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Role of Artificial Intelligence (AI) in Combined Disaster Management

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Abstract

Disaster management is an important part in case of catastrophe for the wellbeing of humanity to save them from severe effects. For active disaster management combined approaches may be used such as applications of artificial intelligence, e.g. geographical analysis, risk mapping and tracking, obscure sensing ability, advance technologies for drone and machine learning and urban planning based on smart cities technology, analysis of hotspots and analysis of environmental impacts are modern technologies which needs to be studied more in the context of disaster management. Researchers of social sciences used different procedures and technology to analyze the hazards, risks and catastrophe between disciplinal. They utilized empirical and evaluative collection of data and itsanalysis techniques. The current study is an overview of present applications of AI being helpful in disaster management throughout its tetrahedral states. AI is important in all states of disaster management as it's a faster solution than other technologies. Integration of two basic supportive tools which are Remote Sensing (RS) and Geographically Information System (GIS) in disaster management provides higher level of planning and its analysis. It can help authorities to take quick and effective decisions in case of natural disaster.

Keyword: Artificial intelligence; Geographic information; Remote Sensing; Disaster Management

Introduction

A catastrophe is an event which may create destruction on massive level by the deprivation of humans lives, harmful for the environment or diminution of economic growth. It is far away from the response capacity of the society (Ajzen, 2020). As per report of Center for Research on the Epidemiology of Disaster, in economic values there was approx. 2.9 trillion USD damages by the countries affected by the disasters during 1998 to 2017 (Rehman,

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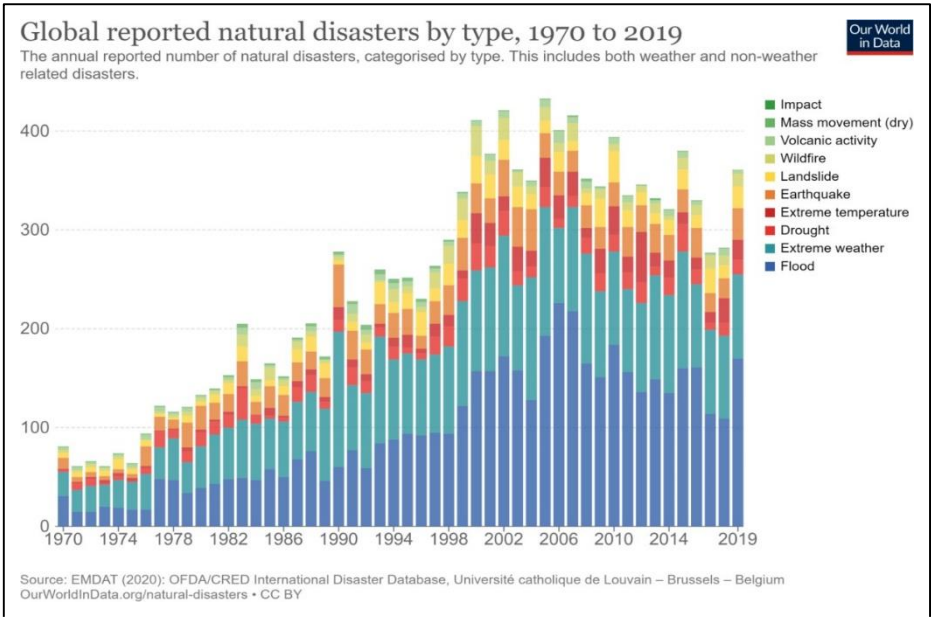
Sahana, Hong, Sajjad, & Ahmed, 2019). In these countries USA is leading with approx. 1 trillion USD loss in economy chased by China, Japan and India. As stated in reports of the UN Refugee Agency, death rates are grown to double in last two decades. Since 1995, the most endangered region is declared to Asia- Pacific (Abid, Sulaiman, Mahmud, Nazir, & Adnan, 2021).

Disaster management is calculated and multi-dimensional methodology for reduction, readily action and healing to keep safe the endangered group from disaster. All stakeholders working for reduction of risk caused by the disaster have a common point of view and agreed to take some proactive response before occurrence of any disaster. Although, all catastrophes are related to human capabilities and its results. So in this case, groundwork and its execution of fruitful disaster management operation is responsible for its success or failure. So, AI has key role in disaster management as it develops more capability to save people and their land in case of disaster.

Figure 1

Global Reported Natural Disasters (Ritchie & Roser, 2014)



Now AI system and Geographical technologies are more developed and have ability to be highly potent in case of crisis (Nunavath & Goodwin, 2018). The geological and climatic conditions, ecology and resources to make availability of machinery plays import role in determining and designing of disaster response. So, it is suggested to utilize operational research and science of management to increase strength in emergent ease by supposing the knock of this solace assets dedicated for population (Ogie, Rho, & Clarke, 2018). Although many journals in this research work concluded for utilization of AI in disaster management (Nunavath & Goodwin, 2019).

For geographical dissemination, many researchers use AI and GIS as important tool (Arinta & WR, 2019; J. Chen, Li, Wang, & Deng, 2020). GIS works as a evaluator that works on inputs, saves, combines , administrate and liberate geographical data for calculated scheming and actual time judgment for on time and purposeful preparation to tackle dangers and crisis (S. K. Abid, N. Sulaiman, C. S. Wei, & U. Nazir, 2021). These systems have capability in management of many disasters like flood, smog, earthquake, rainfall, land sliding etc. In this work, it is reviewed that how AI and its applications is utilizing with integration of disaster management to overcome these crises Shafiq and Ahsan (2014) The destruction caused by disasters and the rise in frequency and concentration of natural disaster events have led developed and developing countries to focus on strengthening their disaster management systems and their response capacity to these contingencies. Early warning is the most important activity to prevent disasters or minimize loss of life and property. ICTs play a vital role in managing natural disasters such as floods and earthquakes. The proposed ICT-based flood warning system can help communities and disaster management authorities to prevent and minimize disaster losses caused by flooding. The system not only triggers early warnings, but also calculates land cover for expected flooding and helps people and officials pinpoint the boundaries ofaffected areas. Through the use of mobile technology, people can easily get early warning information, and through the use of GPS maps, they can easily navigate to save locations.

Literature Review

The 2010 earthquake in Haiti was one of the major disasters after which it

was recognized that the microblogging system could change the way we access and analyze information related to any disaster. It is noteworthy that it was only after the 2010 earthquake in Haiti and the 2011 earthquake in Tohuku that researchers began developing and managing communication data systems that could play a key role in disaster risk management.

Many scientists studied earthquakes from different quarters in history and mathematics. Various geophysical and seismological processes occur during the correction of underground earthquakes. It is thought that these underground events are causing changes in the extraction of groundwater, direct electric field and ionosphere (Aziz, Mardi, Malek, Tan, & Teh, 2018). These previous changes were analyzed and identified by major earthquakes in recent years.

In recent years, studies on flood trends has increased dramatically in many parts of the world (Bui et al., 2019; Dottori, Martina, & Figueiredo, 2018; Santangelo et al., 2011; Tehrany, Pradhan, & Jebur, 2013; Wang et al., 2019; Ahmed Mohamed Youssef, Pourghasemi, Pourtaghi, & Al-Katheeri, 2016), and as a result, a wide variety of models have been suggested in this regard. Among them, bivariate mathematical algorithms are probably the most widely used, i.e., frequency measure, evidence weight, entropy index or mathematical index (Althuwaynee, Pradhan, Park, & Lee, 2014; Rahmati, Pourghasemi, & Zeinivand, 2016; Tehrany, Lee, Pradhan, Jebur, & Lee, 2014; Ahmed M Youssef, Pradhan, Jebur, & El-Harbi, 2015); however, the accuracy of these models is high due to the complex nature of the flood events. In this regard, artificial intelligence is thought to improve the accuracy of the flood forecast, i.e., the vector support system (Tehrany, Pradhan, Mansor, & Ahmad, 2015), the random forest (S. Lee, Kim, Jung, Lee, & Lee, 2017), tree retreat in stages (Khosravi et al., 2018), Advanced retreat trees (Shafizadeh-Moghadam, Valavi, Shahabi, Chapi, & Shirzadi, 2018), As a dependent variant, all of the above models used data containing flood zones occurred in the past, while flood forecasts were used as descriptive variables. Opportunities to evaluate the performance of the model and to confirm the results, represent the significant benefit provided by these methods used to assess the level of flooding. Although the accuracy of flood forecasts obtained from artificial intelligence models has been significantly improved compared to bivariate

statistical models, however, no single method or strategy has been recognized as the best in all areas. Therefore, hybrid models have been considered for flood forecasting in recent years, i.e., a hybrid of flexible statistics and vector support machine (SVM) (Tehrany, Pradhan, & Jebur, 2014), a mixed Bayesian framework (Tien Bui & Hoang, 2017), neural fuzzy combined with metaheuristic efficiency (Bui et al., 2018; Bui et al., 2016; Termeh, Kornejady, Pourghasemi, & Keesstra, 2018), a combination of particle efficiency and neural networks (Ngo et al., 2018), a combination of decision-making and SVM (Choubin et al., 2019), anda combination of decision-making on multiple terms (Wang et al., 2019). A common conclusion is that the power of the flood forecast was greatly improved by these ensembles and models of hybrids; therefore, new ensemble models should be re-investigated.

Ogie et al. (2018) conducted research to address the development of communication between the various stages of disaster management. Artificial Intelligence (AI) is gaining momentum in the area of disaster management. The basis of AI in disaster communication is that equipment can be trained to assist with the immediate release of relevant information and similar planning to improve awareness of situations, alerts, and emergency decisions.

Vieweg, Hughes, Starbird, and Palen (2010) were among the first few researchers to study Twitter communication that occurred during the Grassfires in Oklahoma in 2009 and floods in the Red Riverin 2009. They divided the status updates that were reported during the events into the following categories: “Warnings, Exit Information, Preparations, Volunteer Messages, Flood Level, Wind Speed, Road Conditions, Weather, Air, Appearance, General Advice, Animal Management, and Injury Reports and injuries”.

Saleem, Ahmad, and Butt (2020) conducted a study to analyze the hazards posed by the landslide-prone sub-Himalayan regions through employing the geospatial modelingapproach. The aim of the study was to map the landslide prone areas of Nullah road located in sub-Himalayan range through the technique of Landslide Hazard Zonation (LHZ). Various methods like field surveys were employed to identify the landslide active points and their readings were verified through the Global Positioning

System. The study highlighted seven landslide activating factors, i.e., slope angle, lithology, precipitation, tilt direction, land use/land cover, Normalized Differentiation Vegetation Index and elevation, were evaluated. The results of the study indicated that 69% of the total landslides had their occurrence and emergence in the high susceptibility zone. The geospatial approach was ofan advantage here because it helped to restrict high hazard zones which is of essential value to the planners, geologists, engineers for future area-specific developmental projects and paved way for more practical use of the approach.

Jahan, Sarwar, Younes, Sadaf, and Ahmad (2019) Fog could be a natural environmental development that's intimate with by several areas within the winter months, however, due to the rise in population and therefore the use of technology, pollution is increasing day by day. This increase in pollution regenerates that fog into smogginess, a mix of smoke andfog, terribly restricted analysis work has been done associated with smogginess, therefore, this analysis is aimed to check the pattern of smogginess in the metropolis and its impact on visibility through remote sensing and GIS. Satellite pictures of MODIS and Landsat OLI, November 2016 is used to check the pattern of air pollution, whereas the visibility knowledge was no inheritable from the Islamic Republic of Pakistan earth science Department.

Methodology

The purpose of this work is to furnish a literature review describing role of artificial intelligence (AI) and to elaborate that to what extent disaster management can be boost by using its applications. Forthis purpose, search made on science direct website through keywords e.g. disaster management, artificial intelligence etc. for published work during 2010 to 2021. A number of studies reviewed for this research. In addition to these, many other resources are also searched with the same keywords for excessive amount of data to be analyzed and reviewed.

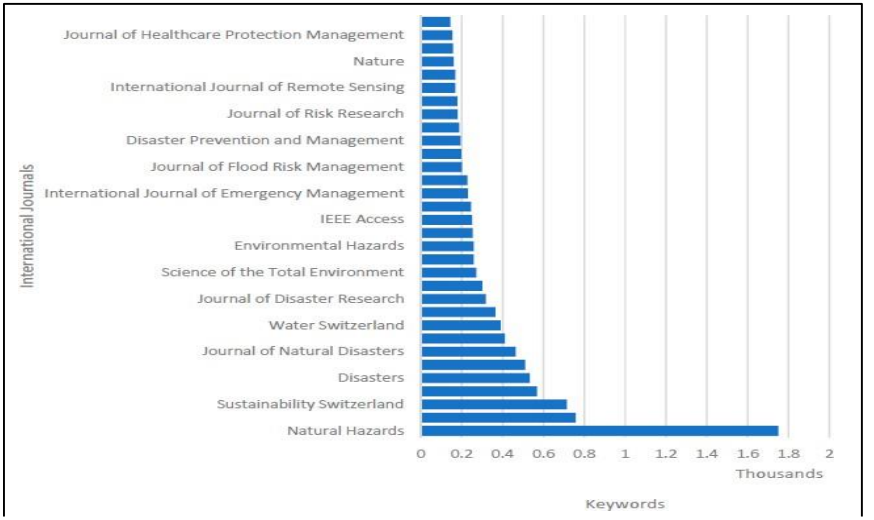
Table 1

Source of Search with Keywords

Sr. No.	Source	Keywords
1	Science Direct Web of Science	1- Artificial Intelligence 2- Disaster Management 3- AI in Disaster Management

Figure 2

Searched Keywords in Different Sources



This Fig. 2 depicts pictorial view of keywords search on different sources and number ofpublications on that keyword for collection of data during time period of 2010 to 2021.

This works is based on reviewing procedure to identify the role of artificial intelligence and GIS incatastrophic situations. elevent literature is reviewed for the study.

A wide list of refreed journals are chosen for review based on AI and disaster management as shown in Fig. 2, 3 and 4 (S. K. Abid, N. Sulaiman, S. W. Chan, et al., 2021). Most of research was done by US and China while other countries also have their share as shown in Fig. 3.

Figure 3

Share of Different Countries in Selected Research Work

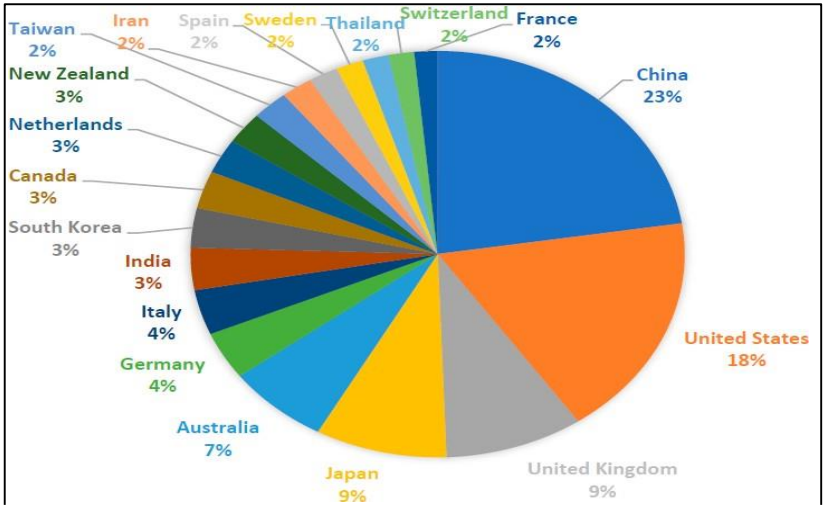
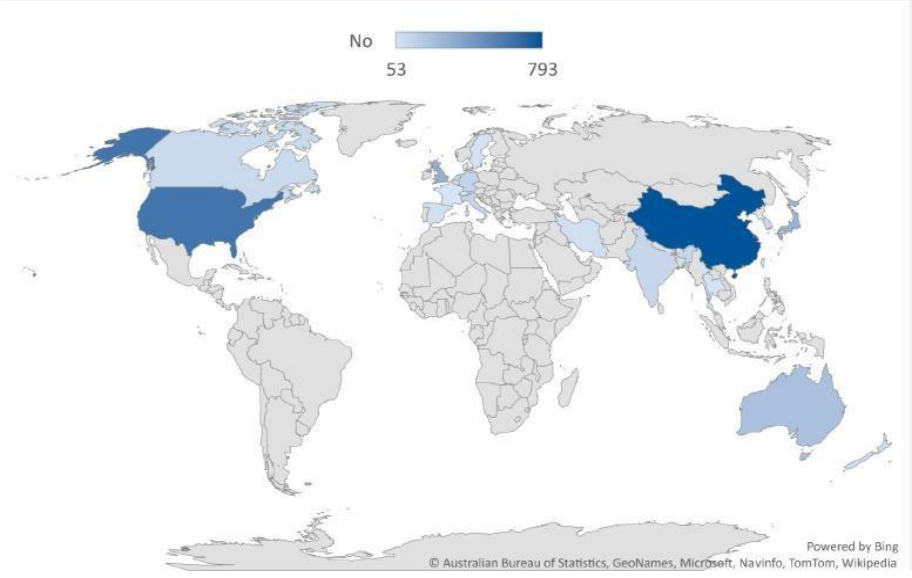


Figure 4

Determined Work on AI and Disaster Management

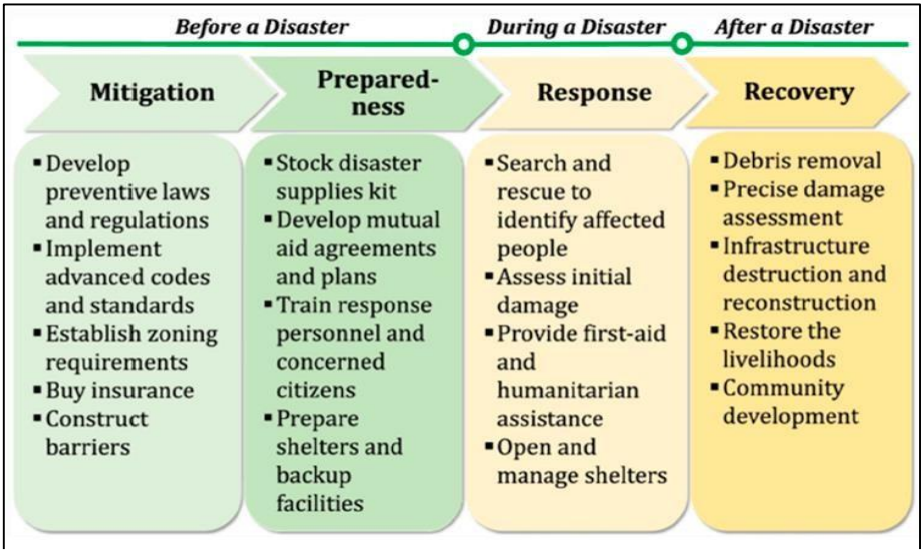


Disaster Management in its Four Stages

The procedure for groundwork to minimize the effect of a catastrophe is known as cycle of disaster management as shown in fig. 5. It also leads the authorities to attain and create strength in people.

Figure 5

Disaster Management in its 4 State



This procedure elaborates 4 states of disaster management which are interconnected activitiessubdivided into 3 other activities which are pre-disaster, ongoing and post disaster tasks.

These tasks are joint to minimize the risks for human losses. Before a catastrophe, the designing indicating to alleviation consists of creating policy rules and execution of standards to fight against any disaster or emergency. It's also advised to get prepare well as per available resources, this stage of DMC is regarded as most important stage to reduce the loss of a catastrophe. At the time of a disaster, action and relive tasks are done. The purpose is to give first aid and other assistance for effecties. At this stage initially loss is also estimated. After a catastrophe, revival tasks are performed i-e revival of livelihood and also loss is précised at this stage.

Disaster Management and AI

AI is the procedure of various interconnected machines replicating human conduct. AI trades in computer based tasks bothered with machine intelligence. During past 10 years, AI advancement is raised our capability to foresee catastrophe and give help during that disasters (Canon, Satuito, & Sy, 2018; Kumar & Sud, 2020; Sangmin Park et al., 2018; Saravi et al., 2019). AI advancement could be reliable in preparations for disaster, people presence information system, its savior, and distribution of humanitarian services (Kumar & Sud, 2020; Sangmin Park et al., 2018). As artificial intelligenceis available in many shapes, but in this works we focused on use of AI as a drones, robotics, sensors based technologies, Machine learning and programs used in relevant to the scenarios of disaster prediction and providing faster savior and relief distributing tasks (Chakraborty et al., 2020; Mosavi,Ozturk, & Chau, 2018). Robotics is an older technology and being in use since decades, but because of advancement in computer and sensors technology, robotics is matured from mechanical devices to actively automated AI machines capable to make decisions (Shinsuk Park, Oh, & Hong, 2017).

Unlike robotics, Machine learning is being in use since years, is now a entirely advance part of AI.Its programs can perform any specific task in the absence of any supervision, by choice of learnsfrom pattern and conclude from input data so it's also categorized as AI (Noymanee, Nikitin, &Kalyuzhnaya, 2017). Machine learning is a type of complex software which have capacity to learn through words, mathematical numbers, pictorial views and videos and other data which is feed intoits database and then utilize it in analyzing and prediction of the output (binti Sulaiman, bintiMahmud, Nazir, & Abid, 2021; M.-F. R. Lee & Chien, 2020). Airborne drones have ability of access more in catastrophically zones to analyze damage and to provide support (Axel & van Aardt, 2017). AI tries to improvise and enhance the effectiveness of disaster management procedures. AI basedsensors and machines collect informations and pass on to the authorities which is helpful in decision making as for decision making actual ground information is required for any instance (Erdelj, Natalizio, Chowdhury, & Akyildiz, 2017). AI is a necessarily a power enhancing agent to guard population in case of disaster.

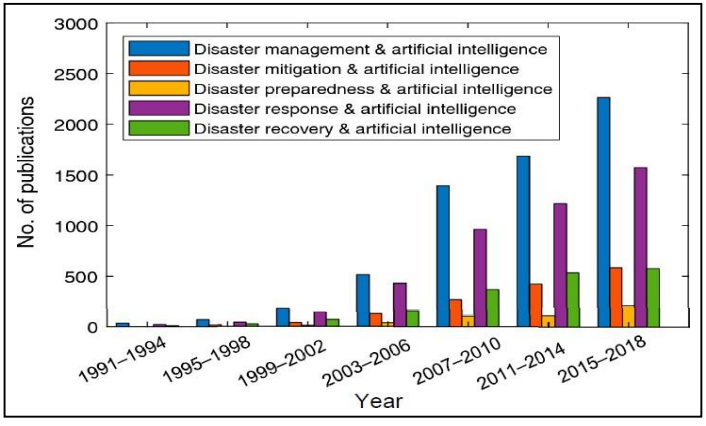
Generally population can share and utilize informations among each other through use of social media and other advance technologies (Villodre & Criado, 2020). During disaster caused by persons or force majeure a lot of people shares information on these social media platforms (Aisha, Wok, Manaf, & Ismail, 2015; Shaluf, Ahmadun, Said, & Sharif, 2002). These informations can be helpful for the decision making authorities but due to a huge number of messages and videos manual analysis of these information is complex and time killing (Shaluf et al., 2002).

During any incident caused by a person of force majeure, people have increased the usage of social media platform by posting pictures, messages and videos of happening of that time (Khouj, López, Sarkaria, & Marti, 2011). During last natural disasters like flooding, wildfires, earthquakes or others,these social media platforms are found important for getting real-time informations (Roslan, Fernando, Biscaya, & Sulaiman, 2021).

Here is a fig. 6 showing publications in worldCat database during 1991 to 2018 relating to role of AIin disaster management. From the various stages of disaster management, highest number of publications are for action stage. Most of application of AI is in response stage than the other stages.Applications of AI sort out big data of information faster in disaster scenario and give useful information for decision making to improvise disaster management in all dimensions.

Figure 6

Publication by Numbers in Different Years



AI in more specific terms machine learning perform a core part in analyzing of bunch of data to reproduce it into useful information. Human like intellectuality is posed by AI applications during sorting of big data, importantly improvising effectiveness of different jobs, procedures and pattern from bulk amount of data (Munawar, Ullah, Qayyum, Khan, & Mojtahedi, 2021).

As there is a lot of work on disaster management by analysis of data received from social media platform through various ML programs, but a few work have organized on advancement (Oakley, Mohun Himmelweit, Leinster, & Casado, 2020). such kind of advancement for prediction is deep learning (Kabir, Gruzdev, & Madria, 2020), likewise for bound the danger of disaster there is a time series analysis. By integrating Time series with deep learning there is an additional procedure used to resolve problems of forecasting the disaster (Yang &Cervone, 2019; Yao et al., 2020).

DHARA a flood forecasting mobile application is developed using AI applications of Long Short Term Memory (LSTM) (Kumar & Sud, 2020). A prediction model for rainfall is suggested in (S. K. Abid, N. Sulaiman, S. W. Chan, et al., 2021) which concept for assessing environmental conditionsis focused to predict. Regression comprises of linear, nonlinear, logistic regression are the methods of AI which are used for prediction of hazards and risks and its effects. SVM (support Vector Machines) are also used for prediction and analysis of risk. K means clustering, Hierarchical clustering and Neural Clustering, fuzzy clustering and principal components analysis are used to generate and compare reduction techniques, training system and method for evaluation of catastrophe (Ci, Liu, & Wang, 2019; Sulistijono & Risnumawan, 2016). Though, Deep Neural Networks, Convolution Neural

Networks, and perception of multilayered are skills of deep learning which are being used for plotting for disaster (Baldazo, Parras, & Zazo, 2019; Fu, Sun, Meng, Li, & Zhang, 2020). For the fastest and near to exact forecasting multiple algorithms of deep learning are used in combination (Jena, Pradhan, Beydoun, Alamri, & Sofyan, 2020). Though a wide range of data is required to forecast any upcoming disaster for this highly efficient methods are used for this (Deshmukh & Bamnote, 2021).

Disaster Management and GIS

At a time of catastrophe, availability of related data with reasonable presentation is necessary for response and taking vital steps. Catastrophes may influence the whole government or a few dimensions of a government. Workers associated with departments who are dealing with emergency situations have information about electrical and plumbing system and other necessary informations. All related departments can communicate with each other through a specified database or computer generated plotting by utilizing GIS (Albrecht et al., 2020; Termeh et al., 2018). In the absence of these facilities a large number of manpower is required to analyze a large data which is time taking and not beneficial for a case of disaster. In disasters, GIS is helpful in organizing and showing vital information graphically. To reduce effect of catastrophe, it is required to respond on nick of time based on brief and trustworthy informations. Local officials gather data from affected sites. This data comprises of before and after information of the affected area which is integrated into GIS for planning of rescue tasks at the affected area (S. Abid, N. Sulaiman, C. Wei, & U. Nazir, 2021).

Analysis of geographical data give pictorial and graphical output which includes plots, tables and graphs for further action and prediction of disaster. These plots provide a verity of forecasting and reduction techniques before a calamity happens. Moreover, it strengthens the authorities by make them able to take necessary preventive steps before disasters. There are 3 primary objectives of the disaster management which are 1) Protection of life. 2) Protection of infrastructure and 3) protection of its environmental conditions. For DMC, GIS is an priceless resource for achieving these requirement consisting of reducing the danger, its preparation and action needs to be done at the time of danger. Each state links with each other and uses GIS for furnishing a groundwork for disaster management (Fava, Fritz, & Castellano, 2010). Early warning system is an expertise of obscure sensing and satellite imaging which produce mechanism to observe helpful preparationtasks for disaster. Aerial survey is utilized for identification and marking of location for taking steps to reduce the loss (Lai & Tsai, 2019).

For analysis of data and planning for environmental GIS is regarded as most efficient tool (Kankanamge, Yigitcanlar, & Goonetilleke, 2020). It is

because of GIS provided spatial analysis givebetter visibility and modern aspects which translate the link of conditions of ecology and different parameters of environment like steep, slope, exposure and danger analysis and many other required analysis (S. K. Abid, N. Sulaiman, S. W. Chan, et al., 2021). GIS is a logical composition which reproduce spatial data and perform analysis on it. GIS is a system in which various parts are interconnected to perform dedicated tasks. These parts are software programs or hardware based (Fariza, Rusydi, Hasim, & Basofi, 2017).

At each phase of disaster management, GIS activities consists of 3 stapes which are as follows,

- Firstly, collection of data from trustful sources
- At second step it sort out the data in readable form e.g. numbers, graphs, tables etc.
- At last, this refined data is given to the user for decision making

Another quality of GIS is that it give data in form of layers. So, in case of danger it provide vast collection of data in many layers for visualization and understanding the actual situation which is helpful in decision making and response activities (Der Sarkissian, Zaninetti, & Abdallah, 2019; Sharma, Misra, & Singh, 2020). GIS programs have ability to perform geometrical and arithmetical analysis in each state of disaster management. These results are helpful to foresee future behavior. Various layers of GIS are used to conduct loss analysis (Acquah, Asamoah, & Konadu, 2017).

Findings of this Work

In this work, it is shown that by implementation of advance technologies like Artificial intelligence and GIS in disaster management can be more effective as it provides on time indications for mitigation, preparedness, response and recovery and also helpful in take early action to reduce adverse effects of disaster. AI and GIS provides broad spectrum of disaster affected area to analyze destruction caused by the disaster and helps to developed road map for rehabilitation activities in those areas. AI have been widely applied to support disaster management in decision makers need to identify hazard and risks, predict possible impact, assess vulnerability, and develop strategies in order to create powerful, cautious, and better resilient societies.

Sensor based technology is used to monitor environmental conditions effectively and gives indication if there is any change in normal environmental conditions.

Conclusion

This work intended the role of AI and its applications in disaster management. It is shown in this work that in what way AI and its applications are useful and enhance the capacity of disaster management. In this work, many researches are reviewed advocating that various applications of AI are used to identify the disaster and many techniques are also proposed for implementation state of disaster management. It is also concluded that the present mode emphasizes on how to react and reduce disaster. Technologies like geospatial are consistently expanding and produce on time solution. These days, remote sensing and GIS are strong mechanism which are enabling new capacities for understanding and responding an emergent situation.

It is assumed that in future, AI technology will evolve as more composite and will be able toproduce multi spectral data which will definitely help to reduce effects of a disaster. That's why AI has massive power to deal with disaster caused by persons or force majeure. Although its affectivity also integrated with other important technological components which are used to increase success ofmanagement team.

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