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A Review on Big Data Analytics with IoT in Disaster Management

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Abstract:

The current rise of Internet of Things (IoT) and Big Data Analytics (BDA) technology presents a huge chance to aid disaster-related authorities, including public health, fire, emergency responders, and law enforcement. These technologies provide state-of-the-art support and enhanced insights to enable timely and accurate decision-making. The goal of this research is to clear the path for the efficient application of opportunities that the BDA and IoT together present to anticipate, comprehend, and keep an eye on crisis scenarios. Most current disaster management systems do not support many new data sources and real-time big data processing approaches that can help decision-makers receive timely and accurate findings. The significance of BDA and IoT for disaster management is emphasized in this research. Next, give a thorough analysis and look into recent research that has been done in this area. Lastly, talk about and emphasize the major research issues in this crucial field of study that still require attention.

Keywords: Internet of Things, Big data analytics, disaster management

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مراجعة لتحليلات البيانات الضخمة باستخدام إنترنت الأشياء في إدارة الكوارث

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الملخص:

إن زيادة النمو الحالي لتقنيات إنترنت الأشياء (IoT) وتحليلات البيانات الضخمة (BDA) يمثل فرصة هائلة لكل من أنظمة إدارة الكوارث والسلطات ذات الصلة بالكوارث (الدفاع المدني، الشرطة، الصحة العامة، وإدارات الإطفاء) للحصول على أحدث المعلومات – المساعدة الفنية والرؤى المحسنة لاتخاذ القرارات الدقيقة وفي الوقت المناسب. الدافع وراء هذا البحث هو تمهيد الطريق للاستخدام الفعال للفرص المقدمة بشكل تعاوني من قبل BDAو IOTللتنبؤ بحالات الكوارث وفهمها ومراقبتها. تفتقر معظم أنظمة إدارة الكوارث التقليدية إلى دعم العديد من مصادر البيانات الجديدة وأدوات معالجة البيانات الضخمة في الوقت الفعلي التي يمكن أن تساعد صناع القرار في الحصول على نتائج سريعة ودقيقة. تسلط هذه الورقة الضوء على أهمية BDA وIOT لإدارة الكوارث. نحن نقدم مراجعة شاملة ونحقق في الدراسات الحديثة الموجهة نحو نفس المجال. أخيرًا، نناقش ونسلط الضوء على التحديات البحثية الرئيسية التي يجب معالجتها في مثل هذا المجال البحثي المهم.

الكلمات المفتاحية: إنترنت الأشياء، تحليلات البيانات الضخمة، إدارة الكوارث.

Introduction

Human life, infrastructure, and the environment can all suffer greatly from disasters, whether they are man-made or natural. In the 2021, a total number of 432 natural disasters such as flood, earthquake, landslide, tsunami, etc. are identified by EM-DAT, report 2021(*Inflation (CPI)*, 2021). The economic losses associated with these disasters estimates at about 252.1 billion USD, These caused 101.8 million individuals to be impacted and 10,492 deaths. Furthermore, news stations nearly always feature stories about

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catastrophic catastrophes like terrorist attacks, oil spills, nuclear meltdowns, transportation mishaps, etc. Most of the major cities in developing countries with increasing population density are considered the most disaster-prone areas of the world. This is because their authorities lack status information in the event of a disaster, since they are largely limited by the lack of resources(Wei et al., 2016). Preventive and reactive actions must be planned ahead of time for both natural and man-made catastrophes in order to minimize the likelihood of casualties and damage to the environment and infrastructure.

Thus, in order to speed evacuations and anticipate disasters, disaster management systems must effectively harvest affirmative knowledge and monitor and evaluate the ground status. To improve disaster management techniques, government officials, academics, and practitioners investigate novel concepts from a variety of study disciplines, such as information technology, cartography, health sciences, and environmental sciences. Their ultimate objective is to enhance the phases of disaster management systems' data collection, management, processing, and visualization in order to promote prompt and precise decision-making. In order to meet the precise and expeditious decision-making requirements of disaster management systems, a number of cutting-edge technologies must be used and integrated.

With the emergence of the latest data analytics, service, and communication technologies such as BDA, IoT, cloud computing, fog computing, etc., disaster management systems are on the way to getting equipped with multiple new probative data sources as well as fast and cost-effective data processing tools that can potentially be employed to help decision- making in all four phases of a disaster (i.e., rescue, reaction, mitigation and preparedness). During the course of any disaster, applicable and timely decision- making based on accurate and up-to date information determines the effectiveness of a disaster management system (Hristidis et al., 2010). operations demanding real- time operations on their high- speed data streams need fast and large- scale streaming data analytics to achieve asked results(Mohammadi et al., 2018). Disaster management systems

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can access a larger range of data by employing many data sources, such as crowdsourcing information and physical sensing devices. This results in multi-dimensional data that can be successfully processed to yield improved outcomes and innovative insights.The growth of communication through Web2.0; the possible integration of implicit miscellaneous data sources(social media, IoT enabled sensors, satellites, smart- phones, authoritative/ public data depositoriesetc.); and the emergence of the important big data analytics tools (Hadoop, Spark, Kafkaetc.) with interactive visualization operations (Kibana, Tableau, Plotlyetc.) can cause disaster management systems to undergo a paradigm change. The conception of smart city is being extensively considered as an ideal result to attain high- quality cooperative multimedia services (Albino et al., 2015). Cities are getting equipped with the latest digital structure of networks, sensors and smart devices that are generating an enormous quantum of data; which can contain rich streams of contextual, spatial and temporal information (Kitchin, 2014). Smart city impulses can significantly contribute to loss reduction by providing fresh insights and information for creatively handling crisis circumstances. The conventional methods of gathering and managing data are being put to the test by the excessive usage of smartphones and other portable mobile devices with sensors (such as GPS receivers, high-definition cameras, microphones, and accelerometers). Big sensed data can give a number of benefits such as, situational awareness improvement, improved allocation of resources and provision of a better source for informing disaster threat reduction strategies and hazard assessments(Watson et al., 2017). Several data sources have the ability to send a sizable volume of unstructured data to the distant station upon request or after reporting the comprehensive activity. Even still, when a catastrophic event occurs, processing these enormous amounts of unrelated data in real time is quite taxing (Akter & Wamba, 2019).

Practices concentrating on the discovery, collection, bracket, hunt and distribution of real- time disaster information have the

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loftiest precedence for an effective performance in disaster operation tasks (Zheng et al., 2013).

presently, BDA- and IoT- grounded disaster operation is an under-delved exploration area, that includes numerous intriguing openings and challenges. With IoT's capability of offering a frame of ubiquitous network with connected sensors and smart devices(Gubbi et al., 2013), IoT technology retain the eventuality to be incorporated in disaster management and can give a positive impact on every phase of exigency response(Yang et al., 2013). BDA on the other hand, is known to facilitate the real- time processing of IoT and other related data streams(Rathore et al., 2016), and is able of furnishing meaningful results for considerate the states persisting in the disaster- affected areas, hence based on the diagnostic results the deployment of resources is optimal and effective(J. Wang et al., 2016). also, big data generated in the IoT environments can be used for performing data analytics, monitoring, forecasts and generating cautions for unusual events(Ahmed et al., 2017). Therefore, authors argue that the collaborative use of BDA practices and Internet of Things technology can result in the creation of a novel, efficient, and highly-requested disaster management environment.

In order to examine the overlooked prospects and potential difficulties related to their collaboration for efficient, accurate, and timely disaster management decision-making, will mainly evaluate the literature that has already been written on BDA and IoT within the context of disaster management in this study. This paper's primary goal is to demonstrate that combining BDA with IoT technology might result in innovative approaches and potentially useful solutions for applications related to disaster management. This work aims to contribute to the knowledge of disaster management environment design and execution using BDA and IoT by methodically identifying future research opportunities. The main contributions of this paper include:

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A. Determination and clarification of the primary advantages and necessities of disaster management settings based on BDA and IoT.
B. Recent published research efforts regarding the latest BDA and IoT technologies for disaster management applications are reviewed.

The remainder of the paper presents their contributions in the following manner. The second section outlines the primary advantages and essential requirements of a disaster management environment that is BDA- and IoT-based. An analysis of recent research on BDA and Internet of Things-assisted disaster management is presented in the third section. The main issues that must be resolved are covered in the fourth section. Finally, the conclusion is provided in Section five

Big Data Analytics and IOTin Disaster Management

This section explains disaster management systems, including their needs, applications, and descriptions. After that, we'll talk about the advantages that BDA and IoT collaboration offer for disaster management and go over some of the prerequisites.

A. Disaster Management Systems

An information system known as a disaster management system (DMS) facilitates in the acquisition, handling, and use of disaster data by responders and decision-makers for efficient and prompt disaster management.The main components of a disaster management system (DMS) can be divided into data integration, data mining, and multi-criteria decision-making (Peng et al., 2011). Disaster Management systems (DMS) can be considered as very complex integrated systems that require application-specific design and maintenance.

The design and execution of a disaster management system involves numerous interconnected data nodes, and the volume of data necessitating real-time analytics makes it a multifaceted and challenging task today. Applications for disaster management can be divided into pre- and post-disaster phases due to the variety of features they offer and the varying demands they have on accuracy, efficacy, and response time. The study of quantifiable and thorough

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data is the main emphasis of pre-disaster applications such early warning systems, modeling exercises, and disaster predictions. However, automatic and precise results are needed for post-disaster applications including monitoring, rescue, and evacuation. All DMS applications, however, need to facilitate remote and diverse data sources and enable interactive extraction of relevant information by decision-makers. DMS must possess the desired technical factors such as reliability, availability, maintainability, accuracy and usability requirements (Bayrak, 2009).

B. Big Data Analytics and IOT

Disaster management systems require modern environments that support numerous data sources and are equipped with state-of-the-art technology that offer a larger range of capabilities to enhance connection, storage, real-time analytics, and economically viable applications. These environments can be successfully deployed by immersion in both BDA and IoT technologies for disaster-related operations.The advantages of combining BDA and IoT for disaster management systems are shown in Figure 1, along with the key prerequisites for setting up an environment that combines BDA and IoT for disaster management(Shah et al., 2019).

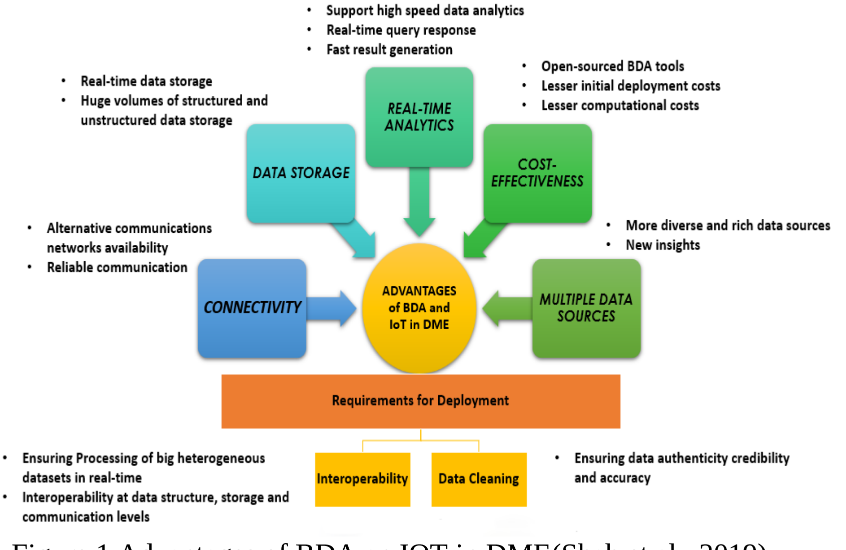

Figure 1 Advantages of BDA an IOT in DME(Shah et al., 2019)

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1. Advantage

Within the field of disaster management, BDA and IoT-based disaster management environments can offer several benefits. The subsequent subsections include descriptions of a few of the primary benefits.

a) Communication

Large-scale data gathering from diverse data sources to high-performance computer systems and increased information exchange with disaster management authorities necessitate communication. One of the primary benefits of a disaster management environment based on BDA and IoT is the ability to deliver dependable communication due to the availability of numerous communication methods. The communication between the interconnected data nodes and the disaster management system acts as a backbone to secure successful operations.

b) Storage

In typical DMS systems, real-time storing of massive volumes of heterogeneous data might be difficult. Large volumes of organized or unstructured data sets can be efficiently stored on inexpensive commodity hardware by utilizing BDA technologies like Hadoop. The efficiency of data processing as a whole can be improved, and real-time systems with streaming storage capabilities for IoT devices and other data sources can offer distinct advantages for particular applications (Cai et al., 2017). Additionally, while preserving the storage of enormous unstructured data sets, BDA technology can provide effective processing with minimal latency for data analytics.

c) Analytics in Real-time

The capability that the BDA offers to perform rapid analyzes with real-time inquiries is necessary to assist decision-makers in obtaining the results required for efficient emergency response.

d) Cost

When it comes to disaster management operations, licensing data processing software solutions is more expensive than using BDA technologies, which are primarily free source. In poor nations,

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where funds are scarce and disaster management systems are not implemented, cost is a critical consideration for disaster authorities.

e) A Variety of Data Sources

Data processing is made possible by BDA technology, and many data sources can be integrated to provide fresh and insightful data. Using a variety of data sources offers different approaches to challenges that call for multidimensional data representations in order to identify common patterns for a solution that cannot be found using a single data source (Li & Liu, 2017). Disaster management settings based on BDAs and IoTs can surpass traditional DMSs in terms of data sources due to the availability of diverse and abundant sources.

2. Requirements

a) Compatibility

The ability to manipulate and link two or more pieces of data is known as compatibility. It's likely that datasets gathered from diverse sources won't correlate with one another or that it will be challenging to see any connections between them. Achieving the highest degree of compatibility is crucial but difficult when combining and aggregating data in real time. At the technical, syntactic, semantic, and pragmatic levels, compatibility can be guaranteed (Janssen et al., 2014). Thus, in order to guarantee high reliability, it could be a good idea to use compatibility checks at the data structure, storage, and communication levels through abstraction and virtualization.

b) Data Cleaning

For disaster management, data cleaning is essential because imprecise, unclear, and incomplete data can cause further problems and waste time. Data purification parameters determine the accuracy of the analysis performed on a given data set. However, since data purification operates on a complex relationship model and can require additional computational power and processing time, a balance must be maintained between the data purification model and improving the accuracy of the analysis (Hu et al., 2014). Furthermore, a new kind of unstructured data is emerging as a result

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of the growing usage of social media data for disaster management activities, and it requires accuracy, trustworthiness, and validation.

Review of Recent Literature

In order to identify important study areas and to showcase the most recent advancements that have been acknowledged as improving procedures connected to disaster management, this section examines current research contributions.

a) Big Data Analytics Perspective

In order to identify hidden patterns and comprehend the situation on the ground, big data analytics offers a variety of solutions on multi-source, enormous data sets gathered from the disaster region. This allows for the efficient management of logistics and the successful execution of rescue operations. One of the main advantages of using a BDA is that it enables data scientists to analyze vast amounts of data that include different data sources that may not have been collected using traditional tools (Mikalef et al., 2018).

The authors in (F. G. De Assis et al., 2018) designed an interoperable mechanism for flood risk management, integrated heterogeneous sensors that enable near-real-time data access and filtering using Spark. The methodology they employed in their study provides a means of using heterogeneous data flows—that is, crowdsourcing data and sensors—to enhance near real-time applications. A big data crisis mapping system was designed by (Avvenuti et al., 2018)that is capable of collecting and analyzing Twitter data using Kafka and Spark. Using categorization and semantic annotation technologies, the system pulls information about disasters from geotagged tweets. Early in a crisis, emergency personnel can better understand the situation by using a web-based dashboard that visualizes the data. In another study (Lin et al., 2018) it was determined that a computation based on Spark on large sets of historical data provides better simulation performance to determine the feasibility of a hurricane risk assessment. The authors in (Liu et al., 2018) proposed an algorithm for real-time collection and classification of mobile phone location data by stream

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processing environments such as Kafka and Spark to produce a high-resolution heat map of the earthquake-affected population. (Z. Wang et al., 2017) introduced an integrated disaster management system developed by combining Hadoop and Spark. Their solution offers predictive risk analytics to maximize fire response resources and evacuation planning, and it addresses challenges with large-scale data sets for spatiotemporal perspectives.

b) IOT Perspective

Recent disaster management research has extensively examined the Internet of Things as a means of obtaining multidimensional and multisource data for prompt decision-making. Disaster detection may benefit from the use of the Internet of Things. The main components of situational awareness for efficient decision-making are the intelligent gathering, integration, and analysis of multi-dimensional and multi-source data that the Internet of Things provides. In a study, the authors(Greco et al., 2018) demonstrate how IoT can be successfully deployed with semantic web technologies to detect earthquake-related events. The proposed system was capable of semantic annotation of streams retrieved from web services that collect IoT-based sensor data for effective earthquake event detection. (Xu et al., 2018) Introducing an IoT-based system that focuses on the rapid and regular evacuation of large crowds of people after disasters. (CLOTHO) Through the use of a mobile cloud computing platform and an Internet of Things (IoT) solution, the Crowd Life Path Oriented System seeks to lower the death toll. The cloud-powered system powers the system's storage and data analysis components, while the IoT-powered mobile terminal powers the system's data gathering portion. The authors in (Ben Arbia et al., 2017) proposed an emergency and disaster relief system that is monitored by a cloud-based IoT platform. The system, known as Critical Operations and Rescue utilizing Wearable Wireless Sensor Networks, combines many communication protocols, including WiFi and Bluetooth, with heterogeneous wireless devices, including smartphones and sensors, to provide end-to-end network connectivity. This system helps

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rescuers in emergency situations connect to any working network or the Internet.

c) Crowd Perspective

The concept of "People as Sensors" makes use of crowdsourcing, which has gained recognition in the field of disaster management recently, to integrate fresh and big data sets that can be modified to get more insightful information when needed. Crowdsourcing can be unsuccessful because social media platforms are often used to collect data with or without the contributor's knowledge, or it can be active where people voluntarily participate to offer data. One of the most recent large data sources for disaster management research to emerge is social media. In particular, with the increasing use of smartphones in the past few years, geospatial data generated by social media platforms has become more and more in demand for traditional data sources for disaster management (Haworth & Bruce, 2015). The concept of voluntary geographic information (VGI) (Goodchild, 2007) is widely used for disaster management, as citizen participation in disaster response is increasing. Kusumo and others. (Kusumo et al., 2017) Examine the benefits of using VGI for spatial planning of evacuation shelters. Using the floods in Jakarta as a case study, they conducted an analysis that revealed 35.6% of the shelter locations that the citizens had requested coincided with the locations of the government-run evacuation shelters. In another study (Feng & Sester, 2018), VGI extracted from social media was used for real-time precipitation and flood event detection through high-quality user-generated eyewitnesses in the form of text and images by applying deep learning approaches. Flood incidents were focused on in various cities, including Berlin, London, and Paris, where case studies and analysis were conducted using the web mapping application's spatiotemporal clustering and visualization capabilities.

Discussion

In order to obtain a deeper comprehension and information of advancements in the targeted field of study, this part addresses and

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identifies the primary open research issues that must be investigated in the future.

a) Disaster Data Quality

Disaster management depends heavily on the quality of the data that has been gathered because noisy, inaccurate, and incomplete data can cause major issues and waste important time in an emergency situation. This aspect needs to be rectified before any kind of analysis can be done because it adds to the load for BDA and IoT-based disaster management setups.

b) Analytics Application

Selecting the right kind of analysis to run on recently acquired massive data sets for disaster response or management can be difficult. The performance and efficacy of the entire environment will be determined by the analysis method selected, which will ultimately impact the decision-making process. Furthermore, a mix of various analytical techniques may be needed for the analysis and intended findings, which could impact system performance and raise the stress on the system. Finding and analyzing data sets that enable accurate findings to be produced in real-time with ease and efficiency presents another difficulty.

c) Time Factor

It is extremely challenging to extract high-quality information quickly enough to make wise decisions about emergency responses because of the massive volumes of data. Even with sophisticated big data analysis tools, data processing can be time-consuming due to the multi-source data collecting, filtering, and categorization involved. One of the major issues facing today's technology and solutions is pre-processing data and obtaining the necessary outcomes within a given time frame to enable quick emergency response and save lives.

d) Privacy and Security

In the big data and IoT areas, where open personal information is frequently used, privacy concerns have been a major issue. If mishandled, this can result in dangers including profiling, tracking, theft, and discrimination. Big data typically involves private information about individuals or the government, so while it moves across several networks, a high level of security is needed. Due to the fact that social media data sources include user location and personal information, privacy concerns may become more acute. When there are crises like civil wars and resistance movements, these data sets might be extremely sensitive. Furthermore, the majority of Hadoop ecosystem technologies and open-source big data analytics tools lack a sufficient security framework (Kim et al., 2014). A suitable security system is therefore needed to guarantee that the data is safeguarded. Managing the access control of huge disaster data sets is essential to prevent any malicious use of the data..

Conclusion

A novel and more efficient method of carrying out the essential functions of disaster management operations is promised by the combination of BDA and IoT. Modern big data analytics and well-managed IoT solutions allow one to swiftly get the results needed for informed decision-making in addition to collecting a plethora of usable data from diverse data sources. Given the time restrictions and accuracy needs of disaster management systems, however, there is still a great deal of study to be done in order to effectively model and implement these two models. The advantages of BDA- and IoT-based disaster management are discussed in this review paper, which also examines the most recent research on these applications in the literature.classifying the pertinent literature according to an objective classification that highlights the salient characteristics of disaster management environments based on BDA and IoT. Furthermore, in this regard, prospective research directions in rapid development were highlighted, along with the fundamental prerequisites for successful distribution and the hurdles that need to be overcome. In summary, this analysis can serve as a roadmap for comprehending the overall purposes of making beneficial use of opportunities related to BDA and IoT to create an environment that is conducive to effective disaster management.

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