.

Framework was developed through a consensus-driven, open, transparent, and collaborative process that included a Request for Information, several draft versions for public comments, multiple workshops, and other opportunities to provide input. It is intended to build on, align with, and support AI risk management efforts by others" (NIST).

Texas Specific Policies

Texas House Interim Report on AI and Emerging Technologies

"As AI becomes more integrated into society, Texas is challenged to formulate effective policies and regulatory guidelines for AI. With the rapid evolution of AI technology, the state has an opportunity to set standards that ensure the responsible use of AI, protect citizens' rights, and promote innovation." [88] The interim report to the 89th Texas Legislature highlights the need for new legislation on how to approach, implement, and use AI in various ways. Texas is currently waiting for the 89th legislative session to conclude and come out with new laws on AI.

Bill HB1709 "TRAIGA"

Introduced by Representative Giovanni Capriglione, HB 1709 establishes a comprehensive regulatory framework for high-risk AI systems, emphasizing transparency, fairness, and accountability. The bill mandates that certain business entities and state agencies report on their use of AI systems, aiming to ensure responsible AI deployment across various sectors. It applies more specifically to high-risk AI systems within Texas. High risk intelligence systems include AI tools that make "consequential decisions" or have input into those. It would allow AI to have influence over hiring, firing, and employee outcomes. "The Act does not cover several common intelligence systems, such as technology intended to detect decision-making

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[88] *Interim Report*, Nov. 2024, www.house.texas.gov/pdfs/committees/reports/interim/88interim/House-Select-Committee-on-Artificial-Intelligence-Emerging-Technologies.pdf.

patterns, anti-malware and antivirus programs, and calculators." [89] The Bill is still being considered during the current legislative session, and a decision on it will be made soon.

Case Study: University of St. John's AI Use Policy

St. John's University, a private university in New York, specializes in medical education which has generated a far-reaching research and innovation arm that includes advancements in health technology, pharmaceuticals, and laboratory sciences. The university has adopted a tabbing system for its intellectual property that vets whether or not university-affiliated handlers can input its contents into Open AI. The university also outlines an approval system for users who seek to use unvetted research into Open AI. This approval and tabbing system rests on the classification of all university information including data and documentation related to teaching, research, or administration. The four classifications of such materials can be "low impact" which has been assessed as public nonsensitive data, "moderate impact" which contains personal data, "high impact" carries sensitive data, and the highest tier is "restricted" which has specific and unique implications of associated risk when paired with Open AI. These four classifications are outlined in the university's Policy 922 Information Classification Policy. Restricted sources are often as such due to obligations by law, contract, or industry standards. St. John's University would have legal interest to prevent these sources from entering an Open AI related platform, thus users can understand that no considerations will be made in a request to interact these sources with Open AI. High-impact classified data is technically open to requests for Open AI use, but the university considers this data capable of causing significant harm, although there is

[89] Parker, Kathleen. "The Texas Responsible AI Governance Act and Its Potential Impact on Employers." *HUB | K&L Gates*, 13 Jan. 2025, www.klgates.com/The-Texas-Responsible-AI-Governance-Act-and-Its-Potential-Impact-on-Employers-1-13-2025?.

no legal or contractual framework preventing the university from doing so. Moderate risk labeled data contains the most ambiguous classification for risk and is often the most widely requested data classification for Open AI interactions. The low-risk classification communicates to the user that no requesting protocols are needed in order for the source's interaction with Open AI. St. John's University method of safeguarding information creates a dominant and centralized method of control of Open AI interaction, allowing for use when pre-vetted or otherwise accepted, but maintaining control and discipline over any other information that should not be passing through Open AI.

Case Study: European Union AI Act

In March of 2024, the European Union voted in favor of passing the AI Act, which was originally proposed in 2021. The act's passage showcased the ability of governing bodies to adopt a policy that is as comprehensive as their private counterparts. The act classifies AI uses in risk much like St. John's University's four-tier classification system. However, the risk is associated with the congruent oversight that the European Union will apply. The first tier, titled unacceptable use, classifies unacceptable uses that would be deemed illegal within the EU's borders. This includes a clear threat to safety, rights, and freedoms, it is widely believed that this is in direct regards to AI tools such as China's social credit system or any form of mass surveillance. The next tier, titled high risk, provides an overview of regulations by sector as they are deemed high risk by The Union. This includes operations within infrastructure, healthcare, education, law enforcement, and employment. The following tier is titled limited risk, which mostly regulates transparency requirements for any entity that falls under this title. The final tier, titled minimal risk, includes uses such as spam filters or streaming platform recommendations that will face no regulatory obligation under the act. Open AI uses present clear threats to both the private and public sector's missions and internal operations. However, it is not sufficient for one to rely on the policy making of the other to cover their individual interests. Both public and private sector entities that have not plotted extensive outlines regarding AI policy should consider doing so in the near future.

Case Study: Copilot Compliance and Regulatory Framework for Government Use

Governments are increasingly adopting AI-driven solutions to streamline operations, enhance security, and improve service delivery. Microsoft has developed Copilot Studio's government-specific plans to align with the stringent regulatory requirements of U.S. federal agencies. [90] These plans ensure compliance with various standards and frameworks critical to maintaining security and operational integrity in government operations. [91] By meeting these requirements, Copilot Studio enables public sector organizations to implement AI solutions while ensuring data protection and adherence to government policies. [92]

One of the foundational compliance measures is adherence to the National Institute of Standards and Technology (NIST) guidelines. [91];[93] When deployed as part of the Copilot Studio U.S. Government plans, the service aligns with NIST security and operational guidelines, establishing a robust security framework. [94] Additionally, the Federal Risk and Authorization

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[90] Microsoft. 2024a. "What is Microsoft Copilot?" Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/fundamentals-what-is-copilot-studio
Microsoft. 2024b. "Requirements and Licensing for Copilot Studio GCC." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc

[91] Microsoft. 2024c. "FedRAMP Compliance for Copilot Studio US Government." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc

[92] Ng, Kevin K. B., Liyana Fauzi, Leon Leow, and Jaren Ng. 2024. "Harnessing the Potential of Gen-AI Coding Assistants in Public Sector Software Development." *arXiv preprint* arXiv:2409.17434.

[93] Microsoft. 2024d. "Security and Compliance in Copilot Studio." Microsoft Documentation. https://learn.microsoft.com/en-us/microsoft-copilot-studio/requirements-licensing-gcc

[94] Hafeez, Khurram. 2023. "Copilot Studio for US Government Customers." LinkedIn Pulse. https://www.linkedin.com/pulse/copilot-studio-us-government-customers-khurram-hafeez-clapf/

Management Program (FedRAMP) assesses and authorizes cloud services for federal use. [91;93] Copilot Studio's U.S. Government plans are structured to support FedRAMP compliance, ensuring rigorous security and risk management protocols are in place. [93] The FedRAMP Joint Authorization Board (JAB), comprising representatives from the Department of Defense (DoD), Department of Homeland Security (DHS), and the General Services Administration (GSA), grants Authorizations to Operate (ATO) for cloud services. [95;96]

Furthermore, the Defense Information Systems Agency (DISA) has granted Provisional Authority to Operate under the Security Requirements Guide (SRG) Impact Level 4 (IL4) compliance framework. [93;97] This authorization enables defense organizations to utilize Copilot Studio for handling controlled unclassified information, ensuring that sensitive data is managed within approved security parameters. [98] Agencies leveraging Copilot Studio are also required to comply with International Traffic in Arms Regulations (ITAR) and the Defense Federal Acquisition Regulation Supplement (DFARS), ensuring that sensitive defense-related data is handled securely. [97]

Additionally, national law enforcement agencies must adhere to the Federal Bureau of Investigation's (FBI) Criminal Justice Information Services (CJIS) security policy when using Copilot Studio for data processing and AI-driven law enforcement applications. [97] This

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[95] United States Government Accountability Office, and Gregory C. Wilshusen. 2019. *Cloud Computing Security: Agencies Increased Their Use of the Federal Authorization Program, but Improved Oversight and Implementation Are Needed: Report to Congressional Requesters.* Washington, DC: United States Government Accountability Office.
[96] Odell, L. A., R. R. Wagner, and T. J. Weir. 2015. *Use of Commercial Cloud Computing Capabilities and Services.*
[97] Microsoft. 2024e. *International Traffic in Arms Regulations (ITAR) and Defense Federal Acquisition Regulation Supplement (DFARS) Compliance*. Microsoft Learn. https://learn.microsoft.com/en-us/microsoft-copilot-studio/copilot-plugins-architecture
[98] Vandenberg Space Force. 2024. "NIPRGPT: The Department of the Air Force's Newest Initiative." https://www.vandenberg.spaceforce.mil/News/Article-Display/Article/3821906/niprgpt-the-department-of-the-air-forces-newest-initiative/

compliance ensures that criminal justice information is protected according to federal standards, maintaining the integrity and confidentiality of sensitive law enforcement data. [99] By aligning with these comprehensive compliance frameworks, Microsoft ensures that Copilot Studio meets the high-security standards required for government operations, facilitating the safe and effective adoption of AI-driven solutions in the public sector.

[99] Department of Homeland Security. 2024. "AI Inventory for Federal Agencies." https://www.dhs.gov/archive/data/AI_inventory

Quantum Computing and AI

Since the advent of modern computing in the mid-1940's, electrical computers have proliferated drastically, transforming from monstrous machines that take up an entire room to laptops capable of fitting into your backpack. In the past 80 years, computers have become a staple in the lives of most individuals, capable of performing computations at speeds exponentially faster than the human brain. Within the emergency management enterprise, computing is essential to perform many vital functions - monitoring traffic conditions, weather conditions, data analysis, and much more. Thankfully, modern computers have evolved to the point where they excel at performing many of these functions, leaving little to be desired. There are, however, gaps that remain to be filled in the world of computing - gaps which may be soon filled by the enigmatic quantum computer. This section will focus on exploring the world of quantum computing, how it differs from traditional computing, and how it can be (and already is being) applied to improve the accuracy and efficiency of emergency management.

Foundation of Quantum Computing

Quantum computing began in the early 1980s when famous physicist Richard Feynman observed that certain effects within quantum mechanics are unable to be properly simulated on a classical computer. Feynman speculated that it would be better to try and simulate the effects of quantum mechanics using the effects themselves. [100]

Given the fact that quantum computers utilize the rules of quantum mechanics to complete their calculations, one can imagine that quantum computing is quite different from modern computing. Although these two kinds of computers do function differently and excel in

[100] Rieffel, E., & Polak, W. (2000). An introduction to quantum computing for non-physicists. In ACM Computing Surveys (Vol. 32, Issue 3, pp. 300–335). Association for Computing Machinery (ACM). https://doi.org/10.1145/367701.367709

different ways, they share some important commonalities. At their most foundational level, quantum computers and traditional computers use bits, which are a way of representing data as a combination of 1's and 0's - also referred to as binary language. Whereas bits in a modern computer are only capable of existing as either 1 or 0, a quantum computer utilizes quantum bits (qubits), which can exist in a superposition state, representing either 1 or 0, or some combination of both 1 and 0 at the same time. [101] The concept of superposition is what makes quantum computers stand out over modern computers because it allows the quantum computer to perform calculations with exponentially higher speeds than modern computers.

Much like modern computers, quantum computers rely on algorithms for their processing, such as Peter Shor's algorithm from 1994 that served as the foundation for quantum computers. [102] Without these algorithms to sort through data generated by the computer, the device would be unable to function. In the case of quantum computers, AI serves a very important role relating to these algorithms, providing crucial error-correction capabilities, while the quantum computer provides the speed required for the AI to complete such error-correction. This symbiotic relationship makes AI a vital aspect of quantum computing, with each capable of improving alongside the other.

Although quantum computers are exponentially quicker at processing than modern computers, it is important to note that quantum computers are used for different things than modern computers. Quantum computers, utilizing qubits in states of superposition, excel at processing large sets of data and finding patterns and solutions that would take traditional

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[101] National Academies of Sciences, Engineering, and Medicine 2019. Quantum Computing: Progress and Prospects. Washington, DC: The National Academies Press. https://doi.org/10.17226/25196.

[102] IBM. (n.d.). Quantum computing. IBM. Retrieved November 15, 2024, from https://www.ibm.com/topics/quantum-computing IBM. (n.d.). Quantum computing. IBM. Retrieved November 15, 2024, from https://www.ibm.com/topics/quantum-computing

computers an exponentially higher amount of time to solve. For example, given a large, complex maze, a traditional computer would be required to brute force the maze by trying every solution until the correct one is found. On the other hand, quantum computers are capable of trying every solution at once, utilizing the qubits existing as a combination of both 0 and 1, something that traditional computer bits are incapable of doing. [103] This demonstrates how quantum computers are capable of completing complex calculations at a fraction of the time that it would take a traditional computer.

Quantum Computing & Emergency Management

Within the field of emergency management, quantum computing technology is already being applied in a select few areas. Specifically, researchers have implemented quantum computing algorithms for resource allocation planning, simulating disaster scenarios, identifying escape routes, and much more. This section will focus on how quantum computing displays immense promise in increasing the overall efficiency of certain emergency management practices, allowing manpower to be spent elsewhere.

A 2024 article demonstrates the use of quantum computing for data analysis through the use of Unmanned Aerial Vehicles (UAV). Salandra et al. identify the usefulness of UAVs, specifying that they, "...offer rapid deployment, flexibility, and cost-effectiveness." After deployment, these UAVs can collect images of any affected area and generate spatio-temporal models to assist with hazard evaluation. The difficulty with this, however, is that these actions often generate large datasets, drastically increasing the processing time required to sort through

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[103] La Salandra, M., Nicotri, S., Giacinto Donvito, Italiano, A., Colacicco, R., Miniello, G., Lapietra, I., Roseto, R., Dellino, P., Capolongo, D. (2024). A paradigm shift in processing large UAV image datasets for emergency management of natural hazards, International Journal of Applied Earth Observation and Geoinformation, Volume 132, 103996. DOI: https://doi.org/10.1016/j.jag.2024.103996.

the collected data. [104] Because of this, quantum computers can serve as a solution given that they excel at processing large amounts of data.

One of the most promising advantages of quantum computing is its ability to identify patterns in large amounts of data and conduct simulations of the natural environment. One of the most challenging aspects of emergency management is the unpredictability of natural disasters and their inherent chaotic nature. Although emergency managers are skilled in response planning, it is impossible to account for every factor, making surprises a certainty. A quantum computer, capable of analyzing large amounts of data, would be able to simulate different disaster scenarios to determine the most efficient response pattern. Not only could this be the case with disaster scenario modeling, but simulations could also include traffic models, evacuation routes, and much more.

Challenges to Quantum Computing

Quantum computing, although having made massive leaps in recent years, is still in its infancy stages and requires much more testing and improvement before it becomes a widely available resource. This section on quantum computing has focused on the potential applications that quantum computing brings to emergency management, but this is done with the future in mind, as quantum computers have not yet become mainstream enough to make them a viable option.

It is difficult to tell if quantum computers will ever serve a useful purpose for the average person or if they will remain tools for industry and business use. Currently, quantum computers are only in possession by large, wealthy companies, such as Google and IBM. As time progresses and technology is improved upon, however, quantum computers will inevitably

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[104] Chen, S. Are quantum computers really energy efficient?. Nat Comput Sci 3, 457–460 (2023). https://doi.org/10.1038/s43588-023-00459-6

become less expensive and more efficient, just as traditional computers have. At the moment, however, this section merely serves to educate people on the concept of quantum computing and the immense potential for the future that this field demonstrates. Some experts speculate that computing will see a cross-hybrid of quantum and traditional computing, with supercomputers eventually containing a quantum computer chip, in addition to its regular chip, allowing it to perform actions specific to quantum computing. [92]

AI in Communication Systems

Effective communication is key to any successful emergency response system. As AI advances, it is changing the way information is delivered, understood, and acted upon in high-stakes scenarios. Massive amounts of real-time data can be handled by AI-powered communication systems, which can also convert complicated signals into useful insights and make sure that important messages are sent quickly and clearly to the appropriate audiences. At the forefront of this transformation are linguistic models—AI systems specifically designed to process and generate human language. These models bridge the gap between raw data and human decision-making by enabling machines to understand, interpret, and produce natural language across multiple formats and contexts. In the realm of emergency management, Linguistic models serve not only as conduits of information but also as intelligent interpreters capable of improving situational awareness and public communication in quickly changing settings.

Linguistic models, driven by AI and machine learning (ML), offer significant advantages in analyzing, processing, and disseminating crucial information. [105] Linguistic models, particularly those based on natural language processing (NLP)[1], Large Language Model (LLM)[2] and AI play a crucial role in improving communication, enhancing situational awareness, and facilitating decision-making during emergency scenarios. [106]

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[105] Imran, Muhammad, Carlos Castillo, Fernando Diaz, and Sarah Vieweg. 2015. "Processing Social Media Messages in Mass Emergency: A Survey." *ACM Computing Surveys* 47(4): 67.
[106] Javaid, S., H. Fahim, B. He, and N. Saeed. 2024. "Large Language Models for UAVs: Current State and Pathways to the Future." *IEEE Open Journal of Vehicular Technology*.

The Core Functions of HCOHSEM and the Need for Linguistic Models

HCOHSEM operates based on four primary functions: preparedness, response, recovery, and mitigation. [107] Preparedness involves training, risk assessment, and public education to equip individuals and agencies with the necessary skills and knowledge to handle emergency situations effectively. [108] Ensuring a well-prepared community is crucial in minimizing the impact of disasters. Through the implementation of linguistic models, preparedness efforts can be significantly enhanced by automating the dissemination of critical information, personalizing emergency training materials, and facilitating multilingual communication. [109];[110] These models allow for real-time analysis of potential threats, enabling a proactive approach to disaster readiness. [98]

Response, another vital function, involves real-time information processing and coordinated action during crises. [111] The rapid and effective response can mitigate casualties and infrastructure damage. [112] Linguistic models support response efforts by processing vast amounts of data from emergency calls, social media, and news sources, extracting relevant information, and presenting it to emergency responders in an actionable format. [99] Additionally, AI-driven

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[107] Hannan, Jamie, and Kristina Clark. 2025. "Evolution of a Critical Emergency Response Tool." *Domestic Preparedness*, January 8.
[108] Canton, Lucien G. 2019. *Emergency Management: Concepts and Strategies for Effective Programs*. Hoboken, NJ: John Wiley & Sons.
[109] Paramesha, M., N. Rane, and J. Rane. 2024. "Enhancing Resilience through Generative Artificial Intelligence Such as ChatGPT." *Available at SSRN 4832533*.
[110] Hayes, H. 2023. *Tailoring Emergency and Disaster Preparedness Engagement Approaches for Culturally and Linguistically Diverse (CALD) Communities*. Doctoral dissertation, University of Southern Queensland.
[111] Blum, J. R., A. Eichhorn, S. Smith, M. Sterle-Contala, and J. R. Cooperstock. 2014. "Real-Time Emergency Response: Improved Management of Real-Time Information During Crisis Situations." *Journal on Multimodal User Interfaces* 8(2): 161–73.
[112] Richardson, N. 2021. "Emergency Response Planning: Leveraging Machine Learning for Real-Time Decision-Making." *Emergency* 4: 14.

chatbots can provide immediate assistance to the public by answering frequently asked questions and directing individuals to the appropriate resources. [113]

Recovery and mitigation focus on rebuilding affected areas and implementing preventive measures to reduce future disaster risks. [114] Recovery efforts benefit from linguistic models by analyzing community feedback, identifying priority areas for resource allocation, and streamlining assistance programs. [115]; [102] Similarly, mitigation strategies leverage AI-powered analysis to detect vulnerabilities in infrastructure and suggest policy adaptations. [116] By filtering misinformation and enhancing data-driven decision-making, linguistic models improve the resilience of emergency management systems. [104] Their integration into HCOHSEM's operations ensures that both immediate and long-term disaster management goals are effectively addressed.

Applications of Linguistic Models in HCOHSEM Operations

Input Data in Emergency Management

Linguistic models in emergency management rely on diverse data sources to analyze real-time crisis situations effectively. [100] One of the most prominent sources of data is social media, where platforms such as Twitter, Facebook, and Reddit act as rapid information channels. [100] Users often report incidents, express concerns, or share firsthand experiences during emergencies. [93] AI-driven models monitor these platforms by tracking keywords, hashtags, and geotagged posts to identify potential threats and areas of high impact. [117] By analyzing patterns

[113] Li, Z. 2024. "Leveraging AI Automated Emergency Response with Natural Language Processing: Enhancing Real-Time Decision Making and Communication." Applied and Computational Engineering 71: 1–6.
[114] Phillips, Brenda D., and Joseph Mincin. 2023. *Disaster Recovery*. New York: Routledge.
[115] Yazdani, M., and M. Haghani. 2024. "A Conceptual Framework for Integrating Volunteers in Emergency Response Planning and Optimization Assisted by Decision Support Systems." *Progress in Disaster Science* 24: 100361.
[116] Jain, H., R. Dhupper, A. Shrivastava, D. Kumar, and M. Kumari. 2023. "AI-Enabled Strategies for Climate Change Adaptation: Protecting Communities, Infrastructure, and Businesses from the Impacts of Climate Change." *Computational Urban Science* 3(1): 25.
[117] Cordeiro, D., C. Lopezosa, and J. Guallar. 2025. "A Methodological Framework for AI-Driven Textual Data Analysis in Digital Media." *Future Internet* 17(2): 59.

and trends, linguistic models provide emergency management teams with early warnings and situational awareness, enabling swift responses.

Another crucial data input comes from emergency hotlines and calls, which provide direct insights into real-time crises. [118] Speech-to-text technology facilitates the conversion of spoken reports into text, allowing AI-driven linguistic models to process and extract essential information quickly. [119] These transcriptions help authorities assess the severity and location of an incident, ensuring efficient resource allocation. [120] Furthermore, integrating emergency call data with other inputs enhances decision-making processes by offering a comprehensive view of developing situations. [108] News outlets and structured reports also play a significant role in emergency management by serving as verified sources of information. Broadcasts, articles, and official statements from government agencies contribute to situational awareness by providing validated insights. [121]

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[118] Bratić, Diana, Marko Šapina, Denis Jurečić, and Jana Žiljak Gršić. 2024. "Centralized Database Access: Transformer Framework and LLM/Chatbot Integration-Based Hybrid Model." *Applied System Innovation* 7(1): 17. https://doi.org/10.3390/asi7010017.
[119] Brown, Tom, Benjamin Mann, Nick Ryder, and Melanie Subbiah. 2020. "Language Models are Few-Shot Learners." *Advances in Neural Information Processing Systems* 33: 1877-1901.
Canton, Lucien G. 2019. *Emergency Management: Concepts and Strategies for Effective Programs*. Hoboken, NJ: John Wiley & Sons.
[120] Allen, D. K., S. Karanasios, and A. Norman. 2014. "Information Sharing and Interoperability: The Case of Major Incident Management." *European Journal of Information Systems* 23(4): 418–32.
[121] National Academies of Sciences, Division on Engineering, Physical Sciences, Computer Science, Telecommunications Board, Committee on the Future of Emergency Alert, and Research Directions. 2018. *Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions*. Washington, DC: National Academies Press.

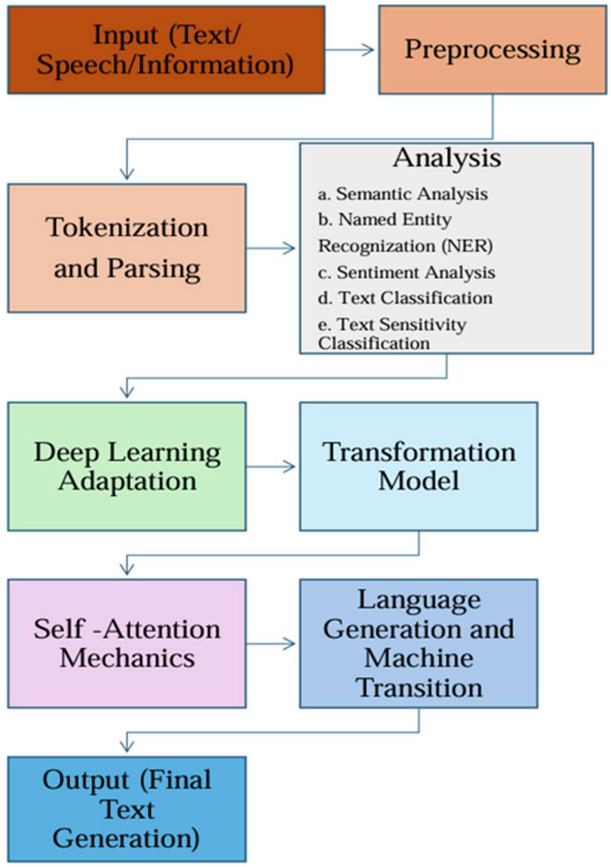

Figure [106]: The Integration Process of NLP and LLM for Generating Contextual Information.

AI models scan and summarize these reports, enabling response teams to quickly grasp key developments. [122] Additionally, public sensor data from automated weather stations and IoT-enabled disaster monitoring systems offer valuable real-time updates on environmental conditions. [123] Combining these structured and unstructured data sources ensures that linguistic models can accurately analyze emergencies, support decision-making, and improve disaster response strategies.

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[122] Syrowatka, A., M. Kuznetsova, A. Alsubai, A. L. Beckman, P. A. Bain, K. J. T. Craig, et al. 2021. "Leveraging Artificial Intelligence for Pandemic Preparedness and Response: A Scoping Review to Identify Key Use Cases." *NPJ Digital Medicine* 4(1): 96.
[123] Selvam, A. P., and S. N. S. Al-Humairi. 2023. "The Impact of IoT and Sensor Integration on Real-Time Weather Monitoring Systems: A Systematic Review."

Early Warning and Risk Assessment

The early warning mechanism in emergency response relies on key natural language processing (NLP) techniques that include preprocessing, tokenization, parsing, and analysis:

Preprocessing, Tokenization, Parsing

The early warning mechanism in emergency response heavily relies on advanced natural language processing (NLP) techniques to analyze vast amounts of data from multiple sources. [106] One of the foundational steps in this process is preprocessing, where raw text data undergoes normalization to enhance accuracy and reliability. [106] This includes noise reduction, language identification, and spelling correction, ensuring that the data is clean and structured before further processing. [124] Given the diversity of emergency-related content from social media, emergency hotlines, and news reports, preprocessing ensures that NLP models can effectively manage linguistic variations, slang, and informal expressions often present in real-time crisis communication. [93]

Once the text data is preprocessed, tokenization and parsing play a crucial role in structuring the information for deeper analysis. [106] Tokenization involves segmenting text into meaningful units such as words or phrases, which enables AI-driven models to analyze linguistic patterns efficiently. [106] Parsing further enhances this process by breaking down sentences into their grammatical components, helping to extract key details such as named entities (locations, organizations, and people) and event descriptions. [125] This structured data is then utilized by

[124] Chai, C. P. 2023. "Comparison of Text Preprocessing Methods." *Natural Language Engineering* 29(3): 509–53.
[125] Sewunetie, W. T. 2024. *Faculty of Mechanical Engineering and Informatics Extended Sentence Parsing Method for Text-to-Semantic Application*. Doctoral dissertation, University of Miskolc.

emergency response teams to assess the severity, location, and nature of incidents, allowing for timely and targeted interventions. [126]

These NLP techniques significantly contribute to the automation of early warning mechanisms by enabling real-time monitoring and alert generation. [93] By leveraging AI-driven parsing and entity recognition, emergency management systems can identify critical threats based on textual evidence and provide alerts with high precision. [127] Furthermore, combining NLP techniques with geospatial analysis allows authorities to pinpoint affected areas more accurately, improving response coordination (Mansourian and Oucheikh 2024). As linguistic models continue to evolve, their integration into emergency response frameworks ensures more efficient risk assessment and disaster mitigation strategies.

Analysis Techniques

In addition to preprocessing and parsing, analysis techniques further enhance the early warning system by providing deeper insights into emergency-related content. Semantic analysis identifies the context and meaning behind textual information, enabling systems to detect critical emergency-related content based on intent and subject matter. [128] This allows for more accurate classification of emergencies and the extraction of crucial contextual details.

Named Entity Recognition (NER) is another key NLP technique used to extract relevant entities such as locations, names, organizations, and disaster types from unstructured text data. [115] This approach helps emergency responders quickly identify the affected areas and key

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[126] Peng, Y., Y. Zhang, Y. Tang, and S. Li. 2011. "An Incident Information Management Framework Based on Data Integration, Data Mining, and Multi-Criteria Decision Making." *Decision Support Systems* 51(2): 316–27.
[127] Bancale, L. 2022. "Named Entity Recognition Network for Cyber Risk Assessment in Healthcare Domain."
[128] Devlin, Jacob, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2018. "BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding." *arXiv preprint arXiv:1810.04805.*

stakeholders involved in an incident. [115] By automating the extraction of structured information, NER enhances situational awareness and facilitates faster decision-making. [129]

Sentiment analysis is employed to evaluate the emotional tones in social media posts, hotline transcripts, and news articles to assess the severity and urgency of a situation. [130] By analyzing public sentiment, emergency management agencies can identify distress signals, gauge the level of panic, and adjust their communication strategies accordingly. [131] This technique provides valuable real-time feedback on how communities are responding to crises.

Text classification categorizes emergency-related information into predefined types such as natural disasters, public safety threats, or health crises, enabling authorities to filter and prioritize response efforts efficiently. [132] Similarly, text sensitivity classification differentiates between routine information and highly sensitive emergency alerts, ensuring appropriate response prioritization.[133] This technique prevents misinformation and ensures that critical warnings reach the appropriate agencies and public channels in a timely manner.

These NLP techniques significantly contribute to the automation of early warning mechanisms by enabling real-time monitoring and alert generation. [134] By leveraging AI-driven parsing and entity recognition, emergency management systems can identify critical threats based on textual evidence and provide alerts with high precision. Furthermore, combining NLP

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[129] Intezari, A., and S. Gressel. 2017. “Information and Reformation in KM Systems: Big Data and Strategic Decision-Making.” *Journal of Knowledge Management* 21(1): 71–91.
[130] Kydros, D., M. Argyropoulou, and V. Vrana. 2021. “A Content and Sentiment Analysis of Greek Tweets during the Pandemic.” *Sustainability* 13(11): 6150.
[131] Zellers, Rowan, Ari Holtzman, Hannah Rashkin, and Yonatan Bisk. 2019. "Defending Against Neural Fake News." *Advances in Neural Information Processing Systems* 32: 9054-9065.
[132] Khallouli, W. 2024. Harnessing Social Media for Disaster Response: Intelligent Identification of Reliable Rescue Requests During Hurricanes. Doctoral dissertation, Old Dominion University.
[133] Damaševičius, R., N. Bacanin, and S. Misra. 2023. “From Sensors to Safety: Internet of Emergency Services (IoES) for Emergency Response and Disaster Management.” Journal of Sensor and Actuator Networks 12(3): 41.
[134] Lamsal, R., and T. V. Kumar. 2020. “Artificial Intelligence and Early Warning Systems.” In AI and Robotics in Disaster Studies, 13–32.

techniques with geospatial analysis allows authorities to pinpoint affected areas more accurately, improving response coordination (U.S. Department of Homeland Security 2015). As linguistic models continue to evolve, their integration into emergency response frameworks ensures more efficient risk assessment and disaster mitigation strategies. [135]

Crisis Communication and Public Alerts

Effective crisis communication is essential to ensuring public safety during emergencies. Linguistic models powered by deep learning and transformer-based AI systems have revolutionized the dissemination of emergency alerts. [136] Deep learning adaptations leverage neural networks to refine emergency messaging, reducing ambiguity and enhancing clarity in crisis communications. [116] These models continuously learn from historical crisis communications and feedback, enabling them to craft messages that are concise, informative, and contextually appropriate. By automatically adjusting language complexity based on audience demographics, deep learning-powered NLP models ensure that emergency alerts are easily understood by all affected individuals, including those with limited literacy or cognitive impairments. [120]

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[135] Otal, Hakan T., Eric Stern, and M. Abdullah Canbaz. 2024. "LLM-Assisted Crisis Management: Building Advanced LLM Platforms for Effective Emergency Response and Public Collaboration." *IEEE*. https://ieeexplore.ieee.org/document/10605553/

[136] Sufi, F. 2024. "A Sustainable Way Forward: Systematic Review of Transformer Technology in Social-Media-Based Disaster Analytics." *Sustainability* 16(7): 2742.

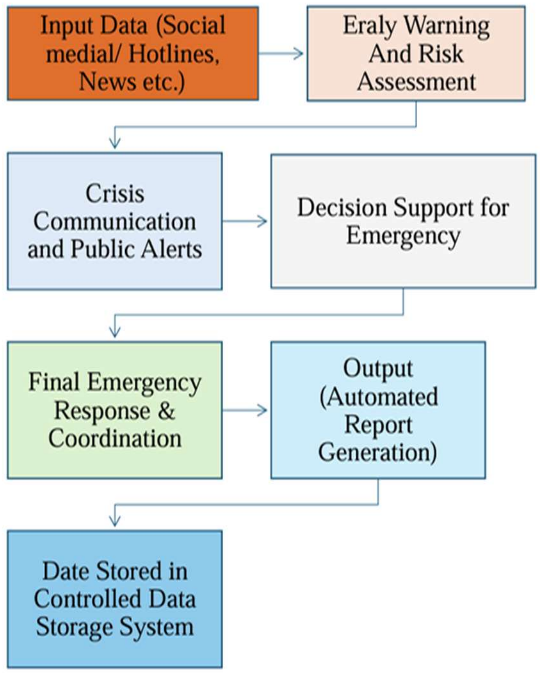

Figure [123]: The Integration Process of NLP and LLM for Generating Contextual Information in Emergency Management.

In addition to deep learning, transformation models such as modern transformer-based AI systems play a crucial role in crisis communication by processing multilingual data in real time. [137] These models facilitate instant translation and dissemination of emergency alerts across diverse populations, ensuring that non-English-speaking residents receive accurate updates. [119] The ability to translate and localize messages into various dialects and regional languages significantly improves inclusivity in emergency management. [138] By incorporating machine translation with contextual understanding, these AI systems reduce the risk of miscommunication

[137] Šutas, M., E. Karčiauskas, and E. Butkevičiūtė. 2024. "Automated Coin Classification Using Transformer-Based Deep Learning Models." In *DAMSS: 15th Conference on Data Analysis Methods for Software Systems, Druskininkai, Lithuania, November 28-30, 2024*, 108–09. Vilnius: Vilniaus universiteto leidykla.
[138] Uekusa, S. 2019. "Disaster Linguicism: Linguistic Minorities in Disasters." Language in Society 48(3): 353–75.

and misinformation, allowing emergency management agencies to maintain clarity and precision in their messages. [120]

Automated chatbots and AI assistants further enhance public engagement during emergencies. NLP-powered systems provide real-time interaction with the public, answering queries related to evacuation routes, shelter availability, and safety protocols. [139] These AI-driven assistants operate in multiple languages, ensuring accessibility for diverse communities. [140] By offering 24/7 availability, they alleviate pressure on emergency call centers and enable faster response times. [127] Additionally, chatbot interactions contribute to the continuous improvement of NLP models by gathering user feedback and identifying new patterns in public concerns. [127;128] The integration of deep learning, transformation models, and automated chatbots within crisis communication frameworks strengthens emergency response capabilities, ensuring timely, accurate, and inclusive information dissemination during critical situations. [141]

Decision Support for Emergency Responders & Final Emergency Response Coordination

Advanced natural language processing (NLP) capabilities significantly enhance decision-making and response coordination in emergency management. [101] One of the core technologies supporting this effort is a self-attention mechanism, which enables AI-driven emergency response models to prioritize key information from vast datasets. [123] This mechanism weighs the importance of words, phrases, and context within emergency communications, ensuring that critical alerts are highlighted for first responders. [116] By filtering through multiple data sources, such as real-time social media feeds, emergency dispatch logs, and official announcements, self-

[139] Ali, G., M. M. Mijwil, I. Adamopoulos, B. A. Buruga, M. Gök, and M. Sallam. 2024. "Harnessing the Potential of Artificial Intelligence in Managing Viral Hepatitis." Mesopotamian Journal of Big Data 2024: 128–63.
[140] Anis, M. 2023. "Leveraging Artificial Intelligence for Inclusive English Language Teaching: Strategies and Implications for Learner Diversity." Journal of Multidisciplinary Educational Research 12(6): 54–70.
[141] Cheng, Y., J. Lee, and J. Qiao. 2024. "Crisis Communication in the Age of AI: Navigating Opportunities, Challenges, and Future Horizons." In *Media and Crisis Communication*, 172–94.

attention models assist emergency teams in rapidly identifying the most urgent threats and deploying resources accordingly. [123]

Another critical application of NLP in emergency response is language generation and machine translation, which enhances situational awareness and inter-agency communication. [142] Contextual summarization enables AI models to extract and condense relevant details from large-scale emergency reports, improving decision-making in high-pressure scenarios. [119] For example, during large-scale disasters, emergency responders must process extensive field reports to determine where aid is most needed. NLP-driven summarization helps emergency teams allocate resources more effectively and prioritize response efforts based on data-driven insights. [143]

Additionally, NLP facilitates inter-agency coordination by ensuring smooth communication among emergency responders, law enforcement, medical teams, and government agencies. [144] Real-time language processing tools automatically translate and standardize terminology across different agencies, preventing miscommunication and reducing response delays. [132] AI-powered systems enable multilingual coordination, ensuring that linguistically diverse teams can efficiently collaborate in emergency scenarios. [145] The integration of self-attention mechanisms, contextual summarization, and real-time language processing within

[142] Kreutzer, T. 2023. *Deeper Understanding: Addressing Methodological Constraints and Ethical Implications of Humanitarian Needs Assessments Using Natural Language Processing.*
[143] Kanungo, S., and S. Jain. 2023. "A Comprehensive Performance Assessment of Machine Learning Models for Disaster Management." In 2023 IEEE International Conference on ICT in Business Industry & Government (ICTBIG), 1–9. IEEE.
[144] Chaudhry, S. 2020. Scalable Communication Frameworks for Multi-Agency Data Sharing.
[145] Allan, J. 2024. *Cross-Culturally Articulate: Generative AI as a Tool for Improved Communication Across Global Teams*. Doctoral dissertation, Southern New Hampshire University.

emergency management frameworks strengthens response coordination, ultimately leading to more effective disaster mitigation and public safety efforts. [146]

Final Text Generation and Structured Emergency Reports

The final stage in linguistic model implementation is the generation of structured emergency reports, which transform analyzed data into actionable intelligence. [147] AI-based language models play a critical role in synthesizing vast amounts of emergency data, ensuring that responders receive real-time, concise, and accurate information. [148] Crisis summaries provide emergency managers with up-to-the-minute situational updates, detailing affected regions, projected impact, and recommended actions. [149] By automating this process, AI models help reduce human error and enhance the speed of decision-making, allowing emergency teams to allocate resources efficiently. [116]

Additionally, incident logs serve as structured documentation of emergency response actions. [150] These logs ensure accurate record-keeping and facilitate post-crisis analysis, which is essential for improving future preparedness. [151] AI-powered linguistic models automatically document emergency response activities, tracking intervention efforts, law enforcement actions, and medical response deployments. [139] This real-time logging capability helps agencies assess

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[146] Ma, Z. 2024. *Natural Language Processing, Social Media, and Epidemic Modeling for Wildfire Response and Resilience Enhancement*. Doctoral dissertation, University of Maryland, College Park.
[147] Perrina, F., F. Marchiori, M. Conti, and N. V. Verde. 2023. "Agir: Automating Cyber Threat Intelligence Reporting with Natural Language Generation." In *2023 IEEE International Conference on Big Data (BigData)*, 3053–62. IEEE.
[148] Al Falasi, H. A. 2024. *Predictive Rescue System Through Real-Time Accident Monitoring Leveraging Artificial Intelligence*. Master's thesis, Rochester Institute of Technology.
[149] Fadhel, M. A., A. M. Duhaim, A. Saihood, A. Sewify, M. N. Al-Hamadani, A. S. Albahri, et al. 2024. "Comprehensive Systematic Review of Information Fusion Methods in Smart Cities and Urban Environments." *Information Fusion*: 102317.
[150] Johansen, G. 2020. *Digital Forensics and Incident Response: Incident Response Techniques and Procedures to Respond to Modern Cyber Threats*. Packt Publishing Ltd.
[151] Grunnan, T., and M. Maal. 2015. "Lessons Learned and Best Practices from Crisis Management of Selected Natural Disasters—Elicit to Learn Crucial Post-Crisis Lessons."

response effectiveness and identify areas for improvement, ultimately strengthening long-term disaster management strategies. [152]

Beyond operational reports, linguistic models also generate community feedback reports that analyze public sentiment and feedback data. During and after a crisis, public concerns, complaints, and recommendations are collected from social media, emergency hotlines, and surveys. [153] NLP techniques process this unstructured data, converting it into structured insights that help authorities refine emergency response strategies. [119] Understanding public sentiment allows agencies to improve crisis messaging, allocate resources based on community needs, and enhance overall emergency preparedness.

By integrating linguistic models at each stage of emergency management operations, agencies can enhance early detection, streamline crisis communication, support decision-making, and ensure effective response coordination. [121] AI-driven structured reporting not only aids in immediate crisis management but also contributes to long-term disaster resilience by preserving detailed records for training, analysis, and policy development. [154] As linguistic and AI technologies continue to evolve, their application in emergency response will further improve the efficiency and effectiveness of crisis management efforts. [142]

Challenges and Ethical Considerations

Despite the numerous advantages of linguistic models in emergency management, their implementation presents several challenges that must be addressed. One of the primary concerns

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[152] Khan, A., S. Gupta, and S. K. Gupta. 2020. "Multi-Hazard Disaster Studies: Monitoring, Detection, Recovery, and Management, Based on Emerging Technologies and Optimal Techniques." *International Journal of Disaster Risk Reduction* 47: 101642.

[153] Alam, F., F. Ofli, and M. Imran. 2020. "Descriptive and Visual Summaries of Disaster Events Using Artificial Intelligence Techniques: Case Studies of Hurricanes Harvey, Irma, and Maria." *Behaviour & Information Technology* 39(3): 288–318.

[154] Paramesha, M., N. Rane, and J. Rane. 2024. "Enhancing Resilience through Generative Artificial Intelligence Such as ChatGPT." *Available at SSRN 4832533*.

is data privacy, as linguistic models rely on vast amounts of personal and sensitive information to function effectively. [155] Emergency response systems collect data from various sources, including social media, emergency hotlines, and government databases, which raises concerns about how this data is stored, shared, and protected. [156] Without strict data governance policies, there is a risk of breaches, unauthorized access, or misuse of information, potentially compromising individual privacy and public trust in emergency management systems. [143]

Another significant challenge is the necessity for on-the-job training (OJT) for emergency responders and personnel utilizing linguistic models. [157] AI-powered systems are only as effective as the individuals operating them, necessitating continuous training to ensure proficiency in interpreting AI-generated reports, alerts, and recommendations. [145] Training programs must be adapted to accommodate technological advancements and evolving emergency scenarios, ensuring that responders can effectively integrate AI tools into their workflows. [158] Additionally, the learning curve for AI adoption may be steep, particularly in government agencies that traditionally rely on manual processes, requiring dedicated resources to bridge the knowledge gap. [159]

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[155] Feretzakis, G., and V. S. Verykios. 2024. “Trustworthy AI: Securing Sensitive Data in Large Language Models.” *AI* 5(4): 2773–800. https://www.domesticpreparedness.com/articles/evolution-of-a-critical-emergency-response-tool.

[156] Davis, Michael and Priya Singh. 2022. "Ethical AI in Emergency Management." *Policy and Technology Review* 41(1): 78-92.

[157] Valecha, R., R. Rao, S. Upadhyaya, and R. Sharman. 2019. “An Activity Theory Approach to Modeling Dispatch-Mediated Emergency Response.” *Journal of the Association for Information Systems* 20(1): 2.

[158] Mehta, R., J. Moats, R. Karthikeyan, J. Gabbard, D. Srinivasan, E. Du, et al. 2022. “Human-Centered Intelligent Training for Emergency Responders.” *AI Magazine* 43(1): 83–92.

[159] Chen, T., M. Gascó-Hernandez, and M. Esteve. 2024. “The Adoption and Implementation of Artificial Intelligence Chatbots in Public Organizations: Evidence from US State Governments.” *The American Review of Public Administration* 54(3): 255–70.

The controlled data storage system is another essential consideration in maintaining the reliability and security of linguistic models. [160] Large-scale emergency response systems require secure and scalable storage infrastructure to handle real-time data influx while ensuring compliance with regulatory standards. [119] Implementing controlled data storage solutions involves encryption mechanisms, role-based access controls, and continuous monitoring to prevent data leaks and cyber threats. [148] Furthermore, ensuring data integrity is crucial for maintaining the accuracy of AI-driven decision-making, as misinformation or tampered data can severely impact response efforts and public safety. [161]

Finally, algorithmic biases and continuous model training pose ethical challenges that must be mitigated to ensure fair and effective AI deployment. [162] Bias in AI models can arise from imbalanced training data, leading to disparities in how emergencies are assessed and addressed across different communities. [116] Ensuring that linguistic models are trained on diverse datasets and regularly updated helps reduce bias and improve response accuracy. [163]Moreover, transparency in AI decision-making processes fosters public trust and accountability, ensuring that emergency response agencies can justify AI-generated recommendations. [164] Addressing these ethical and technical challenges is essential to fully realizing the potential of linguistic

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[160] Mohammad, Naseemuddin. 2021. "Enhancing Security and Privacy in Multi-Cloud Environments: A Comprehensive Study on Encryption Techniques and Access Control Mechanisms." *International Journal of Computer Engineering and Technology (IJCET)* 12(2): 51–63. http://iaeme.com/Home/issue/IJCET?Volume=12&Issue=2.

[161] Omotunde, H., and M. Ahmed. 2023. "A Comprehensive Review of Security Measures in Database Systems: Assessing Authentication, Access Control, and Beyond." *Mesopotamian Journal of CyberSecurity* 2023: 115–33.

[162] Hanna, M., L. Pantanowitz, B. Jackson, O. Palmer, S. Visweswaran, J. Pantanowitz, et al. 2024. "Ethical and Bias Considerations in Artificial Intelligence (AI)/Machine Learning." *Modern Pathology*: 100686.

[163] Yu, Y., Y. Zhuang, J. Zhang, Y. Meng, A. J. Ratner, R. Krishna, et al. 2023. "Large Language Model as Attributed Training Data Generator: A Tale of Diversity and Bias." *Advances in Neural Information Processing Systems* 36: 55734–84.

[164] Cheong, B. C. 2024. "Transparency and Accountability in AI Systems: Safeguarding Wellbeing in the Age of Algorithmic Decision-Making." *Frontiers in Human Dynamics* 6: 1421273.

models in emergency management while maintaining fairness, security, and public confidence in AI-driven systems.

In conclusion, Linguistic models serve as powerful tools in strengthening the emergency management functions of HCOHSEM. By leveraging AI-driven language processing, the agency can improve preparedness, response efficiency, misinformation management, and community engagement. As technology advances, the integration of sophisticated linguistic models will continue to shape the future of emergency management, ensuring resilience in the face of disasters.

AI in Meteorology

The integration of AI into meteorology and environmental sciences dates back to the 1980s.[165] While modern AI often evokes thoughts of machines that understand speech or operate autonomously, even earlier systems contributed meaningfully to environmental research. Today, AI—especially through machine learning (ML)—transforms how we predict weather, offering faster, more accurate forecasts and timely warnings.

ML models identify patterns in data, learn from them, and forecast outcomes. Programs like GraphCast, developed by Google DeepMind, showcase AI's power by predicting weather events like Hurricane Beryl's landfall more accurately than traditional models.[166] Similarly, GenCast forecasts up to 15 days in advance with accuracy rates nearing 99.8% [167], while NVIDIA's Earth-2 applies generative AI for hyperlocal super-resolution forecasts.[168] These advancements reduce the time and computing power required by traditional models and allow meteorologists to better anticipate extreme conditions. Agencies such as the National Oceanic and Atmospheric Administration and the European Center for Medium-Range Weather Forecasts are studying similar systems to further their applications.

Additionally, industries reliant on weather accuracy—like agriculture and aviation—benefit greatly from these advancements. Farmers can use ML models to analyze past yields,

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[165] Haupt, S. E., Gagne, D. J., Hsieh, W. W., Krasnopolsky, V., McGovern, A., Marzban, C., Moninger, W., Lakshmanan, V., Tissot, P., & Williams, J. K. (2022). The History and Practice of AI in the Environmental Sciences. *Bulletin of the American Meteorological Society*, *103*(5), E1351–E1370. https://doi.org/10.1175/bams-d-20-0234.1

[166] Broad, W. J. (2024, July 29). Artificial Intelligence Gives Weather Forecasters a New Edge. *The New York Times*. https://www.nytimes.com/interactive/2024/07/29/science/ai-weather-forecast-hurricane.html

[167] Price, I., & Willson, M. (2024, December 5). GenCast predicts weather and the risks of extreme conditions with state-of-the-art accuracy. Google DeepMind. https://deepmind.google/discover/blog/gencast-predicts-weather-and-the-risks-of-extreme-conditions-with-sota-accuracy/

[168] Gadhia, B. (2025, February 24). NVIDIA Earth-2 Features First Gen AI to Power Weather Super-Resolution for Continental US. NVIDIA Blog. https://blogs.nvidia.com/blog/earth-2-ai-high-resolution-forecasts/

optimize planting, and adopt sustainable practices, reducing losses and increasing profits (FFA, 2023).[169] In aviation, AI helps pilots make informed decisions about turbulence and flight paths, improving both safety and passenger experience.[170] Additionally, AI's accessibility on personal devices enhances its adoption, allowing more professionals to engage with forecasting tools. This is crucial, as weather forecasting remains complex due to fluctuating atmospheric factors such as humidity, air pressure, and cloud cover. Traditional models are limited to roughly ten-day forecasts. With systems like GraphCast, longer-range forecasts with greater reliability become possible—a significant leap from the limited three-day forecasts that were standard practice only a few decades ago.

AI's capabilities also bolster emergency management. Real-time, high-accuracy data allows faster decision-making during crises. For instance, in Aragon, Spain, a €17.2 million AWS-backed project integrates sensor networks with AI for flood monitoring.[171] In Austin, Texas, AI-driven wildfire detection ensures faster alerts and community safety.[172] Norfolk, Virginia, leverages AI to forecast street-level flooding, aiding emergency responders and city planners.[173] These applications demonstrate how AI empowers local authorities to act swiftly and strategically, minimizing damage and saving lives. By enabling earlier evacuations, targeted

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[169] FFA , N. H. (2023, August 18). *How AI Can Impact Agriculture*. National FFA Organization. https://www.ffa.org/technology/how-ai-can-impact-agriculture/
[170] Putol, R. (2025, February 25). *AI being tested to prevent stalls and reduce air turbulence for smoother flights*. Earth.com. https://www.earth.com/news/ai-being-tested-to-prevent-stalls-and-reduce-air-turbulence-for-smoother-flights/
[171] About Amazon Team. (2025, March 3). AWS AI powers new water projects in Spain. EU about Amazon. https://www.aboutamazon.eu/news/sustainability/aws-ai-powers-new-water-projects-in-spain
[172] Austin Energy. (2024, August 29). Austin Energy announces full deployment of AI-driven Early Wildfire Detection System. Austinenergy.com. https://austinenergy.com/about/news/news-releases/2024/austin-energy-announces-full-deployment-of-ai-driven-early-wildfire-detection-system

[173] Bloomberg. (2025, February 18). How AI – Underpinned by Strong Data – Will Help Cities Combat Extreme Weather in 2025. What Works Cities; Bloomberg Philanthropies. https://whatworkscities.bloomberg.org/news/how-ai-underpinned-by-strong-data-will-help-cities-combat-extreme-weather-in-2025/

warnings, and optimized resource allocation, AI ensures that emergency protocols are more proactive than reactive. As extreme weather events grow in frequency and severity, the integration of AI into emergency infrastructure is not just beneficial—it's essential for resilience and long-term climate adaptation.

However, while the promise of AI in meteorology is vast, its implementation must be approached with care. Technology heavily on the quality and completeness of historical data. Gaps, inconsistencies, or embedded biases can affect predictive outcomes. Additionally, many AI-generated forecasts are probabilistic in nature, requiring expert interpretation and integration with traditional systems. For this reason, AI should be seen as a complement to human expertise, not a replacement.

Ethical and privacy concerns also come into play. Questions about data ownership, transparency in model design, and equitable access must be addressed to ensure fair and responsible use. Ongoing education and training for meteorologists, emergency responders, and policy-makers will be essential to navigate this evolving landscape and build public trust in AI-driven systems.

Furthermore, AI is no longer a futuristic concept in meteorology—it is actively transforming how we interpret and respond to environmental challenges. With the ability to process real-time data, apply machine learning, and generate high-resolution forecasts, AI is shifting communities from reactive approaches to proactive climate resilience. Its accessibility on everyday devices empowers a wide range of users—from researchers and students to emergency planners—to make timely, informed decisions. This democratization of advanced forecasting tools supports more localized, precise responses to weather events and natural disasters. As AI continues to evolve, it promises not just faster predictions but more equitable access to critical environmental insights.

The impact of AI is further amplified through collaboration. Cross-sector partnerships between technology firms and environmental agencies are driving innovation and extending AI's reach. For example, Bloomberg Philanthropies highlights how cities are leveraging strong data infrastructure and AI to strengthen resilience against climate threats (Bloomberg, 2025). As climate risks intensify, these collaborative efforts offer scalable, data-driven solutions that not only improve forecasting but also enhance public safety and long-term sustainability. Moving forward, the continued integration of AI with technologies like satellite imagery, IoT, and remote sensing will deepen our understanding of weather systems and environmental change. Ultimately, AI in meteorology is more than a technological upgrade—it is a vital tool for building a safer, smarter, and more resilient future.

Current Uses of AI for Meteorology

Since 2008, the changing climatic conditions of our atmosphere have contributed toward an increase in natural disaster occurrences, as well as their intensity. With the rapidly changing weather conditions, it is difficult for emergency management teams to determine the scale of a storm and the extent they should prepare. This can result in infrastructure loss, fatalities, and other shortcomings on behalf of emergency preparedness. However, AI can be of help in this field. Because of AI's ability to digest large amounts of data, AI can help natural disaster management by analyzing atmospheric conditions, assessing risk, and even recommend certain strategies to help emergency managers during times of crisis. [174]

A review of modeling practices by a group of researchers led by Ling Tan aims to determine if trends in natural disaster management can be detected by AI programs. Since the implementation of advanced AI programs is still relatively new in the emergency management field, a review of AI model practices is necessary to differentiate which models work best during each phase of disaster preparedness. [102] Natural disaster management can be separated into four stages: risk assessment, website application, emergency resource demand prediction, and emergency warning system construction. These stages of natural disaster management help the public and emergency managers alike feel more secure and prepared when faced with extreme weather conditions.

Risk assessment is an important aspect of emergency management and is especially critical in the wake of a natural disaster. Assessing risk can look like using maps to designate at-risk areas or utilizing technology like drones to survey a geographical area. [102] Using multiple methods of risk assessment ensures an emergency manager covers all bases during preparation for a natural disaster. Risk assessment can also help determine the resources available to an emergency management team, which in turn helps them predict demand for other resources. This can prevent shortages of essential items like food, shelter, and infrastructure preparation materials. [102]

The next stage focuses on website application and how an emergency management team can utilize a website to connect with and inform the public. In this new age of technology, large

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[174] Tan, L., Guo, J., Mohanarajah, S. *et al.* 2021. "Can We Detect Trends in Natural Disaster Management with Artificial Intelligence? A Review of Modeling Practices". *Natural Hazards.* 107, 2389–2417. https://doi.org/10.1007/s11069-020-04429-3

amounts of the public turn to social media and websites to receive information in real time. [102] Because of this, it is crucial for emergency management departments to have multiple online presences and methods for outreach. For example, a central website could be helpful during a natural disaster by listing weather updates, where resources or shelters are available, instructions for being prepared, and departmental contact information. [102] Additionally, social media posts can be used to spread information faster than turning on the television, especially if there is a loss of power. Important safety and natural disaster-related alerts through text message may also be utilized for efficient communications.

The stages outlined in this study can be of use when approaching how to combat integrating AI into risk management operations. Although these stages and recommendations can look different depending on your organization, this study provides a framework to follow and adjust to your organization's needs.

Another area of emergency management that is currently implementing AI is recovery and response operations. The Federal Emergency Management Agency (FEMA) has recently begun incorporating AI into its day-to-day activities and assessing their outcomes to see which areas of emergency management can benefit most from these technologies. [175] One initiative, geospatial damage assessment is implementing AI technologies to help locate damage to infrastructure and presence of debris after a natural disaster. The Response Geospatial Office (RGO) is inquiring about whether this can help speed up the process of identifying areas that were more severely damaged than others and help prioritize response efforts to those specific locations. Methods such as machine learning and computer vision are being integrated into

[175] U.S. Department of Homeland Security. 2024. "Federal Emergency Management Agency – AI Use Cases: Homeland Security". https://www.dhs.gov/ai/use-case-inventory/fema

existing systems that deal with imagery identification. [103] By developing these new systems, RGO geospatial analysts can increase the number of images reviewed and disperse response efforts accordingly. Utilizing AI in this endeavor helps cover more mileage in the aftermath of a storm and helps to characterize the type of damage sustained. [103] Similar technologies could be employed by local authorities to increase response times and accurate damage assessments in smaller areas.

FEMA has also been using supervised learning models to help predict the amount of assistance needed from individuals amidst natural disaster occurrences. The supervised learning models can project the quantities of response efforts needed in terms of individuals potentially affected by the natural disaster, housing needs, public assistance activities, and the number of sites that will need to be covered when assessing these projections. [103] By predicting these numbers, emergency managers and other local authorities can make more accurate and informed decisions during essential response times. Additionally, agencies can know how much funding will be required for such operations, as well as how many personnel will be needed to execute each operation. [103] Supervised learning models also gauge the interests of the public in receiving and participating in these services which also aids authorities in the decision-making process about whether or not to utilize resources.

Regarding personnel needs, FEMA has established an incident management workforce deployment model that analyzes historical data of previous response efforts and circumstances which can then predict which personnel are needed and what their response efforts will be. [103] Being able to anticipate staffing requirements for natural disasters can help increase the efficiency of the agency and allow for ample time and resources to be dedicated to certain operations in the interest of public safety. This kind of development model is used for planning purposes, making the decision-making process of those in charge of recovery and response operations confident in delegating their workforce during times of crisis.

Another interesting use of AI being developed by FEMA is the use of a chatbot specifically tailored to hazard mitigation assistance (HMA). [103] The HMA chatbot is currently in the pre-development stages but is planned to be implemented within hazard mitigation offices once it is fully functional. This chatbot's primary use will be for all FEMA staff across all of the nation's regions and headquarters. This type of technology will help direct any new hires or stakeholders involved in grant applications, feasibility of projects, and scoping for other operations. [103] The amount of processing and information required for hazard mitigation assessment can be overwhelming, and utilizing a chat bot can make the experience for new employees and others not familiar with grants and application processes learn with the aid of the chat bot. This bot will be equipped with all the necessary FEMA policies, documents, etc., to provide users with the most accurate information possible when they use the platform. [103] The chatbot can also give users quicker access to data, increasing the efficiency of offices implementing this technology. The HMA chatbot was created with hopes of enhancing the decision-making process of those working for FEMA and allowing others to learn internal processes through first-hand agency-specific information provided by the chatbot. Additionally, the HMA chatbot is programed using natural language processing, which helps provide information to the user within the context of HMA and FEMA-related guidelines and policy measures.[166] The prospects for the hazard mitigation chatbot seem promising, and further analysis will be required to assess whether it was successful in its mission of improving workplace efficiency and increasing service delivery to the public.

Creating an agency/organization specific chat bot could be considered a worthwhile endeavor, especially for agencies who are responsible for generating real time data and reports to inform communities, those who engage in the process of grant applications and project feasibility, and others who are required to generate agency wide memos and briefs during emergencies. Tailoring a chatbot with agency-specific data and letting only agency-approved staff have access could transform efficiency and communications during a crisis.

AI in Critical Infrastructure

As AI technologies become more advanced and accessible, their integration into critical infrastructure systems is reshaping how sectors such as energy, water, transportation, and finance operate. AI is already being used to improve operational efficiency, detect anomalies, forecast demand, and support real-time decision-making.[176] However, its deployment also introduces new vulnerabilities, including expanded system complexity, risks of data misuse, and challenges in testing, validation, and explainability. The rise of generative AI further complicates this landscape, enabling autonomous task execution and producing outputs that may be difficult to verify or control.

Energy

AI presents transformative opportunities for enhancing emergency management within the energy-critical infrastructure sector, playing a pivotal role throughout the phases of mitigation, preparedness, response, and recovery. Similar to the application of AI in wastewater infrastructure management, the energy sector can benefit significantly from AI's predictive and analytical capabilities, helping to address the sector's unique vulnerabilities and interdependencies.[177] The U.S. energy sector, integral to national security and economic vitality, encompasses electricity, oil, and natural gas systems, which are all highly dependent on stable and secure operations.[178]

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[176] Kyle Crichton, Jessica Ji, Kyle Miller, John Bansemer, et al., "Securing Critical Infrastructure in the Age of AI" (Center for Security and Emerging Technology, October 2024). https://doi.org/10.51593/20240032
[177] Krishnan, S. R., Nallakaruppan, M. K., Chengoden, R., Koppu, S., Iyapparaja, M., Sadhasivam, J., & Sethuraman, S. (2022). Smart Water Resource Management Using Artificial Intelligence—A Review. Sustainability, 14(20), 13384.
[178] Cybersecurity and Infrastructure Security Agency (CISA). (2015). Energy Sector-Specific Plan. U.S. Department of Homeland Security.

In the mitigation phase, AI is crucial for identifying potential threats and preventing incidents that could disrupt energy systems. AI-driven predictive analytics can continuously monitor equipment across electricity grids, natural gas pipelines, and oil refineries, recognizing early signs of wear and deterioration. This predictive maintenance capability enables proactive interventions, reducing downtime and averting costly outages. [104] Machine learning (ML) models are particularly effective at analyzing large-scale datasets from historical performance metrics and environmental conditions to anticipate infrastructure failures. Such predictive capabilities are essential for managing aging infrastructure, a significant concern identified in the Energy Sector-Specific Plan. [104]

AI-driven threat detection technologies also play a crucial role in cybersecurity, a growing concern within the energy sector. By scrutinizing network traffic and operational data, AI systems can rapidly detect cyber threats, including those potentially initiated internally by malicious actors. Given the intricate operational technology (OT) and information technology (IT) systems intertwined in the energy sector, AI-powered cybersecurity measures provide essential defensive layers against increasingly sophisticated cyberattacks. [179]

Preparedness, another critical phase of emergency management, significantly benefits from AI innovations. AI-based tools facilitate advanced scenario simulations, resource allocation models, and training exercises. For instance, digital twin technologies, which create accurate digital replicas of real-world energy infrastructure, can simulate emergency scenarios to test potential outcomes and optimize responses without physical risk. [104] This technology allows operators to rehearse complex disaster scenarios virtually, enabling them to refine emergency response plans,

[179] Department of Energy (DOE). (2015). Energy Sector-Specific Plan: An Annex to the National Infrastructure Protection Plan. U.S. Department of Energy.

train personnel effectively, and mitigate vulnerabilities proactively. Furthermore, AI can analyze and optimize the allocation of emergency resources—such as workforce deployment, emergency fuel supplies, and critical spare parts—ensuring that responses to incidents are swift, coordinated, and effective. [105]

During the response phase, real-time decision-making becomes crucial. AI technologies can significantly enhance this process through improved situational awareness and automated operational management. AI-driven systems integrate data streams from IoT sensors, aerial drones, and satellite imagery to provide instantaneous damage assessments and real-time monitoring of emergency situations. [105]Intelligent grid management systems powered by AI algorithms enable automatic rerouting of electricity supplies to minimize disruptions, especially crucial in hospitals, emergency services, and communications infrastructure. Additionally, AI-enhanced platforms can assist emergency response teams in prioritizing critical incidents, deploying repair crews efficiently, and managing crisis communications to keep the public informed with timely and accurate updates. [104]

The recovery phase, characterized by restoration and rebuilding activities, similarly harnesses AI to expedite and streamline efforts. Post-disaster assessments can be significantly accelerated through AI-driven technologies like image recognition and drone technology. AI-driven visual recognition tools quickly analyze images from drones, satellites, and surveillance systems to assess the extent of infrastructure damage, speeding up the prioritization of repair activities and restoration of energy services. [104] AI applications also support supply chain resilience and logistics, predicting and circumventing disruptions to critical supplies and resources needed for effective recovery.

In addition, AI has long-term benefits post-disaster by enabling infrastructure resilience planning. AI models use data gathered during disasters to analyze patterns and identify infrastructure vulnerabilities, providing valuable insights for designing more resilient energy systems capable of withstanding future incidents. [105] By forecasting future vulnerabilities based on historical data and contemporary challenges such as climate change, AI enables energy infrastructure planners to build resilience into future projects and retrofit existing systems.

Energy Concerns in Harris County, Texas

Harris County, Texas, encompassing Houston and its surrounding areas, is a critical hub for the U.S. energy sector, hosting a vast array of oil refineries, petrochemical plants, and energy infrastructure. This concentration underscores the region's economic significance but also highlights its vulnerability to various energy-related challenges.

The region's susceptibility to extreme weather events poses significant threats to its energy infrastructure. Hurricane Harvey in 2017 exemplified this vulnerability, causing unprecedented flooding that disrupted operations across multiple energy facilities. A study by the American Society of Civil Engineers highlighted the need for enhanced infrastructure resilience, noting that many facilities experienced operational challenges despite existing preparedness measures. [180] Similarly, Winter Storm Uri in 2021 led to widespread power outages across Texas, including Harris County, exposing critical weaknesses in the state's power grid. Research published in Natural Hazards detailed how the storm's severity resulted in cascading energy infrastructure failures, leaving millions without electricity and highlighting the grid's vulnerability to extreme cold events. [181]

[180] American Society of Civil Engineers. (2018). Hurricane Harvey Infrastructure Resilience Investigation Report.
[181] Sun, W., et al. (2024). Winter Storm Uri and the Texas Power Grid. Natural Hazards.

Beyond physical threats, the cybersecurity of Harris County's energy infrastructure is a growing concern. The increasing integration of digital technologies in energy systems, while enhancing efficiency, also introduces potential vulnerabilities to cyberattacks. A report from Sam Houston State University emphasized that disruptions to critical infrastructure could lead to theft of intellectual property, supply chain disruptions, electricity outages, and operational losses. [182]

The aging nature of much of Harris County's energy infrastructure presents additional challenges. While Houston has diversified its economy to include sectors like healthcare and technology, the energy industry remains a cornerstone. This diversification necessitates modernizing existing energy infrastructure to support new industries and ensure resilience against both physical and cyber threats. [183]

Energy disruptions disproportionately affect socially vulnerable populations. A study in Energy Research & Social Science examined the disparate impacts of the 2021 Texas winter storm, revealing that low-income and minority communities in Harris County experienced longer outages and faced greater challenges during recovery. [184]

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[182] Sam Houston State University. (2022). Cybersecurity Threats to Critical Infrastructure in Harris County.
[183] City of Houston. (2020). Resilient Houston.
[184] Smith, J., et al. (2024). Energy Disparities in Texas' Winter Storm. Energy Research & Social Science.

Water & Wastewater Recovery Systems

Water, the lifeblood of our planet, is facing unprecedented challenges in the 21st century. Approximately 97% of all water on Earth is saltwater, unsuitable for drinking. Additionally, several sectors, such as intensive agriculture, mining, industrial production, and untreated urban runoff, are major causes of water pollution globally.[185] Driven by population growth, industrial expansion, and climate change, the pressures on existing water resources are intensifying. From strained potable water supplies to the increasing volume and complexity of wastewater discharge, municipalities and industries are grappling with the crucial need for efficient, sustainable, and reliable water and wastewater management systems. Traditional methods, while foundational, are increasingly proving insufficient to address the escalating demands and complexities of modern water management. This necessitates a shift fueled by innovation and intelligent solutions. AI is a transformative technology that is rapidly reshaping industries across the globe. With its capacity for complex data analysis, predictive modeling, and adaptive learning, AI offers a promising pathway toward optimizing water and wastewater management systems. This section explores the field of AI applications within this critical infrastructure sector, examining its potential to revolutionize how we understand, control, and conserve our precious water resources.

The challenges facing water and wastewater systems are complex. Potable water production requires meticulous monitoring and control of treatment processes, often involving intricate chemical and physical processes. Water distribution networks, sprawling across vast geographical areas, are prone to leaks, bursts, and inefficiencies. Meanwhile, wastewater

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[185] Krishnan, S.R.; Nallakaruppan, M.K.; Chengoden, R.; Koppu, S.; Iyapparaja, M.; Sadhasivam, J.; Sethuraman, S. Smart Water Resource Management Using Artificial Intelligence—A Review. Sustainability 2022.

treatment plants are tasked with removing a diverse range of contaminants, from organic pollutants and heavy metals to emerging microplastics, while minimizing energy consumption and sludge production. AI presents an innovative solution to these challenges by enabling proactive management, predictive maintenance, and optimizing operational efficiency. Through machine learning (ML) algorithms, AI can analyze vast datasets generated from sensors within the system, identifying patterns and anomalies previously undetectable. This allows for early detection of leaks, predictive maintenance of equipment, and optimized chemical dosing in treatment processes, reducing operational costs and improving water quality.

Furthermore, AI facilitates adaptive water management strategies that can respond to changing environmental conditions. Predictive models powered by AI can forecast water demand fluctuations, predict rainfall patterns, and optimize reservoir operations, ensuring that water resources are allocated efficiently and effectively, even during periods of drought or flood. In wastewater treatment, AI can optimize treatment processes based on influent characteristics and effluent requirements, minimizing energy consumption and chemical usage while meeting stringent regulatory standards.

Water Management

Deep learning, a subset of machine learning, uses large, multi-layered artificial neural networks (ANNs) to process massive sets of data. Popular deep learning algorithms include Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM), Autoencoders, Graph Neural Networks (GNNs), and Deep Reinforcement Learning (DRL), with multiple being currently applied in a variety of industry sectors, such as healthcare and finance.[186] Currently, deep learning has been used in a variety of areas, such as urban water management, focusing

[186] Guangtao Fu, Yiwen Jin, Siao Sun, Zhiguo Yuan, David Butler, The role of deep learning in urban water management: A critical review, Water Research, Volume 223, 2022.

primarily on anomaly detection, system prediction, asset assessment, system operation, and maintenance planning. Anomaly detection is a kind of diagnostic tool used to identify certain failure events, such as leakages, contamination, blockages, and cyberattacks. System operation and maintenance planning are used to identify the best solutions with a given constraint.[187] These concepts can be applied in a variety of water and wastewater management systems, such as water supply and distribution systems, urban wastewater systems, and urban flooding.

Water Supply & Distribution

The first application of deep learning in water supply and distribution systems is demand forecasting, assisting professionals in predicting peak demand hours for water usage to allow an efficient distribution of resources across time. With the increase in the use of smart water meters, deep learning has the potential to transform our understanding of water usage and provide professionals with the necessary knowledge to ensure equal resource distribution. Second, leakage detection and localization are other potential usages for deep learning within water supply & distribution systems. Here, deep learning models are trained on certain data points, such as pressure, flow, acoustic, and vibration signals within the system, to identify normal and abnormal situations. In a study conducted by Fang et al., (2019)[188], six CNN models utilized pressure data and were able to successfully detect leakage events, with the best model achieving an accuracy of 97%. Additionally, acoustic and vibration signals, generated by leaks from pressure changes, can be detected by CNN models.[189]

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[187] Ibid

[188] QianSheng Fang, JiXin Zhang, ChenLei Xie, YaLong Yang; Detection of multiple leakage points in water distribution networks based on convolutional neural networks. Water Supply 1 December 2019.

[189] Guangtao Fu, Yiwen Jin, Siao Sun, Zhiguo Yuan, David Butler, The role of deep learning in urban water management: A critical review, Water Research, Volume 223, 2022.

Urban Wastewater

Typically, the conditions of sewers are traditionally managed by closed-circuit television (CCTV) by professional inspectors, which is very labor-intensive and takes a lot of time. Deep learning, however, has been utilized in this area to assist with image classification and object detection.[190] Several studies have been conducted using CNN models, such as Gutierrez-Mondragon et al., (2020)[191] training a CNN model to identify the obstruction level of sewer pipes, drastically reducing the manpower required to maintain these systems. Once a potential obstruction has been identified within the system, object detection can be used to gather more information on the situation and assist professionals in making informed decisions. In addition to image classification and object detection, deep learning models can also be utilized to predict sewer flow and water depth, which is very useful in translating predictions to real-world operational practices, such as reducing overflow.[192]

Urban Flooding

Hydrodynamic flood modeling is one way in which emergency managers can plan for and mitigate future flooding, but this often relies on accurate, high-resolution data. Deep learning can play a crucial role in processing large amounts of data from sources such as aerial photography, LiDAR data, and satellite and radar data.[193] Similar to the sewer system monitoring systems, deep learning is capable of extracting information from raw data and processing it for the user.

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[191] Gutierrez-Mondragon, M.A., Garcia-Gasulla, D., Alvarez-Napagao, S., Brossa-Ordoñez, J., and Gimenez-Esteban, R., 2020. Obstruction level detection of sewer videos using convolutional neural networks.
[192] Guangtao Fu, Yiwen Jin, Siao Sun, Zhiguo Yuan, David Butler, The role of deep learning in urban water management: A critical review, Water Research, Volume 223, 2022.
[193] Guangtao Fu, Yiwen Jin, Siao Sun, Zhiguo Yuan, David Butler, The role of deep learning in urban water management: A critical review, Water Research, Volume 223, 2022

Similarly, deep learning models are being used to predict flooding, even in urban environments, which has proved difficult to predict compared to the simplicity of a flowing river. Guo et al., (2020)[194] developed a model to predict the maximum flood depth for rainfall events. The model was even capable of providing accurate predictions for various terrains, such as flat, steep, around buildings, upstream, downstream, etc.

[194] Guo Z, Leitão JP, Simões NE, Moosavi V, 2020. Data-driven flood emulation: Speeding up urban flood predictions by deep convolutional neural networks.

The Port of Houston

Port operations are becoming more automated than ever before. The integration of AI technologies is paving the way for port systems that maximize efficiency with machine learning technologies.

Currently, AI tech can be seen in action through the optimization of job duration between docked ships and ships in waiting. This translates to the data tracking of ship size, cargo contents, available resources, and more to systematically allocate resources to ensure that ships are docked for the least amount of time as possible. Data tracking can also include berth, a ship's allocated place in a dock, and crane management. Berth management can prove to be the biggest contributor to failure in port management due to the specific needs of various ship types and various cargo extraction/ onboarding needs. Massive shipping wait lines can form due to a shared need for a specific berth to be freed up even while other berths remain open due to their incompatibility. In fact, some ships have remained in queues for available berths due to the unnavigable dimensions of backed up shipping traffic. Additional innovations brought on by AI to the port sector include autonomous shipping boats.[195] Several companies have begun experimentation and investment in autonomous ships to reduce the need for human crew and increase optimization of fuel efficiency and shipping routes.[196]

As the shipping industry continues to push forward with the integration of AI technologies, emergency managers must become aware of the congruent rise in potential for cyber security risks. Increased reliance on AI platforms and technologies produces increased

[195] "Are There Risks in Using AI to Manage Risk in Port?" Riviera. Accessed March 12, 2025. https://www.rivieramm.com/news-content-hub/news-content-hub/what-are-the-risks-of-using-ai-to-manage-risk-in-port-82585.
[196] "How AI Is Transforming Ports into Smart Hubs of Efficiency." Maritime Fairtrade, February 22, 2024. https://maritimefairtrade.org/how-ai-is-transforming-ports-into-smart-hubs-of-efficiency/.

exposure for bad actions to infiltrate these systems and cause disruptions. Many disruptions could ultimately back up ports and increase traffic levels in the queues, ultimately dismantling the original intention of optimization with the technology. Perhaps more threatening, a future where autonomous ships become the norm presents the possibility of cyberattacks that either intentionally or unintentionally cause collisions with other vessels or water-based infrastructure.

Some experts in the field of autonomous navigation remain skeptical of the potential for autonomous navigation of the sea. Storm and tide conditions alike provide a major source of unpredictability in navigation, and much like our inability to predict the weather accurately 100% of the time, these same experts predict that those developing autonomous cargo ships will run into trouble with navigation when conditions become unpredictable. This could result in autonomous ships veering from their original paths or inflicting damage on themselves or other vessels.[197]

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[197] Abstract The safety and reliability of autonomous ships are critical for the successful realization of an autonomous maritime ecosystem. Research and collaboration between governments. "Research on Risk, Safety, and Reliability of Autonomous Ships: A Bibliometric Review." Safety Science, July 25, 2023. https://www.sciencedirect.com/science/article/pii/S0925753523001984.

AI in Healthcare

Artificial Intelligence (AI) is revolutionizing emergency management in healthcare by enhancing decision-making, optimizing resource allocation, and improving patient care. However, AI also introduces significant risks to critical healthcare infrastructure. These risks range from cybersecurity vulnerabilities and data integrity concerns to ethical dilemmas and operational challenges. As healthcare systems increasingly integrate AI into emergency response and management, it is essential to understand these risks to mitigate potential threats effectively.

Cybersecurity threat

AI systems rely on vast amounts of patient data, hospital records, and real-time monitoring to support emergency response. These systems, if not adequately secured, become prime targets for cyberattacks, including ransomware, data breaches, and adversarial AI manipulation. Ransomware and data breaches are among the most concerning threats. AI-powered emergency management systems require seamless access to patient records and hospital databases. Cybercriminals can exploit vulnerabilities in these systems to launch ransomware attacks, locking hospitals out of critical data until a ransom is paid. In 2017, the WannaCry ransomware attack crippled the UK's National Health Service (NHS), disrupting emergency services and delaying patient care.[198] Adversarial attacks on AI algorithms are another growing concern. AI systems in emergency healthcare rely on machine learning models trained on historical data. Hackers can use adversarial attacks to manipulate AI decision-making by injecting misleading data or altering algorithm parameters. [199] This can result in incorrect triaging, improper resource allocation, or misdiagnosis, thereby endangering lives.

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[198] Wheeler, T., & Alderdice, J. L. (2022). Cyber collateral: Wannacry & the impact of cyberattacks on the mental health of critical infrastructure defenders. Changing Character of War Centre (CCW).
[199] Cartwright, A. J. (2023). The elephant in the room: cybersecurity in healthcare. Journal of Clinical Monitoring and Computing, 37(5), 1123-1132.

Data Integrity and Reliability Issues

AI-driven emergency management relies on accurate and up-to-date data to make informed decisions. However, several risks threaten the integrity and reliability of the data used in AI models. Bias in training data is a major issue, as AI systems learn from historical data, which may contain biases. If the training data is incomplete, outdated, or biased, AI decision-making may disproportionately disadvantage certain populations. For example, AI-driven emergency response systems may under-prioritize minority communities if historical data underrepresents their healthcare needs. False positives and false negatives in AI-driven diagnostics and resource allocation models also pose risks. [200] False positives, such as misidentifying a non-critical condition as an emergency, and false negatives, such as failing to detect a critical condition, can strain emergency services and lead to life-threatening situations. AI errors in predicting patient deterioration, for instance, may lead to unnecessary hospital admissions or, conversely, a failure to escalate care in time.

Ethical and Legal Concerns

AI in healthcare emergency management raises ethical and legal questions regarding patient rights, liability, and algorithmic accountability. One of the primary concerns is the lack of transparency and explainability in AI systems. Many AI models operate as "black boxes," meaning their decision-making processes are not transparent. This lack of explainability makes it difficult for healthcare professionals to understand why an AI system recommended a particular course of action. [201] In emergency situations, healthcare providers must have confidence in AI

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[200] Sheliemina, N. (2024). The use of artificial intelligence in medical diagnostics: Opportunities, prospects and risks. Health Economics and Management Review, 5(2), 104-124.
[201] Prateek, M., & Rathore, S. P. S. (2025). Clinical Validation of AI Disease Detection Models—An Overview of the Clinical Validation Process for AI Disease Detection Models, and How They Can Be Validated for Accuracy and Effectiveness. AI in Disease Detection: Advancements and Applications, 215-237.

recommendations, but opaque algorithms undermine trust and accountability. Legal liability in AI-driven decisions is another pressing issue. If an AI system makes an incorrect diagnosis or misallocates emergency resources, determining liability becomes complex. Should responsibility fall on the software developers, healthcare providers, or institutions that deployed the AI? Legal frameworks have not yet fully evolved to address these challenges, leaving significant gaps in accountability. Patient privacy and consent also come into question as AI systems require extensive patient data to function effectively. However, collecting, storing, and analyzing sensitive medical information raises privacy concerns. Ensuring patient consent and compliance with regulations like the Health Insurance Portability and Accountability Act (HIPAA) is critical to maintaining trust in AI-driven healthcare solutions.

Operational Challenges in Emergency Management

The integration of AI into emergency healthcare infrastructure also introduces operational risks that could compromise the effectiveness of emergency responses. One such risk is the overreliance on AI systems. Emergency management personnel may become overly dependent on AI recommendations, leading to complacency and reduced human oversight. [202] While AI can enhance decision-making, it should not replace human judgment, particularly in critical healthcare situations where nuanced, context-driven decisions are required. System failures and downtime further complicate AI-driven emergency management. AI systems require robust infrastructure to function effectively. However, system failures, software bugs, or power outages can disrupt AI operations, delaying emergency responses. Without adequate backup plans, such failures could lead to catastrophic outcomes. Scalability and interoperability issues also pose challenges. AI solutions must integrate seamlessly with existing healthcare infrastructure,

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[202] Vearrier, L., Derse, A. R., Basford, J. B., Larkin, G. L., & Moskop, J. C. (2022). Artificial intelligence in emergency medicine: benefits, risks, and recommendations. The Journal of Emergency Medicine, 62(4), 492-499.

including electronic health records (EHRs), emergency dispatch systems, and hospital networks. Many healthcare organizations struggle with legacy systems that may not be compatible with modern AI technologies, creating interoperability challenges that hinder the effectiveness of emergency management solutions.

Potential Mitigation Strategies

Enhancing cybersecurity measures is critical, with multi-layered defenses such as encryption, intrusion detection systems, and regular security audits helping to protect AI-driven emergency management systems from cyber threats.

Ensuring data integrity and bias mitigation is equally important, with AI models trained on diverse, high-quality datasets to minimize biases and improve accuracy. Regular audits and bias detection frameworks can help ensure AI decisions are fair and equitable. Improving explainability and transparency in AI decision-making allows healthcare providers to understand and validate AI recommendations. Policymakers and regulatory bodies must develop clear guidelines for AI liability and ethical AI frameworks to ensure that AI-driven emergency management aligns with patient rights and legal standards. Implementing fail-safe mechanisms is another key strategy. AI systems should have built-in fail-safes, including manual override options, redundancy protocols, and contingency plans in case of system failures. [203] Human oversight should always be maintained to ensure AI errors do not compromise emergency responses.

OpenAI-type platforms, including advanced AI models capable of generating text, analyzing data, and providing recommendations, can be exploited by bad actors to compromise the Harris County emergency management network. These bad actors could use OpenAI-type

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[203] George, A. S., Baskar, T., & Pandey, D. (2024). Establishing Global AI Accountability: Training Data Transparency, Copyright, and Misinformation. Partners Universal Innovative Research Publication, 2(3), 75-91.

platforms to generate false emergency alerts, manipulate public perception, or create realistic but misleading reports that disrupt emergency management efforts. This could lead to unnecessary panic, misallocation of resources, or delays in responding to actual emergencies.

Additionally, OpenAI-type platforms may inadvertently facilitate data breaches by making it easier for individuals to generate queries that extract sensitive information. If AI models are trained on improperly secured datasets, they could unintentionally reveal confidential patient records, emergency response protocols, or strategic plans for disaster management. [204] This exposure could compromise public safety and lead to long-term security risks for healthcare providers and emergency management agencies.

To mitigate these risks, Harris County emergency management must implement stringent cybersecurity protocols and safeguard AI-driven tools against exploitation. Harris County, which encompasses one of the major medical hubs in the United States, has a unique opportunity to integrate AI into its emergency management operations, particularly when it comes to healthcare and critical infrastructure. This integration can enhance the county's ability to respond to disasters, manage public health crises, improve the efficiency of medical facilities, and optimize infrastructure resilience. The core goal of emergency management is to anticipate, prepare for, respond to, and recover from emergencies. In this context, AI can be applied in multiple phases of emergency management, especially in a healthcare-related scenario where quick and accurate decisions can save lives. [205] With healthcare infrastructure being so critical in a region with a

[204] Herzog, N. J., Celik, D., & Sulaiman, R. B. (2024). Artificial intelligence in healthcare and medical records security. In Cybersecurity and Artificial Intelligence: Transformational Strategies and Disruptive Innovation (pp. 35-57). Cham: Springer Nature Switzerland.
[205] Gupta, N. (2024). Security Risks of Generative AI in Financial Systems: A comprehensive review. World Journal of Information Systems, 1(3), 17-24.

dense population and complex medical needs, AI can improve both the resilience of infrastructure and the efficiency of emergency medical responses.

One of the primary ways AI can benefit emergency management in healthcare is through predictive analytics. AI can analyze vast datasets, including historical emergency responses, real-time hospital occupancy rates, weather patterns, traffic patterns, and even social media feeds to predict and model potential crises or emergencies. For example, during a natural disaster such as a hurricane or flood, AI could provide real-time predictions about the most vulnerable areas of the county, pinpointing where hospitals and healthcare facilities may face increased demand or potential damage. This predictive capability allows emergency management teams to proactively prepare for these events, such as ensuring that hospitals have the necessary resources and personnel on hand, evacuating at-risk patients, or rerouting critical supplies.

AI can assist in improving the operational efficiency of hospitals and clinics, reducing bottlenecks, and optimizing patient flow. For example, machine learning models can forecast hospital admissions based on patterns seen during similar crises in the past, allowing facilities to prepare for surges in demand. AI-driven systems can also help healthcare administrators optimize staffing levels and manage the allocation of medical supplies, preventing shortages during critical moments. In a city as large as Houston, with its vast healthcare infrastructure, AI systems can be integrated into the existing network of hospitals, clinics, and urgent care facilities to create a more seamless response across the region.

AI can also support resource management and supply chain logistics. Healthcare facilities in Harris County rely on a continuous supply of medicines, medical devices, and personal protective equipment (PPE), especially during times of crisis. AI can optimize the supply chain by predicting demand for specific resources, identifying potential disruptions in supply lines, and even helping coordinate deliveries of essential items. In an emergency situation, where time is of the essence, such AI-driven systems can reduce delays, improve procurement strategies, and ensure that critical supplies reach the hospitals and clinics that need them most. AI's role in public health surveillance is also vital. By analyzing data from hospitals, clinics, and public health reports, AI can detect emerging health threats, such as disease outbreaks, and provide early warning signals to local authorities. This is particularly important in a region like Harris County, which is home to a diverse population and has large-scale medical events, such as international conferences and sports games. AI can track patterns in healthcare data to identify outbreaks of infectious diseases, allowing the emergency management team to act swiftly and mobilize resources in a targeted manner.

One of the most promising areas for AI integration into healthcare emergency management is telemedicine. In the wake of the COVID-19 pandemic, telemedicine has proven to be an invaluable tool in maintaining healthcare access during lockdowns or quarantine situations. [206] AI-powered telemedicine platforms can conduct virtual consultations, triage patients remotely, and monitor ongoing conditions using wearable medical devices. This reduces the burden on emergency rooms and ensures that healthcare providers can focus on the most critical cases while still addressing non-emergency medical needs. The integration of AI into emergency management in Harris County can lead to long-term improvements in the healthcare system's ability to respond to future crises. As AI systems learn and improve over time, they will become more effective at predicting outcomes, identifying risks, and optimizing responses to complex scenarios. These continuous improvements can lead to a more resilient healthcare

[206] Altinisik Ergur, G., & Nuhoglu, S. (2022). The patient perspective of telemedicine in the context of the COVID-19 pandemic. *Bulletin of Science*…. Retrieved from https://journals.sagepub.com/doi/abs/10.1177/02704676221094735

infrastructure, better coordination during emergencies, and improved overall public health outcomes in the region.

Public perception of AI in emergency management, particularly in the context of critical healthcare infrastructure, is complex and multifaceted, shaped by both optimism and concern. As AI technologies become more integrated into emergency response systems, including healthcare infrastructure, there is growing interest in how these systems can improve efficiency, reduce human error, and enhance decision-making. However, there are also significant concerns regarding privacy, reliability, accountability, and the potential for AI systems to malfunction or exacerbate existing inequalities. Understanding these diverse perspectives is crucial for ensuring the successful implementation of AI technologies in healthcare emergency management.
During the COVID-19 pandemic, AI demonstrated its potential to transform healthcare systems. AI-powered systems were used to track virus spread, predict healthcare resource shortages, and optimize vaccine distribution, which was crucial in an unprecedented health crisis. These successes have contributed to a more favorable public view of AI in healthcare emergencies, with many seeing it as an essential component of future public health strategies. Additionally, AI's ability to enhance telemedicine services, allowing people to access healthcare remotely during lockdowns, further solidified its positive role in emergency management.

However, the public's perception is not entirely positive. Concerns about AI in healthcare emergency management often revolve around issues of privacy, bias, and accountability. AI systems rely on vast amounts of personal and health data, which raises concerns about data security and the potential for misuse. There is anxiety that personal health information, if mishandled or exposed, could lead to identity theft or discrimination. This is particularly worrisome when it comes to sensitive health data, which is often used to train AI algorithms. A breach of this data or an AI-driven decision that negatively affects a person's access to care could significantly damage public trust. Additionally, the potential for bias in AI algorithms is a significant concern. AI systems are only as good as the data they are trained on, and if that data is flawed or unrepresentative, it can lead to biased outcomes. [207] In emergency healthcare management, where decisions made by AI could determine the prioritization of care, this could have life-or-death consequences. For example, if an AI system disproportionately prioritizes certain demographics or fails to recognize the unique health needs of minority populations, it could exacerbate existing healthcare disparities. This issue is particularly relevant in diverse regions like Harris County, which has a large and varied population. Without adequate oversight and ethical consideration in the design of these AI systems, there is a genuine fear that they may perpetuate inequality.

There is also apprehension about the role of AI in replacing human decision-making in healthcare. Many people value the empathy, judgment, and experience that healthcare professionals bring to emergencies. Concerns about the "dehumanization" of healthcare, where patients are treated as data points rather than individuals, could lead to a resistance to AI implementation in emergency management. Public acceptance may depend on how well these technologies are integrated into human-led processes and how transparent the decision-making processes are. Beyond these concerns, there are fears about the reliability of AI systems during critical healthcare emergencies. If an AI algorithm were to fail or produce incorrect recommendations during a crisis, the consequences could be catastrophic. For instance, a faulty prediction of hospital bed availability or an error in resource allocation could delay treatment for patients who urgently need care. The public may be skeptical about entrusting machines with

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[207] Jiang, H., & Nachum, O. (2020, June). Identifying and correcting label bias in machine learning. In International conference on artificial intelligence and statistics (pp. 702-712). PMLR.

such vital responsibilities unless there is strong evidence of the reliability and safety of AI systems. Therefore, any AI implementation in healthcare emergency management must be thoroughly tested, regularly updated, and monitored for performance issues to address these concerns.

Findings and Recommendations

Recommendations for Policymakers on Ethical AI Implementation and Regulation

As AI finds increasing prevalence in emergency management and public governance, policymakers need to guide the development of ethical frameworks that will allow AI to be incorporated because AI has the potential to yield significant benefits while still ensuring that it is being deployed responsibly. An ethical AI policy must take into account important factors, including, but not limited to, transparency, accountability, fairness and equity for individuals, privacy and security, and support for innovation.

Transparency and Explainability

Policymakers should require Explainable AI (XAI) to ensure AI decisions can be interpreted and audited. The AI incorporated into emergency management and public-facing services must clearly justify its outputs, especially in high-stakes moments, such as law enforcement or disaster recovery. The National Institute of Standards and Technology (NIST) recommends public trust is preserved when AI models have been developed with mechanisms for transparency[208]. Requiring AI developers to log decisions and provide audit trails can reduce the "black box" dilemma and encourage regulatory management.

Bias and Fairness Mitigation

AI models that are trained on biased datasets can reinforce systemic inequalities, resulting in unfair outcomes in disaster relief allocation and more. In terms of governance of AI, policymakers should enforce strict bias detection protocols as well as mitigation protocols. AI systems deployed in public administration must undergo fairness testing before their utilization

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[208] NIST. (2023). AI Risk Management Framework. U.S. Department of Commerce. Retrieved from https://www.nist.gov/itl/ai-risk-management-framework

as per the European Union's AI Act (2024). The same way, independent review panels can be created by the U.S. government to assess the fairness of AI models used in important sectors like emergency management and law enforcement. [209]

Privacy Protection and Data Governance

AI systems often use a wealth of data, including information about people, as well as surveillance video images in real-time. To ensure that AI does not violate civil liberties, robust privacy policies must be put in place. AI emergency response systems use social media, location data, and body measurements to evaluate crises. Data collection should be compliant with prevailing privacy laws like Privacy Act 1974, General Data Protection Regulation (GDPR) in EU to avoid misuse. Executive Order 14110 (2023) of the Biden Administration seeks to secure AI data and prevent its use without authorization. [210]

Accountability and Human Oversight

In the case of emergencies and public policy, AI should act as a decision-support tool, not a decision-maker. The DHS (Department of Homeland Security) AI Roadmap[211] states that all DHS AI recommendations must undergo human verification before execution during crisis situations. Human-in-the-loop (HITL) oversight means that AI-generated decisions remain subject to ethical review and contextual judgment.

Cybersecurity and AI Resilience

To avoid adversarial attacks, misinformation spreading, and alteration of AI models, AI systems used in emergency management must be hardened against cyber threats. Government

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[209] European Commission. (2024). The European Union AI Act. Retrieved from https://ec.europa.eu/ai_act
[210] White House. (2023). Executive Order 14110: Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence. Retrieved from https://bidenwhitehouse.archives.gov
[211] DHS. (2024). AI Roadmap for Homeland Security Applications. Retrieved from https://www.dhs.gov/topics/disasters

agencies should embrace the principles of Zero Trust Architecture (ZTA), which require continuous verification of AI system integrity. In addition, the federal government should start an AI certification program that will check the security of AI models.

Interagency Collaboration and International Standards

Since AI affects many areas of society, policymakers should encourage agencies to work together to create a single set of AI standards for the federal government, states, and local entities. The Department of Homeland Security and Federal Emergency Management Agency should partner with private sector AI developers to develop standardized ethical guidelines. The U.S. should also work to harmonize its AI governance frameworks with those of the OECD, the UN's Centre for Artificial Intelligence, and the UN's AI Advisory Board.

If policymakers can implement these recommendations, they can ensure that the integration of AI into emergency management and public governance is ethically responsible and operationally effective.

Critical Infrastructure - Recommendations for Enhancing Resilience

To address these multifaceted challenges, Harris County should consider the following strategies:

1. Infrastructure Modernization: Invest in upgrading and weatherizing energy infrastructure to withstand extreme weather events, including both hurricanes and winter storms.
2. Cybersecurity Enhancements: Implement robust cybersecurity measures to protect against potential cyber threats targeting critical energy systems.
3. Community Engagement: Develop targeted programs to support vulnerable populations during energy disruptions, ensuring equitable access to resources and assistance.

4. Policy and Planning: Collaborate with state and federal agencies to develop comprehensive policies that address both current vulnerabilities and future challenges posed by climate change and technological advancements.

Ultimately, AI integration into emergency management strategies across mitigation, preparedness, response, and recovery phases presents a transformative opportunity to enhance the resilience and security of critical energy infrastructure. Given the complexity, interdependence, and evolving threat landscape faced by the energy sector, AI provides robust tools and innovative solutions that significantly improve infrastructure reliability and public safety, vital for sustaining economic and societal functions.

AI in Meteorology – Recommendations

As Harris County faces increasing risks from storms, urban flooding, and excessive heat, using AI in meteorological planning and emergency response is going to become an important aspect of managing emergencies effectively. The following recommendations could give an overview of a path forward:

1. Diverse and High-Quality Data

   Using diverse and high-quality datasets is crucial in meteorology, as AI models rely heavily on the data they are trained on. If the data lacks variety—geographically, seasonally, or in terms of extreme weather events—the model may struggle to generalize or accurately predict rare but impactful conditions. High-quality data ensures the AI system captures the complexity of atmospheric behavior, while diversity helps reduce bias, leading to more robust, reliable, and equitable forecasts across different regions and populations.

2. Invest in Data-Driven Forecasting and Resilience Planning

To effectively use AI in meteorology, the system needs to integrate high-resolution mapping with real-time environmental data to generate localized forecasts, enable earlier alerts, and support smarter evacuation planning. This same data infrastructure can also guide long-term decisions on infrastructure upgrades, helping the county build resilience against increasingly severe weather events.

3. Ensure Human Expertise and Cross-Agency Integration

   AI-generated forecasts should support—not replace—expert meteorological judgment. Emergency staff must be trained to interpret probabilistic outputs and integrate them with existing protocols. Coordination with agencies like the National Weather Service and NOAA ensures AI insights lead to clear, unified, and effective emergency responses.

Linguistic Models - Prospects and Recommendations

The future of emergency management lies in the continued advancement and integration of AI-driven linguistic models with cutting-edge technologies. [212] One of the most promising avenues is the combination of linguistic models with geospatial data analytics, which would enhance situational awareness and improve disaster response efficiency. [213]; [214]; [215] By overlaying linguistic analysis with real-time geospatial mapping, emergency management teams can visualize crisis locations, predict affected areas, and optimize resource allocation. [182] This integration ensures that linguistic insights derived from social media, emergency calls, and news

[212] Paramesha, M., N. Rane, and J. Rane. 2024. "Enhancing Resilience through Generative Artificial Intelligence Such as ChatGPT." *Available at SSRN 4832533*.
[213] Hasanuzzaman, M., S. Hossain, and S. K. Shil. 2023. "Enhancing Disaster Management through AI-Driven Predictive Analytics: Improving Preparedness and Response." *International Journal of Advanced Engineering Technologies and Innovations* 1(01): 533–62.
[214] Karami, A., V. Shah, R. Vaezi, and A. Bansal. 2020. "Twitter Speaks: A Case of National Disaster Situational Awareness." *Journal of Information Science* 46(3): 313–24.
[215] Huang, Q., and Y. Xiao. 2015. "Geographic Situational Awareness: Mining Tweets for Disaster Preparedness, Emergency Response, Impact, and Recovery." *ISPRS International Journal of Geo-Information* 4(3): 1549–68.

reports are contextualized within a geographical framework, enabling a more targeted and effective response strategy. [216]

Another critical area for improvement is the incorporation of social media monitoring tools to enhance real-time information gathering and public sentiment analysis. [217] AI-driven linguistic models can process vast amounts of social media content, detecting emerging threats, misinformation, and crisis trends in real time. [184] By automating the analysis of posts, hashtags, and geotagged updates, emergency management agencies can gain actionable insights, allowing them to respond more quickly to developing crises. [218] Furthermore, social media engagement provides an opportunity for public participation in emergency response efforts, enabling authorities to crowdsource real-time updates from affected individuals. [119]

The adoption of blockchain-based verification systems presents another innovative opportunity to improve data integrity and trustworthiness in emergency management operations. [219] Blockchain technology ensures that crisis-related information remains tamper-proof and verifiable, preventing the spread of misinformation that can hinder emergency response efforts. [186] By utilizing decentralized verification mechanisms, emergency management agencies can maintain the authenticity of critical alerts, ensuring that only accurate and verified data informs response coordination. [220] The integration of blockchain technology with linguistic models could

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[216] Shih, P. C., K. Han, and J. M. Carroll. 2015. "Using Social Multimedia Content to Inform Emergency Planning of Recurring and Cyclical Events in Local Communities." *Journal of Homeland Security and Emergency Management* 12(3): 627–52.
[217] Verma, S. 2022. "Sentiment Analysis of Public Services for Smart Society: Literature Review and Future Research Directions." *Government Information Quarterly* 39(3): 101708.
[218] Khatoon, S., A. Asif, M. M. Hasan, and M. Alshamari. 2022. "Social Media-Based Intelligence for Disaster Response and Management in Smart Cities." In *Artificial Intelligence, Machine Learning, and Optimization Tools for Smart Cities: Designing for Sustainability*, 211–35. Cham: Springer International Publishing.
[219] Hossain, M. I., T. Steigner, M. I. Hussain, and A. Akther. 2024. "Enhancing Data Integrity and Traceability in Industry Cyber Physical Systems (ICPS) through Blockchain Technology: A Comprehensive Approach." *arXiv preprint* arXiv:2405.04837.
[220] Siemon, C., D. Rueckel, and B. Krumay. 2020. "Blockchain Technology for Emergency Response."

further enhance transparency, providing an immutable record of crisis communications and decision-making processes. [179]

Finally, investment in AI literacy programs for emergency management personnel is essential to maximize the effectiveness of these advanced technologies. [221] Training first responders, government officials, and crisis communication teams in AI-driven linguistic tools will ensure that these technologies are properly utilized and interpreted. [116] Providing specialized education on NLP applications, bias mitigation strategies, and AI ethics will further enhance the responsible deployment of these tools in real-world scenarios. [222]; [223]By fostering AI literacy and cross-disciplinary collaboration, emergency management agencies can build a more resilient and adaptive response system, ultimately strengthening public safety and disaster preparedness. [190]; [224]

[221] Dwivedi, Y. K., L. Hughes, E. Ismagilova, G. Aarts, C. Coombs, T. Crick, et al. 2021. “Artificial Intelligence (AI): Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice and Policy.” *International Journal of Information Management* 57: 101994.
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[224] Putra, Raden, Siti Wardhani, Bayu Santoso, Intan Permata, Bishnu Prasad Sharma, Agung Pratama, and Dewi Kartika. 2024. “Strategic Deployment of Collaborative Intelligence to Enhance Cybersecurity Resilience in Large-Scale Emergency Response Initiatives.”

Conclusion

Future Trends and Recommendations for AI in Emergency Management

As time goes on, technology is changing every day, and it is now impacting emergency management too. In the future, AI-driven predictive analytics, automation, and real-time data processing capabilities will bring improvements in situational awareness and operational capacity. All this innovation is not without its challenges — security, ethical, and policy issues related to them. Emergency management organizations should implement the planned and strategic use of AI to maximize its benefits while minimizing risks.

Emergency management professionals can expect the development of predictive analytics and early warning systems through the application of AI. Increasingly, predictive models powered by AI will combine real-time environmental data, satellite images, and historical disaster data to improve forecasts and readiness for disasters. More advanced simulations running on powerful supercomputers, as well as machine learning tools, will allow for more accurate predictions of hurricanes, fires, and earthquakes so that responders can take preventative action before a crisis occurs. [225] Furthermore, AI-enabled surveillance and monitoring solutions will facilitate ongoing evaluation of environmental conditions, allowing officials to more adeptly predict and mitigate potential catastrophes.

In the future, automation will significantly enhance disaster response endeavors; particularly with the assistance of AI-based Robotics, UAVs, and autonomous Emergency response systems. Drones that are powered by AI will conduct damage assessments, search and rescue operations, and supply delivery in areas that are hard to access in real-time. Further,

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[225] European Commission. (2024). The European Union AI Act. *EU Regulation on Artificial Intelligence*. Retrieved from https://ec.europa.eu/ai_act

robotic systems equipped with AI will take assistance in risky environments such as collapsing buildings or chemical facilities, reducing danger to human other responders. There will be improvement in cooperation and reduction in response time between agencies due to the integration of various technologies. The opioids and alliances of AI-IOT further strengthen the disaster response and recovery capabilities. Smart sensors, automated surveillance systems, and disaster monitoring systems will all be interconnected.

AI will evaluate the information from IoT embedded instruments to discover preliminary indications of infrastructure disruption, severe weather events, and other environmental dangers. With the implementation of 5G, the pace of data transfer will increase, enabling management units to receive real-time updates and modify their course of action.

As AI becomes more ingrained in emergency management activities, it will also assist in the optimization of allocation of resources and distribution of humanitarian aid. Platforms powered by AI will ensure that food, medical supplies, and shelter reach affected people systematically. Emergency agencies can use AI-enabled supply chain management tools to anticipate shortages and coordinate relief efforts. [226] This will help minimize delays and make disaster recovery more efficient.

Another area where AI is expected to grow is public communication and misinformation mitigation. Tools using AI and natural language processing will survey various online forums and social media paths for disinformation spread on social media channels. During an emergency, false information can create panic among the public. To address this issue, agencies can make use of AI systems that will heavily help in fact-checking the government's messages to

[226] Department of Homeland Security (DHS). (2024). DHS roles and responsibilities framework for artificial intelligence in critical infrastructure. *U.S. Government Publishing Office*. Retrieved from https://www.dhs.gov/topics/disasters

the public. [227] AI chatbots and virtual assistants will also provide people with real-time updates as well as guide them on emergency preparedness and response.

Although AI can be beneficial in various ways, its growing use in emergency management can raise some ethical issues like biased decision-making. It is necessary to stress-test AI models for fairness so that discrimination does not happen during disasters. To ensure that AI-generated recommendations do not discriminate against vulnerable populations, governments and agencies should take measures to develop ethical frameworks for AI. [228] Using transparent systems will encourage accountability for and equitable bias-free use of AI crime-prediction technology for underprivileged populations. Understanding clearly what an AI-system is meant to do will be charged.

To solve these problems and utilize AI successfully to fix disasters, several important policy recommendations can be made. To ensure the ethical use of AI systems in Emergency Management, governments must formulate comprehensive governance frameworks. Policies should set standards for compliance with privacy laws and civil rights, while mandating transparency in decision-making. There must be sufficient funding for the development of AI training for emergency responders so that they can understand and accurately apply the insights provided. Emergency management training must include AI literacy training in order to use AI responsibly and with human oversight.

As AI continues to become a core part of emergency response systems, it is essential to ensure cybersecurity of these systems. To secure AI driven platforms against cyber threats and

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[227] O'Neil, C. (2016). Weapons of math destruction: How big data increases inequality and threatens democracy. Crown Publishing Group.
[228] European Commission. (2024). The European Union AI Act. *EU Regulation on Artificial Intelligence*. Retrieved from https://ec.europa.eu/ai_act

attacks, strict security guidelines must be imposed. This should include encryption, authentication schemes, and infection detection capabilities along continuous monitoring for ongoing threats. It is critical to improve security efforts in order to guarantee the efficiency and resilience of AI ability. It will be important to work cooperatively to develop AI applications in emergency management.

The focus of public-private partnerships (PPPs) must be on fostering innovations in AI with appropriate regulatory frameworks. In addition, disaster simulations using AI should be included in training exercises for preparedness to test responses, find vulnerabilities and improve coordination ahead of actual disasters. With these simulations, we can make better decisions and become more resilient to disasters.

As AI keeps growing, it is going to be very useful at handling emergencies. To effectively use AI while tackling ethical, security, and operational challenges, we need a balanced approach. Using a series of initiatives, emergency management agencies can turn AI into a powerful tool for improving disaster preparedness, response, and recovery by enhancing management.

Appendix: Interview Questions

Interview Questions for Federal & State, Local, Private, and NGO

Federal Government Agencies

4. What AI tools or platforms, if any, are currently being utilized by your organization to enhance emergency management strategies at the federal level?

5. If AI tools are being used, how does your organization train its employees and state or local partners to understand and operate these tools effectively, especially during disaster response operations?

6. How does your organization coordinate with state, tribal, territorial, and local agencies to address AI-related cybersecurity challenges in emergency management?

7. As a federal agency, how does your organization collaborate with local entities and counterparts in the integration and deployment of AI tools?

8. What is your organization's approach to leveraging AI for public communication during crises, and what safeguards are in place to prevent the spread of misinformation?

9. What are the primary risks your organization has identified regarding AI integration, including potential malicious activities related to open AI tools? How is your organization/agency working to mitigate these risks, and has it conducted or utilized any research—internal or external—to evaluate potential threats and opportunities?

State Government Agencies

1. If your agency is not currently using AI, do you see potential future applications? What specific uses do you envision for your organization or department?

2. If your agency is using or exploring the use of AI, what steps are being taken to ensure these systems do not introduce biases in emergency management decisions due to input "echo chambering"?

3. How is your agency balancing the benefits of AI adoption with the need to mitigate cybersecurity risks?

4. How has the state's ban on technologies like TikTok and Da-Jiang Innovations influenced your agency's approach to adopting AI platforms, such as ChatGPT, for use of state employees/operations?

5. How are state-level agencies like yours collaborating with local and federal counterparts to standardize the use of AI in emergency management?

6. If your agency is using or exploring the use of AI, how does your agency address public concerns about AI while maintaining transparency in AI-driven processes?

Local Government Agencies

1. What AI tools or platforms, if any, are currently being used in your local government's emergency management strategies?

2. If AI tools are being used, how are local government employees trained to understand and operate these tools, and does this process differ during emergencies?

3. How does your agency coordinate with state or federal agencies on AI-related cybersecurity issues in emergency management?

4. How does your agency plan to use AI to communicate with the public during crises, and what safeguards are in place to prevent misinformation?

For-Profit Organizations

1. How is your company currently using or planning to use AI in emergency management operations?

2. If your company utilizes AI, how do you address public concerns or criticisms regarding the use of AI products?

3. If your company offers AI-based products or services, are they applicable to emergency management? If so, how have they been received by government agencies?

4. If your company is not currently utilizing AI, do you see potential future applications? What specific uses would you envision for AI for your company?

5. What cybersecurity challenges do you anticipate in providing or using AI products to support emergency management agencies? If your company offers AI products, how are you addressing these risks?

6. How does your company ensure that AI tools used in emergency management—either internally or by your consumers—do not perpetuate decision bias or result in unfair decision-making?

Non-Governmental Organizations (NGOs)

1. How is your NGO utilizing AI to enhance its emergency response or disaster relief efforts?

2. How does your organization collaborate with government agencies to integrate AI into emergency management while ensuring community-centered solutions?

3. What role do you see AI playing in humanitarian efforts, especially in improving the speed, accuracy, and efficiency of emergency relief?

4. How do you ensure that AI tools used by your NGO in emergency management operations do not disproportionately affect marginalized or vulnerable populations?

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