



“AI FOR DISASTER MANAGEMENT: PREDICTING NATURAL DISASTERS AND OPTIMIZING EMERGENCY RESPONSES”

Sheraz Fatima

Associate analyst at The Business Research Company

Email ID: sherazfatima@gmail.com

ABSTRACT

Disasters and particular catastrophes including hurricanes, earthquakes, and floods today put significant threats to human lives, property and the global economy. These event occurrence and their impact are escalating in frequency as well as in intensity the climate change effect is evident here, this calls for the need to develop efficient systems for identifying such events and mitigating their effects. About the subject of this paper it is important to state that artificial intelligence and data analyse boost the probability of the prediction of these disastrous incidents and the severity of their consequences, as well as optimise the strategies of the emergency responses. Information relating to past disaster occurrences, satellite imagery and time-stream data with more accurate early warning systems and resource utilization plans. In addition to increasing the effectiveness of disaster response, they also led to reduced human and financial losses through more fluid preferment planning. The focus, as the research is more focused on AI in operational contexts, is on how its application can enhance the problems of disaster preparedness and response, for instance, based on hurricane examples. This paper also examines critical issues of data access, ethical issues of AI, and good governance to produce fair results.

Introduction

Catastrophes of various kinds, including hurricanes, earthquakes, floods, and wildfires, have been a problem for societies for centuries. They are not merely vandals who destroy property; they replace the property, and are notorious for their economic, social, and even psychological devastation (Gupta & Roy, 2024). The conventional techniques of disaster management involved the use of manpower, static models, and delay data that sometimes do not control the impacts of disaster. However, the application of artificial intelligence (AI) in disaster management has many benefits to offer in the items of predictions, aspect of response, as well as lives saved. Big data, ML and DL, data analytics – these AI technologies can process

mass data and find patterns, deliver accurate prediction. In disaster organized management, the use of AI tools can greatly improve the strategies available on natural disasters, making them more futuristic.



Figure 1: The Role of AI in Disaster Management | by Nuradib Maspo | Super (Google, 2019).

The role of AI in disaster management extends across multiple stages: The business continuity planning process encompasses admission, prediction, prepared, response and recovery. For instance, the early warnings can prevent loss of lives by allowing the people to be evacuated most importantly reduce the degree of the disasters. It can also help to control resources in a way that has not been previously possible for example utilizing medical supplies, food or rescue teams most efficiently. This paper will therefore aim at reviewing the various use of AI in early indication of Natural disasters, response to disaster, as well as the effective and efficient provision of aid, highlighting the advantages of the technology and the related challenges.

AI in Disaster Prediction

The last frontier concerns the prospective ability to forecast and avert natural disasters, the prediction of which is still a major problem of scientific development in the field of disaster management (Harika et al., 2024). Although meteorology and geophysics have been improved in recent years, they have made some

contributions to the prediction of such catastrophes, it is not easy to define the disasters accurately. But the predictions themselves may be made quicker and more accurately by what is known today as artificial intelligence. Using machine learning and other forms AI-based models have the capability to parse through huge streams of data, espouse reasonable patterns and future prognostications which are often beyond human capabilities.

Earthquake Prediction

Earthquakes are among the most devastating natural phenomenon whose occurrence cannot be anticipated in advance. While people can feel motions of the ground through seismic sensors and record these motions, the problem of deciding when and where the next earthquake will happen is still very open (Huang, Wang, & Liu, 2021). However, with development of artificial intelligence, the experts have been able to point out some signs that may point toward an earthquake ahead of time. It involves Ready Made Algorithm that analyze past seismic information which can show signs of seism that may be in the offing. Further, the models are also being designed to estimate the future likelihood of aftershocks, usually occurring after a main quake and they enable authorities more time to prepare.

Seismic data have been analyzed by using neural networks , which are modeled with the ability of human brain to process information (Satishkumar & Sivaraja, 2024). These models can identify new movements in the earth's crust or uncharacteristic seismic activities that could indicate an on set of an earthquake. Although the concept of predicting earthquakes without a doubt still remains a long shot away any help that AI can provide in terms of recognizing the risk areas and issuing timely warnings could greatly improve the situation.



Figure 2: Risks and Disasters | UN-SPIDER Knowledge Portal (United Nations, n.d)

Hurricane Prediction

Hurricanes stand as another field where the use of AI has been applied in order to enhance the prediction. These storms are increasingly produced by the elaborate relationships between the atmosphere, the oceans and the land and as such, their prediction is not easy (Sun, Bocchini, & Davison, 2020). In the past, numerical models of hurricanes have relied on such information as wind speed, pressure, temperature of the sea surface, and others. Although these models are considered to have evolved recently, AI has different levels of accuracy and flexibility.

Unlike traditional artificial intelligence systems, modern deep learning system including recurrent neural networks (RNNs), convolutional neural networks (CNNs) can process massive amounts of weather data in a real-time setting. Using satellite images of the ocean, satellite data from around the world, atmospheric

conditions and with the help of artificial intelligence – go further to forecast the track, strength, and duration of the hurricane. Such predictions can then be used to give alerts and develop evacuation solutions, and may spare lives thus lessen the impact of such storms (Tan et al., 2021).

Flood Prediction

About floods and especially flash floods it is difficult to predict since it depends on many factors, for instance rainfall, river flow and the ground (United Nations, n.d.). Through use of pattern recognition from numerous data inputs including weather, hydrological models and geographical mapping, AI is capable of predicting floods. In decision trees, random forests and support vector machines (SVMs), past rainfall data and river discharge, and geographical features can be used to determine vulnerable regions to floods.

Besides, the topic includes the usages of AI to determine the level of flood as well as to predict flood. For instance, the traditional method of flood records and current weather information lets AI models predict the specified increases in water levels and the penetration of floods. These predictions can be extremely helpful for the organization of rescuing operations and evacuation schemes since they point at the biggest threat areas.

How AI can help to improve decisions in emergency situations

In most cases after natural disaster have taken place the immediate response to such disasters is crucial. The overall emergency response has in the past been very slow and more often than not disorganized, because human decision makers had to work with available data to allocate that response and plan the interventions (Varsha, Naganandini, & Hariharan, 2024). AI, however, can enhance such efforts because it can analyze real-time data in relation to the best response.

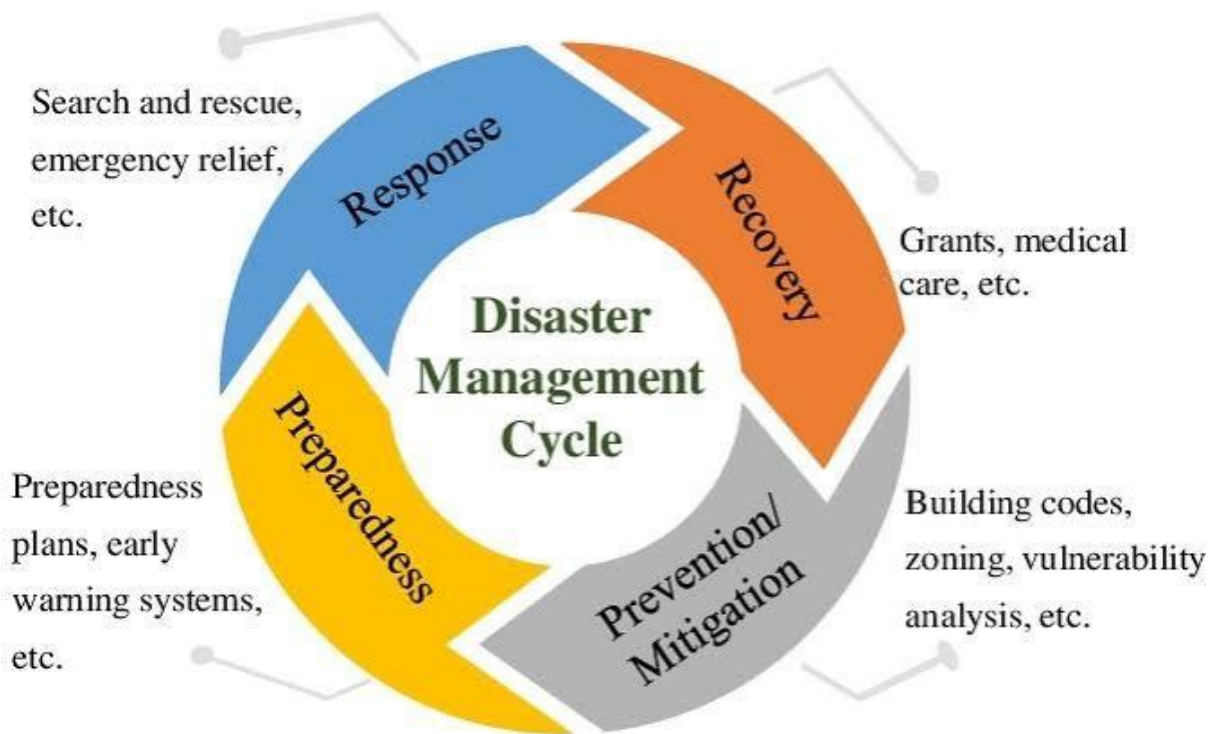


Figure 3: Applications of Artificial Intelligence in Disaster Management (Gupta and Roy, 2024).

Real-Time Resource Allocation

A problem that has been found to be widespread in disaster response is the problem of identifying where the supplies are most required. The actual areas of application include estimating the demand for urgent supplies, including food, water, medicine, and rescue services (Velev & Zlateva, 2023). Based on the geographical coordinates of the affected people, the degree of devastation and available assets it can advise where assets should be allocated. This way, when disaster strikes, responses are fast and effective and saves as many lives as possible.

In fact, AI can prompt emergency teams with the information that satellite imagery or geographical information identify which regions have been most affected. Only then can it recommend the most efficient ways in which resources can be transported, including road conditions, traffic, and damages incurred on the infrastructure. This will allow AI to minimize time wastage and help delivery of aid to the affected persons as first as possible.

Optimizing Evacuation Plans

In a natural disaster, people's timely evacuation is something that can save their lives, so rapid evacuation is necessary. Static evacuation is still typical for traditional plans and never considers appearance of new obstacles, changes in weather, or movement of large groups of people (Venkadesh et al., 2024). AI is an enhancement over conventional strategies in that it uses real-time data to adjust the kind of routes incorporated into the evacuation plan.

Machine learning algorithms can analyze the traffic conditions and road conditions and population density in order to get the best and safest evacuation path. Also, in zoning, AI can determine the right number and location of shelters that can accommodate those in need of shelter and those that need redirection. From the above analysis, one can also deduce that AI will also be able to adapt the evacuation plans based on the new data that keeps coming in to enhance the safe evacuation of the people.

Another application field is predictive Logistics and Supply Chain Management.

Hence, post-disaster management work involves making sure that resources reach the affected areas are promptly. This is where AI can effectively forecast supply chain disruptions and find out the best way to transport helpful items during disasters. Based on data gathered from social media, analysis can estimate which regions of the world will need help the most, helping relief organizations to organize their delivery routes and supplies.

For instance, AI can indicate where foods, water and medicals will be badly required by tracking the real time data of the severity of the disaster, the number of people affected and the degree of availability of commodities in the region. It can also increase the efficiency of the delivery process since it considers roads, whether and transportation networks.

Case Study: AI in Hurricane Preparedness

The event that really brought issues of disaster preparedness and management into sharp focus was Hurricane Katrina of 2005 that submerged large areas of the Gulf Coast. Ever since then other AI based systems have been employed to enhance the forecast of hurricanes and relief operations (Gupta & Roy,

2024). One of the most obvious ways of this is using machine learning model to forecast the trajectory and magnitude of a hurricane in real-time.

Hurricane Harvey hit Houston, Texas, and its communities in September 2017. Even after the storm, the AI system helped in estimating storm's trajectory and its intensity providing localized and more accurate evacuation warnings to the local government. Existing Geographic Information System technology and analysis techniques were used to integrate satellite imagery data to assess areas most susceptible to floods and machine learning approaches to manage resources and funding appropriation a lot better.

To disseminate information to the public, robots such as chatbots and virtual assistants based on AI intervened in an immediate response system. These latter tools enabled the restoring of the knowledge of evacuation instructions, the identification of shelter areas, and the receipt of timely messages on road traffic and security precautions. AI was beneficial for this instance because it helped reduce loss of lives and improve response operations leadership; a good lesson for future emergencies.

Learning and Teaching Implications, Challenges and Ethical Considerations

However, several challenges persist concerning the use of AI in disaster management even though there are benefits in this approach. The effectiveness of the forecast is contingent upon the data set implemented in feeding those AI models. In many vulnerable regions of the world, related data gathering infrastructure may be limited or not be accurate, thus, presenting problems to AI systems (Harika et al., 2024). Moreover, the cost of integrating AI technologies is still high, particularly in the areas of low economic development.

Conclusion

Machine learning is widely used in the prevention of natural disasters and in the case of other forms of disasters, learning the best response is of great promise in disaster management. Many people and organizations around the world accept that AI can offer better prediction in disasters, better coordination of resources, and better execution of evacuation and relief operations by utilizing machine learning, data analysis, and real-time surveillance systems. Even then there are issues still limiting the use of AI for instance some data may not be available, ethical issues still arises when using the AI in disaster

management the possibilities are endless. With the advancement of artificial intelligence AI technology its application in the emergency response to natural disasters will maintain importance in the realm of saving lives, sustaining loss minimization and future human resilience to disasters.

References

- Abdul, S., Adeghe, E. P., Adegoke, B. O., Adegoke, A. A., & Udedeh, E. H. (2024). AI-enhanced healthcare management during natural disasters: conceptual insights. *Engineering Science & Technology Journal*, 5(5), 1794-1816.
- Albahri, A. S., Khaleel, Y. L., Habeeb, M. A., Ismael, R. D., Hameed, Q. A., Deveci, M., ... & Alzubaidi, L. (2024). A systematic review of trustworthy artificial intelligence applications in natural disasters. *Computers and Electrical Engineering*, 118, 109409.
- google. (2019). *What is "Copyright"?* - *Legal Help*. Google.com. <https://support.google.com/legal/answer/3463239?hl=en>
- Gupta, T., & Roy, S. (2024). Applications of Artificial Intelligence in Disaster Management. *Proceedings of the 2024 10th International Conference on Computing and Artificial Intelligence*, 126, 313–318. <https://doi.org/10.1145/3669754.3669802>
- Harika, A., Balan, G., Thethi, H. P., Rana, A., Rajkumar, K. V., & Al-Allak, M. A. (2024, May). Harnessing The Power of Artificial Intelligence for Disaster Response and Crisis Management. In *2024 International Conference on Communication, Computer Sciences and Engineering (IC3SE)* (pp. 1237-1243). IEEE.
- Huang, D., Wang, S., & Liu, Z. (2021). A systematic review of prediction methods for emergency management. *International Journal of Disaster Risk Reduction*, 62, 102412.
- Satishkumar, D., & Sivaraja, M. (Eds.). (2024). *Utilizing AI and Machine Learning for Natural Disaster Management*. IGI Global.
- Sun, W., Bocchini, P., & Davison, B. D. (2020). Applications of artificial intelligence for disaster management. *Natural Hazards*, 103(3), 2631-2689.

Tan, L., Guo, J., Mohanarajah, S., & Zhou, K. (2021). Can we detect trends in natural disaster management with artificial intelligence? A review of modeling practices. *Natural Hazards*, 107, 2389-2417.

United Nations. (n.d.). *Risks and Disasters*. UN-SPIDER Knowledge Portal. <https://www.un-spider.org/risks-and-disasters>

Varsha, V. R., Naganandini, S., & Hariharan, C. (2024). Utilizing AI and machine learning for natural disaster management: predicting natural disasters with AI and machine learning. In *Internet of Things and AI for Natural Disaster Management and Prediction* (pp. 279-304). IGI Global.

Velev, D., & Zlateva, P. (2023). Challenges of artificial intelligence application for disaster risk Management. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 48, 387-394.

Venkadesh, P., Divya, S. V., Marymariyal, P., & Keerthana, S. (2024). Predicting Natural Disasters With AI and Machine Learning. In *Utilizing AI and Machine Learning for Natural Disaster Management* (pp. 39-64). IGI Global.