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Application of Artificial Intelligence for Disaster Response and Management

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Abstract: *Natural hazards may result in catastrophic damage and significant socioeconomic loss.In recent decades, there has been an increasing trend in the actual damage and loss that has been observed. Disaster managers are therefore under increasing pressure to proactively safeguard their communities through the development of effective management techniques. In order to support informed disaster management, several research studies process disaster-related data using artificial intelligence (AI) techniques. The four stages of disaster management—preparation, response, recovery, and mitigation—are covered in this study's summary of current AI applications. Along with some useful AI-based decision support tools, it provides examples of how various AI techniques can be applied and highlights their advantages for assisting with disaster management at various stages. We discover that most AI applications concentrate on the phase of disaster response. In order to motivate the scientific community to develop AI methods for resolving these issues in subsequent studies, this study also identifies challenges.*

Keywords: Artificial Intelligence, Disaster Response and Management

I. INTRODUCTION

Natural or man-made disasters pose serious risks to the community. It causes a great deal of destruction, which leads to loss of public property and human suffering. Unfortunately, both natural and man-made disasters are happening more often these days.(3) Any catastrophic event that results in a large number of fatalities and the devastation of the environment, private property, and public infrastructures due to the effects of natural phenomena rather than human-driven activities is considered a natural disaster.(1) An effective and responsive disaster management system is essential to reducing these losses. Early warning, early detection, alerting the public and relevant authorities, response mobilization, damage containment, and distributing relief supplies to impacted citizens are all generally components of an effective disaster management strategy. The four primary stages of disaster management (DM) are response, recovery, mitigation, and preparedness. (3) Users of social media, sensors, cameras, satellites, and similar devices produce enormous volumes of data whenever a disaster strikes. This information is used by victims and emergency personnel for safe evacuations, decision-making, and situational awareness.Making sense of the generated data in time-bound scenarios is difficult, though, because intelligent systems are required to process, analyze, and visualize the large amounts of data. (2) Artificial Intelligence (AI) has become a potent instrument in disaster management in recent years, providing innovative approaches to more effectively anticipate, respond to, and recover from disasters. In a disaster, artificial intelligence (AI) can make decisions more quickly than humans, analyze enormous volumes of data in real time, and spot patterns and trends. AI has enormous and expanding potential to revolutionize disaster management procedures, from early warning systems to post-disaster recovery initiatives.With an emphasis on its primary uses, the technologies enabling it, and the obstacles and emerging trends that will influence its function in this crucial area, this article examines how artificial intelligence is transforming disaster response and recovery.(4)

WHAT IS DISASTER?

The astrological notion that a bad event will occur when the stars are in an unfavorable position is the origin of the word disaster, which means "bad star" in Greek. The simplest definition of a disaster is a violent interaction between humans, technology, or nature. "A severe disruption, ecological and psychosocial, which greatly exceeds the coping capacity of the affected community" is how the World Health Organization (WHO) defined a disaster in 1992. "Any

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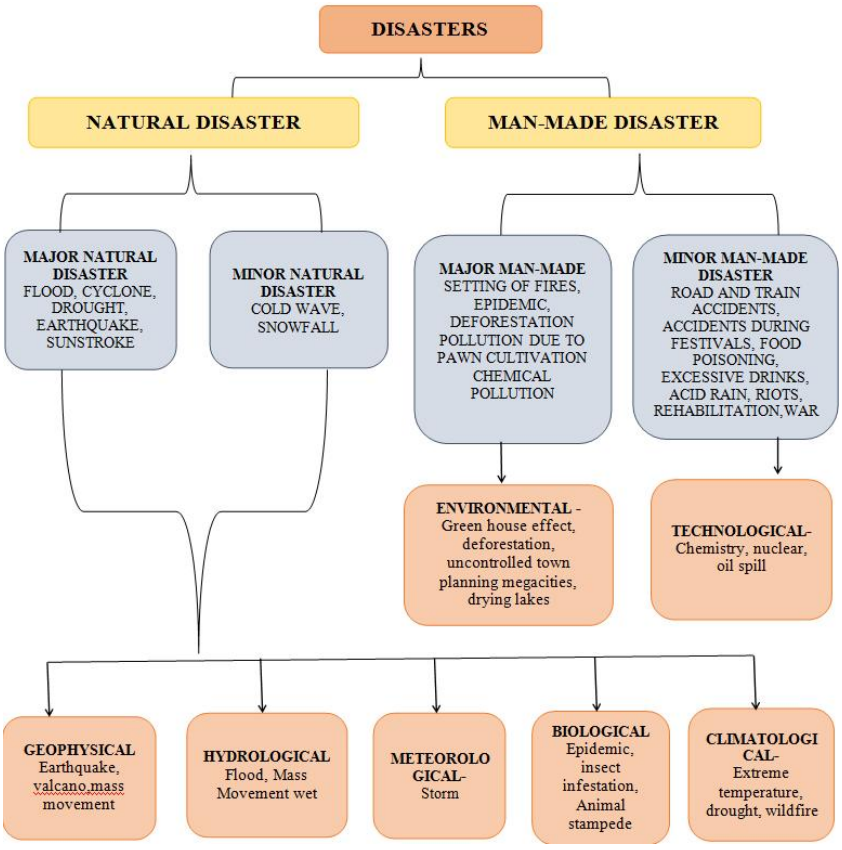
natural catastrophe, regardless of cause, any fire, flood, or explosion that causes damage of sufficient severity and magnitude to warrant assistance supplementing State, local, and disaster relief organization efforts to alleviate damage, loss, hardship, or suffering" is how the US Federal Emergency Management Agency defined a "disaster" in 1995. (5) According to the Disaster Management Act of 2005, a "disaster" is defined as a catastrophe, mishap, calamity, or grave occurrence in any area that results from natural or man-made causes, or from accident or negligence, and that causes a significant loss of life or human suffering, as well as damage to, destruction of, property, or degradation of the environment, and that is of a magnitude or nature that is beyond the ability of the local community to cope."A serious disruption of the functioning of a community or a society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" is the definition of disaster given by the United Nations International Strategy for Disaster Reduction (UNISDR) for 2009.(6) As per the WHO AI Overview, a disaster is defined as an abrupt ecological occurrence of sufficient magnitude to necessitate outside aid. This means that a disaster is an abrupt, large-scale event that exceeds a community's capacity to manage its effects on its own.

WHAT IS DISASTER MANAGEMENT ?

It's a huge undertaking. They are not restricted to any one place. They also don't go away as fast as they come. As a result, effective management is essential to maximize planning and response efficiency. Because resources are scarce, cooperation between the public, private, and community sectors is required. To prevent, prepare for, respond to, and recover from emergencies and their effects as quickly as possible, this degree of cooperation necessitates a concerted and planned effort. (10)

CLASSIFICATION OF DISASTERS AND ITS CONSEQUENCES



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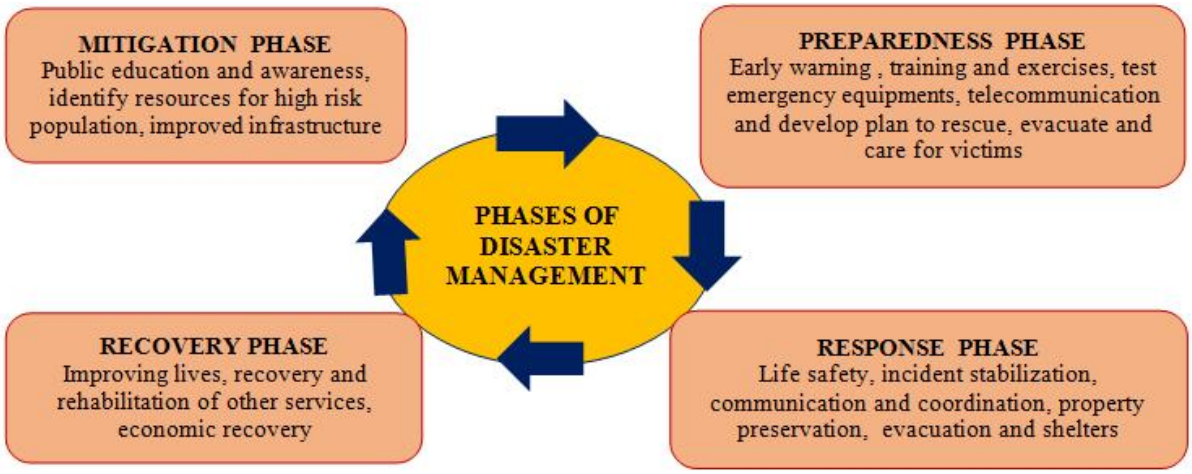
LEVELS OF DISASTER- When planning and addressing disaster management, consideration must be given to the authorities' ability to handle the situation as well as the area's susceptibility. As a result, in its 2001 report, the High Power Committee on Disaster Management divided disaster situations into three "levels": L1, L2, and L3. Disaster risk reduction should make use of the L0 period of normalcy.

- **Level-L1:** The degree of disaster that can be controlled at the district level using the resources and capabilities available. State officials will, nevertheless, continue to be prepared to offer support if required.
- **Level-L2:** This designates disaster scenarios that call for aid, proactive state-level resource mobilization, and the establishment of state-level disaster management agencies. If the state calls for an immediate deployment, the central agencies must be on guard.
- **Level-L3:** This denotes an almost disastrous circumstance or a massive calamity that surpasses the capacity of State and local authorities. The Disaster Management Act of 2005 makes no reference to the division of disaster situations into levels LO to L3. Furthermore, there is no provision in the DM Act for designating any disaster as a "national calamity" or "national disaster."(6)

ROLE OF AI IN ALL PHASES OF DISASTER MANAGEMENT

Different kinds of data are required for each stage of disaster management. Numerous government agencies, social media platforms, private organizations, and other emergency responders have gathered a significant amount of data based on the disaster's characteristics. Research on how to use this data to extract valuable information for improving disaster preparedness, prevention, and recovery plans is lacking, though. Data mining, decision support, information extraction and retrieval, and other data analysis technologies can be used to process such data. Analyzing such vast amounts of disaster data effectively is made possible by AI techniques. Thus, artificial intelligence (AI) methods improved disaster preparedness and mitigation strategies while also speeding up response and recovery activities. Image processing, video surveillance, agent-modeling, crisis simulation, and other AI-enabled techniques have given disaster managers more time to prepare for and respond to disasters.(3)



HOW CAN AI BEENHANCED FORDISASTER RESPONSE?

Timely and well-coordinated actions are critical to disaster response effectiveness. AI supports these initiatives by facilitating quicker decision-making, streamlining procedures, and offering real-time insights that enable responders to take prompt, calculated action. AI is enhancing disaster response in the following significant ways:

1. AI in Risk Assessment and Early Warning Systems-In order to reduce the effects of disasters, early detection is essential. By analyzing vast amounts of environmental data, including weather patterns, seismic readings, and ocean conditions, artificial intelligence (AI) improves early warning systems by identifying possible threats early. By examining real-time data from weather patterns, terrain maps, and river levels, artificial intelligence can forecast

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flooding events. Authorities can issue warnings and evacuation orders prior to a flood thanks to this predictive capability. AI can evaluate seismic data to identify earthquake tremors and forecast the strength of subsequent shocks using machine learning algorithms. It is possible to minimize fatalities and infrastructure damage by sending out early alerts.AI systems can identify wildfire-friendly factors like temperature, humidity, and wind speed when combined with satellite data and ground sensors. This enables early warnings in areas that are at risk.

2. **Emergency Response Coordination Automated Systems-** It can be very difficult to coordinate a disaster response when there are several agencies and organizations involved. By automating important tasks and assisting authorities in resource allocation, AI can expedite this process. Real-time data analysis from impacted areas can be done by AI-driven systems to identify the areas that most need resources. This can entail sending medical supplies to the most affected areas or guiding rescue crews to the areas with the greatest number of casualties. Even when road conditions change as a result of the disaster, AI can use real-time traffic data to suggest the quickest routes for emergency responders, such as fire trucks and ambulances.AI tools that are incorporated into incident management platforms can help with resource deployment tracking, rescue team organization, and making sure that critical operations are completed effectively and without duplication of effort. Drones and robots with AI capabilities are now vital components of search and rescue missions, especially in dangerous or difficult-to-reach areas. Artificial intelligence (AI)-enabled drones can fly over disaster areas, take high-resolution pictures, and use computer vision to detect infrastructure damage or locate survivors buried beneath rubble. Responders can obtain vital information from these drones' rapid coverage of wide areas. Robots on the ground, frequently driven by AI, are employed to search for buildings that have collapsed or to traverse dangerous areas.These self-moving robots can find survivors, deliver supplies, or remove debris using AI-driven decision-making. AI is used by drones and robots with thermal cameras to recognize trapped people's heat signatures. This expedites the search process by enabling rescuers to concentrate their efforts on particular regions.

3. **Tools for Instantaneous Communication to Organize Rescue Teams-** In order to coordinate efforts across various teams during a disaster response, effective communication is essential. AI improves communication systems by translating text in real time, evaluating important data, and anticipating when help will be required. International teams can collaborate easily thanks to AI-powered natural language processing (NLP) systems that can process communications in multiple languages. In large-scale international disaster responses, where teams from various nations may be involved, this is particularly crucial. AI can search social media sites for posts about the calamity, identifying individuals in need of assistance or areas that need to be attended to right away. Responders can use this crowdsourced data to identify areas that are most in need and to augment official data. AI can produce real-time crisis maps that highlight the locations of the most pressing needs, like food, water, or medical assistance, by combining data from social media, news sources, and emergency calls. This aids authorities in focusing their efforts on the most vulnerable areas. (4)

HOW CAN AI BE USEDFOR DISASTER MANAGEMENT?

Modern disaster management relies heavily on artificial intelligence (AI), which improves decision-making, optimizes response effort coordination, and offers real-time insights. Throughout the whole disaster lifecycle, from prevention and prediction to recovery and rehabilitation, artificial intelligence is being used.

1. Systems for forecasting and Early Warning- AI can more accurately forecast future disasters by analyzing large datasets, including geological data, weather patterns, and satellite imagery. For instance, authorities can prepare resources and conduct evacuations well in advance of cyclones thanks to AI algorithms' ability to accurately forecast their path and intensity, greatly minimizing both human and financial losses. Seismic data is analyzed by machine learning algorithms to find trends that might point to an approaching earthquake. AI-powered technologies may be able to deliver early warnings, allowing communities to evacuate in a timely manner. The path, intensity, and duration of hurricanes are predicted by AI systems using meteorological data, allowing authorities to make appropriate preparations.

2. Monitoring Disasters in Real Time- It is essential to have timely information during a disaster. Real-time data from sensors, drones, and cameras can be processed by AI-powered tools to give situational awareness, identify anomalies

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like rising water levels during floods or rising temperatures that indicate wildfires, and give decision-makers up-to-date information so they can make dynamic strategy adjustments.

3. Enhancing the Allocation of Resources- Making sure that resources are distributed efficiently is one of the biggest problems in disaster management. In order to prioritize areas in need and assist in the efficient allocation of medical supplies, rescue equipment, and personnel, artificial intelligence (AI) algorithms can analyze factors such as population density, geographic challenges, and the severity of a disaster. For instance, during flooding incidents, artificial intelligence (AI) models assess current water levels and forecast their future courses to strategically place sandbags and emergency supplies where they are most needed, limiting additional damage and fatalities.

4. Risk Evaluation and Vulnerability Study- Based on infrastructure, population demographics, and historical data, AI can assess a region's vulnerability. Governments and organizations can use this information to create specific disaster safety procedures, reinforce buildings, bridges, and dams that are at risk, and provide preparedness education to communities that are at risk. AI applications in seismic risk analysis, for instance, can result in the strategic reinforcement of infrastructure and buildings in seismically active areas, improving safety and lowering the possibility of catastrophic damage.

5. Recuperation After Disaster-The most difficult and drawn-out stage of disaster management is frequently recovery. Through the use of drones and satellite imagery to determine the extent of damage, the analysis of disaster recovery trends to improve future responses, and the use of chatbots and surveys driven by AI to identify people in need of psychological support, AI can help with recovery. To guarantee that recovery plans are carried out efficiently and within anticipated timeframes, AI monitoring systems, for instance, can track the continuous restoration of road infrastructure and utilities after a disaster and provide real-time updates. (8,9)

APPLICATIONS OF AI IN DISASTER MANAGEMENT

1. Priority-Based Processing of Insurance Claims: By using AI technology, the insurance system becomes more responsive and welcoming to individuals impacted by emergencies, in addition to increasing the efficiency of handling claims.

2. Community Participation and Awareness: By developing AI-powered web-based or game-based tools, it is possible to increase community involvement in disaster management. Communities can share information and narrate their experiences during and after disasters by using AI-enhanced web or mobile applications. Communities will be better equipped to prevent and lessen the effects of disasters by becoming more knowledgeable and proactive.

3. Improved Response Coordination: AI tools can help emergency responders and volunteers coordinate more effectively, guaranteeing that aid is delivered in a timely and appropriate manner.

4. Distributing Resources and Optimizing Logistics: By examining needs, available resources, and logistical obstacles, AI can optimize the distribution and delivery of resources (such as food, water, medical supplies, and shelter). This guarantees that, even in complicated disaster situations, aid reaches those in need effectively.

5. Administration of Information and Communication: AI can assist in organizing and screening the enormous volume of data from news sources, social media, and other channels of communication during emergencies.

6. Training and Simulators: Volunteers and emergency responders can be trained in a range of disaster scenarios using virtual reality and AI-powered simulations. Without the dangers of actual disaster response, this method enables hands-on training experiences. (3)

REAL-WORLD EXAMPLES OF AI IN DISASTER MANAGEMENT

1.Weather Corporation, IBM: This company uses artificial intelligence (AI) to provide precise weather predictions and early warnings for severe weather conditions. In order to enable prompt evacuation and preparation efforts, their AI-driven platform analyzes enormous volumes of weather data to forecast hurricanes, floods, and other natural disasters.

2.Google's Reaction to Crisis: Using artificial intelligence (AI), Google's Crisis Response team provides real-time information during emergencies. SOS Alerts and Crisis Maps, two of their AI-powered tools, combine information from multiple sources to provide impacted populations with timely updates and resources.

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3.Project Alphabet's Loon: This initiative uses balloons driven by artificial intelligence (AI) to bring internet connectivity to areas affected by disasters. This guarantees that during and after disasters, impacted communities and emergency responders can interact and obtain critical information.(7)

ADVANTAGES OF USING AI IN DISASTER MANAGEMENT

1. Improved Coordination: AI systems make it easier for different agencies involved in disaster response to communicate and work together. AI eliminates inefficiencies and delays by centralizing data and automating communication, guaranteeing prompt and well-coordinated action.

2. Automating Repetitive Tasks: Data entry, analysis, and reporting are examples of tasks that can take up significant time and resources during disasters. These procedures are automated by AI, freeing up human responders to concentrate on urgent, high-priority tasks that require human judgment and intuition.

3. Adaptation to Climate Change: AI aids in spotting trends and evaluating the long-term effects of climate change. As a result, future risks are reduced and resilience to climate-related disasters is increased, allowing governments and communities to create sustainable adaptation plans.

4. Instantaneous Decision Making: By using predictive analytics, AI offers real-time insights that assist decision-makers in acting swiftly and decisively. AI-driven early warning systems, for instance, can notify localities of approaching hurricanes or floods, preventing fatalities and minimizing damage.

5. Better Resource Allocation: By evaluating needs and ranking the most impacted areas, AI makes sure that resources are allocated as efficiently as possible during disasters. By doing this, waste is reduced and assistance is given to those who need it most.

CHALLENGES OF USING AI IN DISASTER MANAGEMENT

1. Expensive Implementation: Creating and implementing AI systems necessitates a large investment in cutting-edge hardware, software, and qualified staff. These expenses may be unaffordable for developing countries or organizations with limited resources, which would restrict access to AI solutions.

2. Privacy Issues: AI systems use a lot of data, such as social media posts, communication logs, and geospatial imagery. Despite the fact that this data is essential for disaster management, it raises questions regarding data security, surveillance, and the unauthorized use of personal data. A crucial challenge is striking a balance between data usage and privacy rights.

3. Dependency on Data Quality: The caliber of the data used to train AI models determines their efficacy and accuracy. Inadequate or poor data can result in inaccurate forecasts and less-than-ideal results, which can have serious repercussions in the event of a disaster.

4. Ethical Issues: Due to biases in the data, AI systems may inadvertently favor some groups over others when making decisions in emergency situations. It is imperative to address these biases and guarantee the equitable and moral application of AI.

5. Insufficient Human Monitoring: Relying too much on AI may result in fewer human reviewers for important choices. Although AI increases productivity, it cannot replace human responders' empathy and flexibility in complex or unpredictable situations.(8)

II. CONCLUSION

By offering creative solutions that improve response and recovery efforts, artificial intelligence is transforming disaster management. AI makes it possible to make decisions more quickly and intelligently, from real-time data processing and automation in emergency situations to predictive analytics that aid in risk forecasting and mitigation. Disaster management teams are better prepared to save lives, minimize damage, and expedite recovery efforts when AI technologies like robotics, computer vision, and machine learning are integrated. These technologies have the potential to revolutionize disaster management by providing more effective and efficient means of community protection and crisis response as they develop further.

Disaster management's future depends on the ongoing use of AI-powered solutions that can change to meet evolving needs. AI and human knowledge can be combined to create more robust systems that can manage complicated and

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changing disasters. AI will be a vital ally in reducing effects, enhancing coordination, and guaranteeing a speedier recovery as the world community deals with an increasing number of man-made and natural disasters. AI will continue to be essential in protecting people and property during emergencies as it develops further.

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