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The Use of Artificial Intelligence for Disasters

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Abstract

In recent years, due to an increasing number of extreme meteorological events, the urgent need to use artificial intelligence in their management has emerged. The ability to handle and prevent such events requires disaster management. Artificial intelligence is extensively used in forecasting and preparing for disasters, as well as for mitigating and minimizing damage and in the response phase to effectively help in better and more rapid responses to disasters. This paper examines to identify the uses of artificial intelligence technologies in reducing the impact of various disasters and seeks to investigate the possibility of linking artificial intelligence technologies based on information and communication technology and reducing the effects of disasters. We conclude the paper with the challenges facing artificial intelligence technologies.

Keywords

Artificial Intelligence, Disaster Management, GIS

1. Introduction

As we know natural disasters can be defined as a combination of natural hazards and vulnerabilities that endanger vulnerable communities that are incapable of withstanding the adversities arising from them [1].

Artificial Intelligence (AI) refers to computer science through which programs are created that can simulate human behavior, in terms of the perceptual, theoretical, auditory, and sensory senses. In other words, AI is a branch of computer science, developing intelligent machine with imitating, extending and augmenting human intelligence through artificial means and techniques to realize intelligent behavior [2].

AI has emerged in the field of disaster management, where it plays an important role in mitigation and management of disasters from the forecasting of extreme events and the development of hazard maps to detect events in real-time and to make required decisions promptly.

Nowadays, artificial intelligence technology has been widely used in agriculture, commerce, education, and service industries. The golden age of artificial intelligence has arrived [3].

This raises several questions: What can AI offer to decision-makers? What data or technologies should be provided to improve the AI experience in disaster management? How can these technologies be applied effectively?

In order to use AI in disaster management we need to clearly answer these questions. In general Machine learning (ML) is a subfield of AI, which allows software applications to become more accurate at predicting outcomes without being explicitly reprogrammed. Machine learning algorithms use historical data as input to predict new output values. Artificial neural networks (ANNs) are one type of model for (ML) and have become relatively competitive to conventional regression and statistical models regarding usefulness [4]. The availability of high-quality data and the choice of a suitable model architecture determine how well ML performs for a specific task. Consequently, it is reasonable to anticipate that ML will become more significant in Disaster Risk Reduction (DRR) applications. In fact, DRR applications are increasingly becoming a requirement for disaster and emergency management operations in various regions of the world. The importance of timing considerations in emergency management activities cannot be overstated. In order to respond quickly to extreme crises, emergency managers must make important decisions quickly. To respond, plan for, or reduce disasters, policymakers must have the appropriate information at the correct moment. Therefore, this is achieved through early preparation, by drawing scenarios based on previous experiences or based on early warning systems that detect and predict disasters in advance. The goal of the current study is to learn how AI approaches can be utilized to respond to natural catastrophes that are brought on by various natural hazards, such as earthquakes, floods, landslides, volcanoes, and wildfires. We focus on using various AI algorithms to comprehend the aforementioned natural disasters and how they help with disaster response.

2. Disaster Management

The concept of disaster management can refer to the framework defining the policies and guidelines and organizations for how to act when a disaster occurs [5].

As we mentioned earlier, a disaster is an emergency and unexpected event. Therefore, preparation for the disaster begins long before it, and it goes through stages. This is done in an initial phase that we can call pre-disaster with a long period of time during which previous data is used to prepare for the disaster, such as building shelters, educating individuals on how to act during a disaster, collecting data from previous disasters and analyzing them to build possible scenarios, and then work on all measures that limit or reduce the impact of the disaster. The next stage, which is a short period before the disaster, is the stage in which the possibility of a disaster occurring is very close within days or hours in which organizations and individuals are directed, such as publishing emergency numbers and the locations of shelters in addition to implementing the plans developed in the previous stage. A stage during and after the disaster, in which the response to emergencies and firefighting is done by means of drones, and the areas of fire outbreaks, for example, or the places of landslides are determined by analyzing satellite images, identifying emergency locations, and contacting the responsible authorities. In addition, to repair after a disaster and bringing life back to a normal level, for example in snowstorms, snow-covered roads can be identified through satellite imagery or through the Snow Depth Sensor which can be also measured using ultrasonic [6] or laser [7] sensors.

3. Applying Artificial Intelligence Techniques in Disasters

There are many AI techniques that are used in disaster management. Each technology is specific to a specific task. We will review here one of the most important of these technologies, the applications of AI to Geographic information system (GIS).

Natural disasters, such as floods, earthquakes, and storms, may cause significant damage to both human life and infrastructures. In such adverse events, instant access to relevant information may certainly help in the rescue operations, which will ultimately help in mitigating the damage [6] [8]. When GIS enables AI by utilizing its geographical visualization and spatial analytic skills to further process and mine data in response to AI recognition discoveries, this is referred to as GIS for AI.

Geospatial data is especially important for decision-makers in the various stages of emergency management operations. The perception and investigation gaps in emergency simulations can be filled by GIS technology, which can display a variety of events and their temporal characteristics.

This enables disaster managers to access the necessary information kept in geographical databases and displayed in computer-generated maps or understandable models. When creating well-thought-out counter-disaster response patterns that can address the entire community, GIS can be incredibly helpful. GIS is a helpful tool in disaster management planning, tabletop activities, and a fundamental element of Emergency Operations Centers [5].

Traffic and congestion monitoring is an example of an application for visualizing maps that can offer decision-makers a more intuitive way to present information and decision-making. The integration of AI with GIS gives it more power and is useful in conducting analysis and predictions. For example, in the year 2009 the region of Makkah AMukarramah, specifically the city of Jeddah, a catastrophic flood occurred that claimed the lives of 116 people and many of the victims drowned inside their cars as shown in **Figure 1**. The average precipitation was 90 mm. In November of 2022, it rained in Jeddah, with an average of 179 mm, according to the Saudi National Meteorological Center. However, the

Figure 1. The scale of destruction in the 2009 Jeddah disaster.

losses were negligible compared to 2009. Here the benefit of using artificial intelligence in GIS appeared. Where the rain data for more than 20 previous years were analyzed, and the low places that were exposed to drowning and floods were identified. In addition to determining the places of water crossing based on satellite images, the construction of precautionary dams such as the Jack Dam, which targets the strongest watercourse that caused the most damage in 2009 was realized. An automated early warning system for weather phenomena has also been launched, which works to improve communication and increase the speed of delivery of emergency information to responsible authorities and organizations, as well as to individuals at risk which contributes to protecting lives from the effects of disasters. This is done by studying and analyzing the crossing of floods and redirecting individuals to safer places, as well as directing the rescue authorities to possible places where there are cases that need assistance.

On the other hand, forest fires are common disasters, and one of the biggest problems with them is that by the time they are discovered, they have already spread widely and caused great destruction. Therefore, the importance of using AI in its management has emerged.

AI algorithms were used to look for the characteristics of the fires through signs of a fire's presence such as smoke and changes in thermal infrared data found in satellite images that are updated every few minutes. Also, the AI predicts, based on the previous inputs, and based on the analysis of the wind direction, the direction of the likely growth of the fire, and sends the coordinates to the firefighting officials and the relevant government agencies, in addition to the individuals close to its path. Also, in the field of reducing and tracking fires, drones can be used which. Can deliver water to the affected sites and participate in extinguishing the fire. Also subterranean peat fires can be detected using drones equipped with a thermal infrared camera [9].

In light of the examples we mentioned earlier, we found that AI can be used in different stages of a disaster, some of which fall in the pre-disaster stage with a long period of time where huge geographical or climatic data are collected and analyzed and used for future predictions.

4. Challenges Facing Artificial Intelligence Technologies

Despite the great importance of AI and the great benefit it provides in the service of humanity, there are a number of challenges that hinder it from playing a greater role. There are different dimensions facing AI, which can be categorized in general as: social challenges; economic challenges; ethical challenges; political, legal, and policy-related challenges; organizational and managerial challenges; data challenges; and technological challenges [10]. One of the most important dimensions related to the subject of our research, which may constitute an obstacle AI, is data challenges. AI depends on the quality and validity of the data provided, so the more correct and accurate the data, the higher and more efficient the performance of the AI.

Sharing data that supports AI technologies is also a challenge because information exchange during and after the disaster periods can greatly reduce the losses caused by the disaster [11]. Sharing wrong or incomplete data, may lead to increased losses.

AI techniques work with huge data and a large number of participants that cannot be counted. Participants in collecting and arranging this data may not be qualified for that. It is not certain that all participants are honest, as there may be qualified participants, unqualified participants, and fraudulent participants [12].

This will lead to AI techniques giving false information based on wrong or incomplete information. Therefore, it may underestimate the importance of the risk, causing great material and human losses, or exaggerate the risk estimate, which leads to an increase in the economic cost. Climate changes are considered one of the biggest obstacles and challenges as well. With regard to environmental disasters, the matter has changed in recent years. Climate change like high temperatures, sea level rise, and others has affected the validity of climate data.

For example, in 1972-2018, California experienced a five-fold increase in the annual burned area, mainly due to more than an eight-fold increase in summer forest-fire extent [13]. Also in Australia, the number of fires that developed into violent pyro convective storms during the 2019/20 fire season were also unprecedented [14] [15]. It was noted that climate variability was exacerbating its impacts on fire risk in Australia [16].

Also, higher temperatures resulting from urban heat island (UHI) impacts change the urban microclimate, amplifying the climate variability resulting from global warming, and increasing the severity of rainfall events in these areas [17].

Flood disasters have increased, leading to direct, and indirect impacts on societies including agriculture productivity as well as food availability, accessibility, utility, and stability in communities [18].

For example, in November 2015 Chennai floods in India, resulted in over 500 deaths when Chennai experienced more than three times the usual rainfall [19], and in Kerala, the one- and two-day extreme precipitation values that occurred had return periods of 75 and 200 years respectively when compared to a long term record from 1901-2017 [20].

5. Conclusions

Human life is being significantly impacted by AI. Organizations are also moving toward embracing AI technology, which can help them find new ways to complete jobs and comprehend data patterns for maximum productivity.

Based on the previous discussion, it becomes clear to us that the use of artificial intelligence in disasters depends on two important aspects, human and machine. Machine intelligence relies heavily on credibility and accuracy of information obtained from human. This will affect the capabilities of machine.

It is clear that the capabilities of AI have not been fully developed in the field of GIS and in some areas related to disaster management.

This gap can be addressed by raising awareness of the importance of AI techniques in disaster management. Despite the importance of AI in disaster management, great challenges hinder it. Providing high-quality data is very challenging in many fields. Regarding the provision of data, some governments refuse to share data for security reasons. On the other hand, the high cost of AI applications used in disaster management constitutes an obstacle to their spread.

It is also important for people involved in collecting information related to disasters to be highly qualified in the type of data that is important for this matter.

It is useful to build programs with easy interfaces that the participants deal with, specifying precisely the type of data that must be entered in order to be more organized and useful. Therefore, the presence of neutral, globally supported organizations concerned with collecting highly accurate and credible data is important to solve this problem. On the other hand, the element of surprise in disasters makes building models and tools difficult to confront them.

As for the GIS information, there is a significant lack of entered data, its validity, and stability. Hurricanes, for example, may change their course and cause unexpected disasters in unexpected areas, as happened in Cyclone "Idai" in 2019, which led to huge losses in lives and property [21].

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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